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The Built Environment: Solution to or Cause of Obesity?

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Abstract

The pandemic of obesity is caused in part by rapid urbanization globally. The built environment is part of the modern urbanization phenomenon and includes all aspects of manmade aspects of communities. The major effects of the built environment on obesity have focused on changes in food consumption and physical activity patterns. This review examines the effects of the built environment on the food and physical activity environments which can have either positive or negative effects on overweight and obesity. The direction of effect on obesity will be driven by the specific manner in which elements of the built environment have been implemented. Few studies have included an analysis of the food and physical activity environment simultaneously, limiting the ability to inform public policy. The health enhancing aspects of the built environment are discussed in this review.

Keywords: Built environment; Food environment; Obesity; Overweight; Physical activity

Introduction

There is a global pandemic of obesity. This worldwide epidemic is occurring in some of the poorest countries of the globe. The obesity epidemic is one significant factor influencing health, including fueling the exponential increase in non-communicable diseases (NCDs). Solutions to overweight, and obesity, however, present a newer set of challenges for the appropriate identification and design of policies and programs [1].

A number of factors have been identified as contributing to the burgeoning obesity rates including urbanization, and the nutritional transition where traditional food patterns are being replaced by diets with more fats, sugars, variety and animal sourced foods. This urbanization-diet nexus, in part, is attributed to the build environment [2].

The built environment refers to the human-made aspects of communities we live in including physical features like streets, buildings parts, recreational facilities, housing and goods and services available [3].

The built environment is a concept that has only recently been evaluated as one factor contributing to the rapid, global increase in overweight and obesity. Increasingly, attention to the built environment has become a focus in international public health. The World Health Organization has identified sustainable healthy cities as one significant factor affecting health [4]. Much of the early research on the built environment was conducted in the USA and other developed countries. More recent studies on the built environment are being conducted in developing countries [5].

Until recently, there has been a disciplinary divide in approaches to the question of "how does the built environment affect overweight and obesity?" Public health research has tended to focus on the individual factors such as diet and physical activity as the proximal determinants of weight. Urban designers and architects, on the other hand, have explored a more community based model in understanding the built environment and obesity [6].

The present review synthesizes research from the architectural design and public health literature to summarize evidence on the impact of the built environment on overweight and obesity.

Architectural theories underpinning the built environment

Attention to aspects of the built environment is not completely new. A noted Nobel Laureate in Economics, Robert Fogel, concluded that much of the progress achieved during the industrial revolution can be equated with improvements in the health and sanitary conditions in the urban slums [7]. For example, a well-known epidemiologist, John Snow, tracked down the source of cholera in London to a single source of water [8]. By improving the quality of water from this one pump, cholera rates plummeted. Therefore aspects of the built environment can be positive or negative from a health perspective.

Environmental concerns about the built environment came to the fore front in the 1960s. Rachel Carson's *the Silent Spring*, highlighted the devastating effects of wide spread pesticide use [9]. One of Carson's most noted quotes, "In Nature nothing exists alone", can aptly be applied to examining the built environment effects on health. This spear headed a lot of research related to the built environment and ecology and sustainability.

A milestone in facilitating the postmodern era came in the 1970s and 1980s with Deconstruction Architecture which constituted a broad based critique of Western philosophy in design. "Modern architecture died in St. Louis, MO on July 15, 1972 at 3:32 PM or there about [10]. This quote refers for demolition of the Pruitt-Igoe's 33 blocks of 11 stories high. This development was infamous and illustrated the unintended consequences of violence, poverty and decay associated with some modern architectural designs.

A post- modern scholar, William McDonough, has been a huge critic of the first industrial revolution. In an article titled, *The Industrial Revolution Take Two* [11] McDonough

is quoted as arguing for rejection of the principles of the first industrial revolution. "Why can't a building be as ecofriendly as a tree?" captured the essence of his anti-industrialization stance [11]. He was one of the first architects to use the term, *Smart Design*. In his book, *Cradle to Cradle*, McDonough puts forth the theory that the idea of sustainable design should encompass a more comprehensive approach than simply limiting itself to environmental damage [12]. Indeed, best practices should deal with earth, air, water, energy and ever, perhaps, the human spirit. A good illustration of this principle is the Gherkin building in London which combines attention to water, power (solar) and natural resources in the design [13].

This post-modern approach to architectural design can be seen in approaches such as that of Chad Oppenheim. Recently he observed "that to me it is not just about architecture, it is about the whole sensibility of how life can be lived" [14].

