AC 2012-4955: INVESTIGATION INTO THE IMPACT OF THE BUILT ENVIRONMENT ON OBESITY IN TWO COMMUNITIES

Dr. Fouad H. Fouad, University of Alabama, Birmingham

Fouad H. Fouad is professor and Chairman of the Civil, Construction, and Environmental Engineering Department at the University of Alabama, Birmingham, USA. He teaches and conducts research in the area of reinforced concrete structures and concrete materials, and has published numerous technical papers in the field. His research efforts have led to the development of national standards and specifications for a number of concrete products and building systems, including spun prestressed concrete poles and autoclaved aerated concrete. Fouad is a Past Chairman of ACI Committee 523 Cellular Concrete. He is the Current Chair and founding member of ACI Subcommittee 523A Autoclaved Aerated Concrete. In addition, Fouad chairs the ASTM Committee C27.60 on Autoclaved Aerated Concrete and the PCI Committee on Prestressed Concrete Poles. He is also a member of ACI Committee 224; member of ACI Committee 118, Consulting Member of ACI Committee 345, and Associate Member of ACI Committee 231. Fouad organized and chaired three ACI Technical Sessions on cellular concrete and autoclaved aerated concrete. He is also co-editor of the ACI SP 226 "Autoclaved Aerated Concrete-Properties and Structural Design," published by ACI in 2005. Fouad is a Fellow of ACI and ASCE. Fouad has received a number of prestigious awards due to his professional services in the civil engineering field. Notable awards include: the 2010 Engineering Council of Birmingham Engineer of the Year Award; the "2004 ASPE Circle of Excellence Award for Engineering Educator of the Year," awarded by the Alabama Society of Professional Engineers; and the 1993 Ellen Greg Ingalls Award, UAB's highest honor for teaching. Fouad's current research activities on green materials and construction methods have a global perspective. He recently held two National Science Foundation (NSF) international workshops (Dec. 2007 and March 2009) on sustainable green building design and construction. The last conference was attended by more than 400 scientists, architects, and engineers, and included experts from the USA, Europe, Asia, and the Middle East.

Ms. Sarah Stephens Bettinger
Dr. Virginia Sisiopiku, University of Alabama, Birmingham

Virginia P. Sisiopiku is Associate Professor of transportation engineering in civil, construction, and environmental engineering at the University of Alabama, Birmingham (UAB). She holds a B.S. degree in civil engineering from Aristotle University in Greece, and M.S. and Ph.D. degrees in civil engineering from the University of Illinois, Chicago. Her research interests focus on traffic operations and safety, congestion and incident management, traffic simulation and modeling, and non-motorized transportation. She has served as the principal investigator in 70 projects and authored more than 130 technical papers. Sisiopiku has been recognized by many organizations for her professional achievements including the Institute of Transportation Engineers, the Federal Highway Administration, the Illinois Association of Highway Engineers, and the Women's Transportation seminar. She is the recipient of the 2007 President's Excellence in Teaching Award and the 2010 Dean's Award for Excellence in Mentorship. She is an active member of the Institute of Transportation Engineers and the Transportation Research Board.

Dr. Isabel C. Scarinci, University of Alabama, Birmingham

Isabel Scarinci is currently a professor at the University of Alabama at Birmingham's Division of Preventive Medicine, and Associated Scientist at UAB's Comprehensive Cancer Center, Center for Outcomes and Effectiveness Research and Education, Center for Aging, Sparkman Center for Global Health, and the Minority Health and Research Center (where she also serves as Co-leader of the Training Core). She has had extensive research and clinical experience working with underserved populations. Her primary area of interest is disease prevention among low-income, minority and immigrant women (particularly Latinos and African Americans). The focus of her work is on the application of behavioral science to public health by promoting behavior change at the population level.

Dr. Mona N. Fouad

Investigation into the Impact of the Built Environment on Obesity in Two Communities

Introduction

Obesity is a growing problem in not only the United States but worldwide and has been termed "global epidemic" by the World Health Organization (WHO). Overweight and obesity increase the risk of non-communicable chronic diseases such as Type 2 diabetes, cardiovascular disease, hypertension, and stroke. It is estimated that over one third of the American population is obese.

Part of this problem is the wide availability of convenience foods, that is, quick, cheap foods with low nutritional value, and the increased prevalence of sedentary lifestyle, both at work and in leisure time. However, the impact of the built environment on people's lifestyles should not be discounted. The built environment is, quite simply, our man-made surroundings. It includes our buildings, waterworks, roadways, and, to a certain extent, our environmental conditions. From the layout of streets to the options available for exercise, from the quality of air and water to the condition and upkeep of residences, the built environment exerts silent but significant influence on the way we live our lives.[1]

This paper summarizes the result of a research project to assess the impact of built environment on obesity.

The project presented here is part of a larger multidisciplinary study that aims to develop a measurement model for understanding the social determinants of health and assessing the impact of action. This larger multidisciplinary study investigated multiple social determinants of obesity, including childhood development and education, social environment, health status and genetics, psychosocial factors, lifestyle, neighborhood characteristics, economics and economic development, food systems, and health outcomes, in addition to the built environment.

Neighborhood Selection

The neighborhoods selected for this study are two suburban communities with similar population numbers and median population age. The two neighborhoods are similar geographically and are in close proximity to one another and to a major metropolitan center. Neighborhood A is a predominantly African American incorporated city with its own government and with a poverty level higher than the national average; while Neighborhood B is a predominantly white non-incorporated suburban community within the greater metropolitan area with a poverty level lower than the national average.

Research Approach

The first aim of our research project was to identify civil engineering factors that could influence the rates of obesity in the two targeted neighborhoods. To identify such factors, the chain of events leading to obesity had to be inferred, and the root civil engineering causes determined. Although little information directly correlating civil engineering factors with obesity levels could be found, studies indicated that neighborhoods where people were more involved with their community and had more choices for recreation, shopping, and transportation had a tendency toward overall better health.

From the review of the literature, three basic areas of engineering impact were identified: 1) Housing conditions; 2) Environmental concerns; and 3) Transportation options and livability. Within these areas, potential engineering factors contributing to the incidence of obesity were identified as follows.

Housing Conditions

Of all the engineering factors correlated with negative health outcomes, housing conditions are the most closely tied to actual health, rather than lifestyle, impacts. Seven potential factors were identified: 1) Structural condition and age of houses; 2) Occurrence and prevalence of mold in the structure, which can cause breathing difficulties and asthma, which, in turn, can lead to a less active lifestyle; 3) Prevalence of mosquitoes in the neighborhood, which, it was reasoned, would discourage outdoor activities; 4) Incidence of air conditioning, which is hypothesized to influence obesity in two ways. Firstly, energy is expended to regulate body temperature, and if the temperature is controlled by a HVAC system, fewer calories have to be burned by a body. Secondly, the more comfortable it is to be inside, the less likely a person is to be willing to go outside and be active, especially in an area of high temperatures and humidity[2,3]; 5) Exposure to chemical contaminants, which could have a direct impact on health; 6) Availability and reliability of utilities; 7) Effectiveness and reliability of waste management and waste treatment services.

Environmental Concerns

Environmental concerns are focused on the overall health of the neighborhood rather than on individual structures. Five areas of interest were identified: 1) Indoor and outdoor air quality; 2) Water quality, specifically the quality of the water entering the residence from the water utility provider; 3) Number of brownfields (properties or areas that are chemically contaminated or have such appearance) or chemical contamination sites near or in the neighborhood; 4) Availability and reliability of utilities; and 5) Effectiveness and reliability of waste management and waste treatment services.