There are some scholars who have suggested that the build environment/sustainable design has evolved to now become more complex than originally conceived. For some, the sustainability agenda has become an organizing principle of architecture. The field has been extended further to examine principles that can change human behavior to help improve the environment [12].

Conceptual framework of links between the built environment and overweight and obesity

The determinants of overweight and obesity are many. A mapping of factors linked to obesity is complex and multifaceted; a schema (Figure 1) developed by the Forsythe group provides a representation of this complexity [15]. The main domains of Figure 1 include food production, food consumption, physiology, physical activity environment, individual physical activity, individual psychology, and social psychology. Within each of these seven domains there are variables which influence, to a greater or lesser extent, each of the broader categories. An analogy that I like to use is that obesity is like a puzzle with 1000 pieces; all pieces are important to complete the puzzles but some of these pieces occupy more space than others.

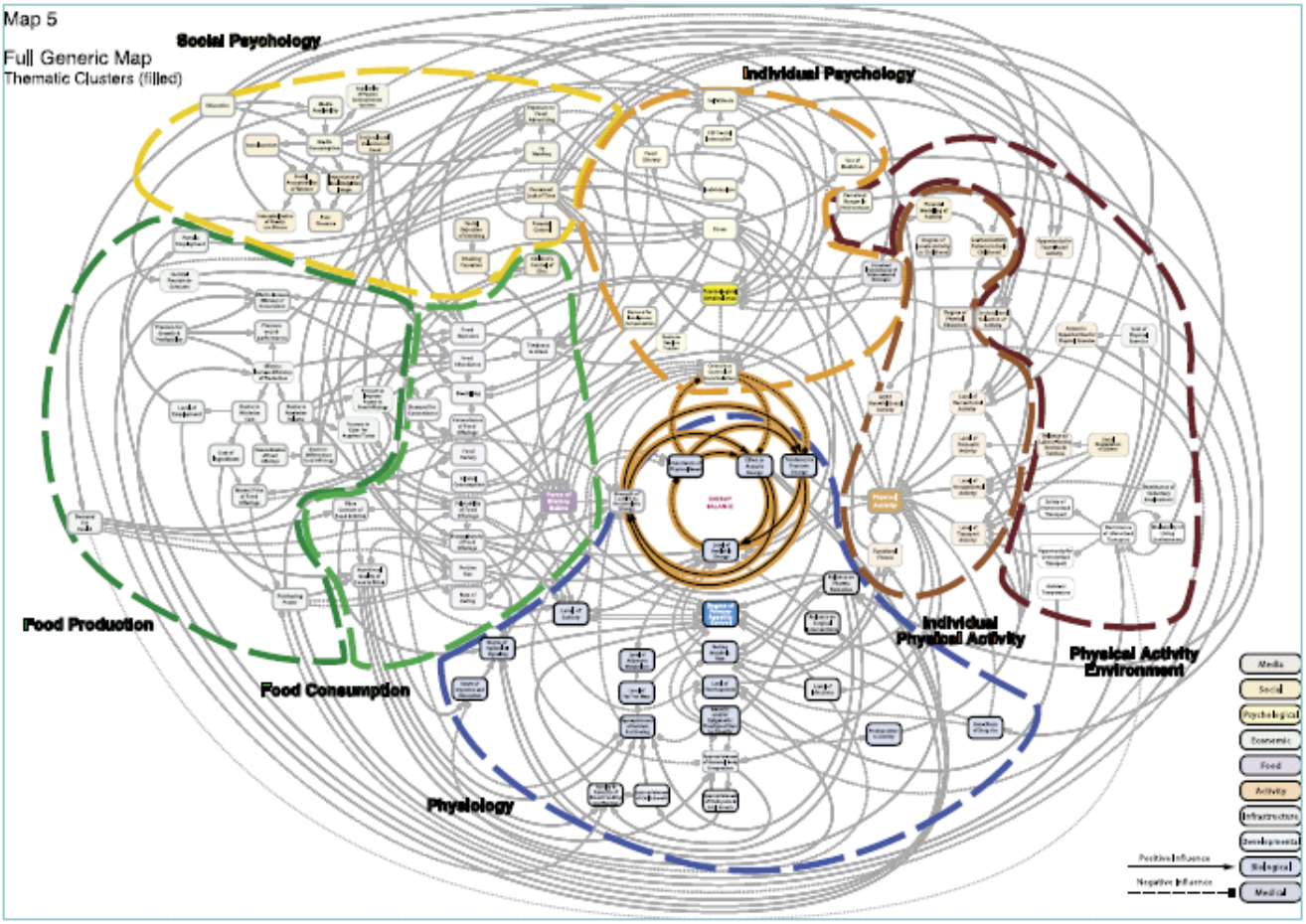

Figure 1: Obesity system influence diagram [15].