Air quality, and especially indoor air quality, is a growing area of concern for public health. Although most municipalities are required by the federal government to monitor outdoor air quality as part of the Clean Air Act, no such regulations apply to indoor air quality in private spaces. Of particular interest to obesity research are the measurements of PM2.5 and PM10, which describe the concentration of particulate matter of less than 2.5 microns and 10 microns in size, respectively, and are measured in units of parts per million, or ppm. Ground Level Ozone, which was also available in our data sets, is generally used as a marker for overall air quality, though exposure can cause inflammation of the lining of the lungs and can worsen bronchitis, emphysema, and asthma.

In relation to water quality, endocrine disrupting chemicals (EDCs) including estrogenic chemicals ingested though water supply have been linked to higher obesity rates in laboratory animals, and most municipalities neither screen for nor remove them during routine water treatment processes. Sources of EDCs in the water are runoff from pesticides and byproducts of the plastics-producing industry, as well as through-flow of chemicals into the water supply from prescription drugs. Although the research on the effects of EDCs is still in the stages laboratory animal testing, studies indicate that prenatal exposure may increase the proportion of fat-storing cells produced in the body. Sources of EDC exposure are not limited to the water supply, however, so significant exposure may occur though contact with contaminated materials and through other forms of ingestion.[4,5]

Neighborhoods where trash is allowed to accumulate are typically unhealthier than neighborhoods with adequate sanitation. People are also less likely to be active in an area where trash has accumulated or there is an unpleasant odor due to improper wastewater management.

Transportation Options and Livability

This study identified three measures of the transportation environment that can be used to benchmark the quality of conditions afforded to users as far as livability is concerned: 1) Proximity to services; 2) Neighborhood design and safety; and 3) Transportation systems availability and accessibility.

Proximity to services (PTS) was evaluated on the basis of walkability, i.e., the accessibility of basic destinations and services on foot. Modeled after the Street Smart Walk Score methodology[6] a community or zone was assigned a walkability score by mapping out the walking distance to the closest amenity locations of nine different amenity categories. Walkability was measured based on the walking distance to the closest grocery stores, restaurants, coffee shops, shopping, banks, parks, bookstores, and entertainment establishments.

Neighborhood design and safety (NDS) was assessed through five measures: a) compact development – residential density measured as the ratio of total housing units and area; b) availability of quality transit amenities – bus stop shelters, bus stop seating, bus maps/schedules, bus stop lighting, phones, trash baskets, bus stop signs, etc.; c) availability of quality pedestrian amenities – assessed based on the quality of pedestrian sidewalks, crosswalks, street corners, tree-lined streets, and compliance with Americans with Disabilities Act (ADA) requirements; d) quality of parks and recreational facilities – the quality of amenities provided and maintenance level of available parks and recreational facilities; and e) traffic safety – measured on the basis of the ratio of Annual Vehicle Crashes/1,000 residents and how it compared to the Average Annual Vehicle Crashes/1,000 residents.

Transportation systems availability and accessibility (TSAA) was evaluated on the basis of six measures: a) commute time – how long people spend travelling to work, by whatever means they use, i.e., foot, bus, car, train, bicycle, or other; b) transit coverage – quantified on the basis of minimum available weekday and weekend transit trips available; c) street network connectivity – measured as the number of intersections per unit of area, e.g. square mile; a higher number would indicate more intersections and higher connectivity; d) condition of pedestrian facilities – assessed on the basis of maintenance, connectivity, and convenience of pedestrian facilities; e) access to public spaces and recreational facilities – measured based on the location of such facilities relative to the location of interest; and f) bicycle network availability and accessibility – measured on the basis of proximity, accessibility, and connectivity.

Data Collection

The primary data collection occurred through state and local databases. For the transportation options and livability assessments, data were obtained from extensive physical surveys during on-site visits, review of detailed Google maps, analysis of state crash records available in the CARE database, review of census data, and online resources.

In addition, semi-structured interviews with key informants from the community were conducted, and a community survey, covering all aspect of the broader multidisciplinary project, was developed. Survey questions relevant to the purpose of this project included perceived neighborhood cleanliness and safety; personal dwelling amenities and condition, including questions about mold in walls, ceilings, and ductwork, perceived water quality, and occurrence of air conditioning; transportation habits and preferences; and occurrence, quality, and personal use of sidewalks and public recreating spaces. The survey also will measure participants' height, weight, calculated Body Mass Index (BMI), and perceived body type (as the BMI calculation can mistakenly classify certain healthy body types as overweight). The survey will be administered to residents of the two study communities. This community involvement not only provides crucial qualitative data that helps explain the quantitative data and demographic information, but also fosters a sense of ownership in the project.

Results

Housing Conditions
The first data set collected the housing records for both neighborhoods. Though the building permit records for Neighborhood A were comprehensive, there were no recorded instances of remediation for mold growth. Additionally, since Neighborhood B is a community in the greater metropolitan area and not a distinct city, building records for Neighborhood B were not available in the same way as for Neighborhood A. Of all available building permits for the greater metropolitan area, only five were for buildings located in Neighborhood B. A natural disaster that hit the area during data collection and caused property damage further contributed to the difficulty in locating building records for Neighborhood B. Since all recent records for the greater metropolitan area are aggregated, the percentage of Neighborhood B records (less impacted by the disaster) was much smaller in comparison to the records from some of the more impacted areas.

Environmental Concerns
The second data set collected outdoor air quality measurements provided by the local Department of Health (DoH.) The DoH has one permanent air-quality monitoring site in Neighborhood A and no site in Neighborhood B. Through a computer program, all available air quality data from the DoH was used to give the most accurate measurements for each of the two communities based on their zip codes. The program data was meant to overcome the shortfalls of analysis conducted by only one monitoring station.

The third data set collected was the water quality information, obtained from the local water board's annual report. Since both neighborhoods are served by the same water treatment facility, no comparative analysis was done on the data. However, the aim of this research is, in part, to develop a model that can be used in the future in other communities. Therefore, in other studies similar to this one, we would encourage the researches to focus specifically on the levels of EDCs in the drinking water supply.

Transportation Options and Livability

The fourth data set focused on elements of the transportation environment and was used to assess the livability of the study communities. This was accomplished through the development and testing of a scoring methodology that utilized the twelve measures of transportation options and livability presented earlier to quantify the livability of the community (or zone) relative to preset standards. Rubrics for the allocation of possible credit points were developed based on literature review recommendations and engineering judgment and used to guide the assessment process. For example, adopted from the LEED methodology[7], a neighborhood or zone with more than 400 intersections per square mile demonstrated excellent network connectivity and was awarded 2 points where as one with 300 to 400 per square mile had average connectivity and received 1 point credit. Finally, poor connectivity was considered for less than 300 intersections per square mile leading to 0 credit points. As another example, communities or zones that provide excellent quality transit amenities such as bus stop shelters, bus stop seating, bus maps/schedules, bus stop lighting, phones, trash baskets, bus stop sign etc received 2 credits whereas those that provide limited amenities (i.e., only bus stop signs receive 1 credit point). Facilities lacking transit amenities received 0 credit points. Table 1 summarizes the measures involved in the scoring process, criteria considered for assigning credits and the maximum credit scores.[8]

Table 1. Livability Measures and Scores

Measure	Max Credits	Criteria
Proximity to Services (PTS); *Max Total Credits=12*		
Walkable Community	12	Distance to services
Neighborhood Design and Safety (NDS); *Max Total Credits=15*		
Compact Development	6	Residential density (DU/acre)
Availability of Quality Transit Amenities	2	Shelters; User information
Availability of Quality Pedestrian Amenities	3	Marked crosswalks, pedestrian signals; tree-lined streets
Availability of Parks/ Recreational Facilities	2	Presence of parks and recreational facilities
Traffic Accident Risk	2	Annual Vehicle Crashes/1,000 people
Transportation System Availability and Access (TSAA); *Max Total Credits=13*		
Commute Time	2	% residents with commute time below 30 min
Transit Coverage	3	Service frequency
Street Network Connectivity	2	Street intersections per square mile
Condition of Pedestrian Facilities	2	Well maintained sidewalks, crosswalks
Access to Public Spaces/Rec. Facilities	2	Distance to public spaces and recreational facilities
Bicycle Network Availability/Access	2	Presence, accessibility, connectivity of bike lanes
GRAND TOTAL	**40**	