Figure 2 provides a simplified model of the Forsythe schema by illustrating a modified ecological framework [15] for analyzing the built environment and overweight and obesity. In the past few decades it has become increasingly clear that efforts that focus exclusively on individual educational or motivational efforts have had limited success in controlling overweight and obesity. There are multiple tiers of factors that influence healthy lifestyles. At the individual level, the two key critical aspects of the ecological framework are that the built environment affects the food environment –

where people get their food - as well as the physical activity environment. Both of the factors, in turn, potentially affect diets and level of exercise, broadly defined. At the societal level, aspects of the built environment can facilitate or hinder the ability to achieve a healthy lifestyle including a nutritious diet and appropriate levels of physical activity. Much of the recent focus on the built environment has concentrated on changes in diet and physical activity levels as the proximal causes of the increases in overweight and obesity in both children and adults.

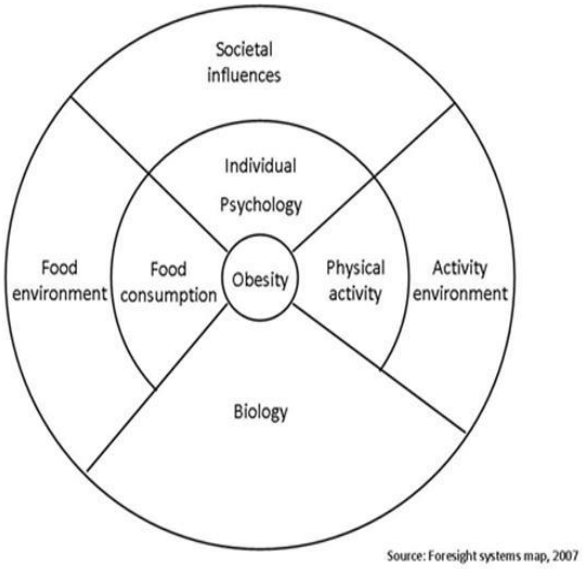

Figure 2: Ecological model of obesity.

Nature of the problem

In adults, overweight is based on a body mass index (BMI) calculation; BMI is a ratio of weight to length calculated as weight in kilograms/ length in meters squared. A BMI of 25.1 to 29.99 is classified as overweight; a BMI of greater than 30 is used to identify obesity [16].

In children, the BMI percentiles calculated from weight for length are used to identify overweight and obesity. A weight for height at the 85% or higher is risk of overweight and above the 95% identifies an overweight and obesity [17].

Data from the National Health and Nutrition Examination Surveys (NHANES) track the trends in overweight and obesity since 1970 [18]. These nationally representative data show that approximately 2/3 of American adults and 35% of children are overweight and obese. Changes in the genetic composition of individuals during this relatively short period since 1970s are unlikely to account for the exponential growth in obesity levels in the USA [19].

Physical activity levels have also been declining since the 1970s in children and adults. At the moment, over 50% of American adults are either sedentary or totally sedentary [2].

Methodology

An Ovid Medline search was conducting for the period 2000 to 2018. Articles in three domains were reviewed: built environment; food environment; physical activity; overweight; obesity. There are some methodological issues that should be flagged. Literature on the built environment and overweight and obesity has used measures of diet and physical activity as the principle factors associated with obesity. It should be noted that most studies have not used direct measures of individual diet or physical activity. Rather, many of the studies that formed part of this review relied on proxy measures of diet quality. The most common include the proximity to food outlets including supermarkets, grocery stores, and fast food restaurants. Other studies also classified food outlets as containing healthy or unhealthy foods. Again, it should be emphasized that rarely does a study contain direct measurement of foods consumed [2].

The geographical areas of focus in exploring the relationship between the built environment and obesity are typically either a census tract or zip code. Critics have observed that the zone identification may not be broad enough to capture the total built environment to which individuals are exposed. For example, the school environment may capture only the food environment to which a child is exposed while in school. Similarly, for adults, the residential environment may only measure exposure while at home. The work and leisure environments which may affect food intake are not captured by simply measuring the residential environment [19].

For physical activity, a common metric used is a walkability score. This score is calculated a scale from zero to 100. Lower scores indicate that reliance on cars is necessary to access services. Alternatively a high score -75 -100 – signals that people can walk to neighborhood services. Increasingly, properties are being marketed in the USA with a walkability score listed [20].