For the case study, the two target communities were divided in zones and livability scores for each zone and the community as a whole were obtained using the scoring methodology. Considering all available inputs, the scores received for the study zones of Neighborhoods A and B communities are summarized in Tables 2 and 3, respectively. For easy reference, these scores were expressed in a scale of 1 to 100 as an index, namely Livability Index or LI (%). It can be observed that certain zones fair better than other as evidenced by the higher score received. Overall, as far as quality of transportation options and livability is concerned, the Neighborhood B community exhibits worse characteristics than Neighborhood A.

Table 2. Zone-by-zone Scores and Livability Ratings – Neighborhood A

		Zone										
Measure		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Walkable community	PTS	0	3	3	3	0	6	3	0	6	3	0
Compact development	NDS	2	2	2	2	2	2	2	2	2	4	0
Quality transit amenities		0	1	1	1	0	1	1	0	1	1	0
Quality pedestrian amenities		0	1	1	1	0	2	2	0	2	1	0
Parks & recreation facilities		1	2	2	2	1	2	2	1	2	2	0
Traffic accident risk		2	2	2	2	2	2	2	2	2	2	0
Commute time	TSAA	2	2	2	2	2	2	2	2	2	2	0
Transit service coverage		0	1	1	1	0	1	1	0	1	1	0
Street network connectivity		0	0	0	0	0	0	1	0	0	0	0
Condition of pedestrian facilities		0	1	1	1	0	2	1	0	2	1	0
Access to public spaces		0	1	1	2	0	2	2	0	2	1	0
Bicycle network availability		0	0	0	0	0	0	0	0	0	0	0
Total Score (out of 40 max)		**7**	**16**	**16**	**17**	**7**	**22**	**19**	**7**	**22**	**18**	**0**
Livability Index, LI (%)		17.5	40	40	42.5	17.5	55	47.5	17.5	55	45	n/a
Livability Quality*		**P**	**A**	**A**	**A**	**P**	**A**	**A**	**P**	**A**	**A**	**n/a**

*P=Poor (LI<40%); A=Average (40% ≤LI<75%); E=Excellent (LI≥75%)

Table 3. Zone-by-zone Scores and Livability Ratings – Neighborhood B

Measure		Zone 1	2	3	4	5	6	7	8	9	10	11	12
Walkable community	PTS	0	0	3	3	3	3	0	3	0	0	3	0
Compact development	NDS	2	2	2	2	2	2	2	2	2	2	2	0
Quality transit amenities		0	0	0	0	0	0	0	0	0	0	0	0
Quality pedestrian amenities		0	0	0	0	0	0	0	0	0	0	0	0
Parks and recreational facilities		1	1	1	1	1	1	1	1	1	1	1	0
Traffic accident risk		-	-	-	-	-	-	-	-	-	-	-	-
Commute time	TSAA	1	1	1	1	1	1	1	1	1	1	1	0
Transit service coverage		0	0	0	0	0	0	0	0	0	0	0	0
Street network connectivity		0	0	0	0	0	0	0	0	0	0	0	0
Condition of pedestrian facilities		0	0	0	0	0	0	0	0	0	0	0	0
Access to public spaces		0	0	0	0	0	0	0	0	0	0	0	0
Bike network availability		0	0	0	0	0	0	0	0	0	0	0	0
Total Score (out of 40 max)		**4**	**4**	**7**	**7**	**7**	**7**	**4**	**7**	**4**	**4**	**7**	**0**
Livability Index, LI (%)		10	10	17.5	17.5	17.5	17.5	10	17.5	10	10	17.5	n/a
Livability Quality*		**P**	**P**	**P**	**P**	**P**	**P**	**P**	**P**	**P**	**P**	**P**	**n/a**

***** P=Poor (LI<40%); A=Average (40% ≤LI<75%); E=Excellent (LI≥75%)

Discussion

The data obtained for housing conditions and environmental concerns were not sufficiently distinguishable between the two neighborhoods to provide a basis for comparison. In contrast, the data for transportation options/livability provided a clear basis for comparison between the two neighborhoods. For all these areas of engineering impact, further conclusions will be drawn after conducting the survey.

Housing Conditions

The researchers' attempt to get the required housing data from government sources was ineffective. Data for housing conditions will have to be obtained from the targeted survey questions posed to participants in each community. Housing conditions, for the purpose of this project, are an area that is very opaque. Census data, which can provide the basics of the social demographics of a community, such as ownership (rent vs. own) and occupancy (number of people in household/ per room) provide no data on the structural demographics of a community. Furthermore, city permitting records have been found to not delve too deeply into the underlying reasons and particulars of repairs. This is, of course, to be expected; in addition to the privacy concerns that would arise from comprehensive personal dwelling records, there is simply no reason for government agencies to expend the resources to keep detailed records.

This means that collection of this data relies entirely on surveying occupants and self-reporting. Self-reporting has its own challenges; in addition to some participants' reluctance to answer some questions they feel are too intrusive, a participant may not know the answer to some targeted questions posed. If we ask a participant if there is mold in their ductwork, they very well might not know the answer, as ductwork is a seldom seen and seldom serviced area of the living environment. Even with the challenges and limitations, however, surveying and participant self-reporting are the best ways, short of dedicated and intrusive research, to collect the necessary data on housing conditions.

Environmental Concerns

The location and proximity of the two studied communities means that environmental concerns are indistinguishable between the two communities. In future studies, where these areas of engineering impact are the main focus of the research, study locations can be chosen to offer a comparison in utility providers, water sources, and air quality. Additionally, locations might be chosen where the water treatment facilities are more advanced, and more likely to test for EDCs and/or estrogenic compounds. Conversely, those areas with more comprehensive water quality reports might not be economically disadvantaged areas, which are more likely to suffer from negative health outcomes.

Transportation Options and Livability

The results from the analysis of livability through the use of the scoring methodology proposed in this study demonstrate the quality of livability afforded by each analysis zones in the study neighborhoods and identify zones that demand enhancements. In the follow-up phase of the research, household surveys of residents will be conducted to collect obesity-related measures by zone. This will enable the study of potential correlations between livability quality and variations in weight status from zone-to-zone and for each community as a whole.

Some of the questions the follow-up analysis will address are:

- Are perceived qualities of the transportation system and neighborhood environment (e.g., walkability, transit coverage, quality of pedestrian facilities etc), consistent with observed ones?
- Is there a correlation between travel mode to work and/or miles driven or walked per day and BMI?

- Is there a direct correlation between livability ratings (as determined on a zone-by-zone level in this study) and obesity level (as expressed by average BMI for each study zone)?
- Are there any significant differences in these correlations with respect to sex, race, and between the two study communities?

Correlations will be further established between the zone-by-zone livability scores calculated above and obesity indicators (such as average BMI) obtained from survey of residents in the study zones of the target communities. The analysis will establish potential trends and will identify the most significant livability contributing factors that explain variation in weight status. Moreover, a refinement of the scoring methodology is currently under way. A questionnaire survey was developed and used to solicit inputs and recommendations by state department of transportation and metropolitan planning organizations personnel on proper selection of scores and relative weights. This process is expected to reduce the potential bias of the scoring methodology and lead to an improved model for possible adoption in the near future.

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