Measurements of levels of physical activity have improved [21]; as these authors observe the early studies relied disproportionally on self-reported physical activity. In the more recent years objective measures of physical activity such as use of accelerometers have been used and have improved the precision of measurements or the use of Geographic Information Systems to provide an objective measure of the physical environment [22].

A common issue raised is the issue of heterogeneity. Heterogeneity refers to diversity in several elements across the studies. Diversity has been noted for (1) research design, (2) definition of the food environment (3) quality of measurements–measured compared to self-reported (4) completeness of the study; most studies either report data on the food environment or physical activity, rarely both [2].

Results

Magnitude of the problem

In the United States, rates of overweight and obesity in both adults and children have been increasing for the past three decades [23]. Two common assumptions in much of the literature are that increases in caloric consumption and decreases in physical activity are the key factors contributing to the obesity epidemic [19].

One study attempted to assess the factors associated with increased energy (caloric) intake in the US population [24]; this study used a series of nationally representative surveys from the late 1970s to 2006. These included the Nationwide Food Consumption Survey of 1977-78, the Continuing Survey of Food Intake by Individuals from 1989-1991 and the National Health and Nutrition Examination Surveys of 1994-98 and 2003-2006. The strength of this analysis is that all the surveys analyzed were based on nationally representative samples of the US population and covered a 30 year time span. Results indicate that small increases in caloric intake (39 calories per day) contributed to excess energy intake [24]. The biggest contributors to the increased caloric intake were increases in the number of eating occasions and larger portion sizes.

This finding of small increments of 39 calories per day is consistent with the finding that weight changes in adults aged 20 to 40 years in the US tend to be gradual with a gain of one to three pounds per year [23]; this report suggests that increments of as little as 100 calories per day can lead to the one to three pound weight gain per year.

The physical activity patterns of Americans are not more encouraging. Approximately 50% of adults in the US are sedentary or totally sedentary [2]. Given these bleak statistics on diet and physical activity, increasingly studies have examined the built environment as a contributing variable to the food environment and the physical activity environment. Most of the studies, to date, have analyzed the food environment or the physical activity landscape but rarely both [2].

Food environment

A 2013 study in New York City (NYC) assessed the effect of retail food outlets on obesity [25]. The study included 94,348 high school students in NYC public schools. In addition to the large sample size, a strength of this study was that the heights and weights of students were measured, not self-reported. The study assessed the relationship of students' home addresses to Body Mass Index (BMI). The home addresses were used to geocode the students to their residential census tracts. This geocode was also used to calculate the fast food outlets in the geocode. Results indicate that students receiving free and reduced price school lunches – a proxy measure for income – were more likely to be obese than full paying lunch students. May be somewhat surprisingly, there were lower rates of obesity rates among students living in neighborhoods with more than the median number of fast food outlets than those under the median. This difference was statistically significant. Similarly, the number of bodegas in neighborhoods was not associated with obesity rates. The authors of this study speculate that this counterintuitive finding of less obesity with more fast food stores might reflect neighborhood commercial investment; put another way, more commercial investment improves health outcomes. The mechanism through which commercial investment's positive health effect might be due to increased employment, crime reduction, venues for social interaction and neighborhood support [25].

Another study in California assessed the relationship between the school and residential food environment and diet among youth [26]. Youth were divided into 8226 children, 5-11 years and 5236 adolescents aged 12-17 years. Food environments were measured by counts and density of businesses, distinguishing between fast-food outlets, convenience stores, small food stores, grocery stores and large supermarkets within 0.1 to 1.5 miles of the sample's home or school. The authors point to a strength of this study being the fact that both the residential and school food environments were measured. This has rarely been done. Here again, rather surprisingly, the authors report that neither more access to supermarkets or less exposure to fast food restaurants or convenience stores improved diet quality or reduced BMI among youth. A possible explanation for these results provided by the study authors related to the possible diversity of store types; the authors suggest that other measures such as store inventories, rating of food quality, or measuring shelf space for specific food items may provide a more predictive method for assessing the relationship between store type and diet and BMI. The authors emphasize that unless the measures used have a greater precision, small differences in BMI may be difficult to detect.

Similar findings are reported from a study by Burdette [27]. There was no association between proximity to playgrounds, fast food restaurants or the level of neighborhood crime and BMI. These findings are in direct contradiction to results reported by Carroll-Scott et al. [28]. This study of 1048 students in the fifth and sixth grades in New Haven, Conn found a direct association between property crime and distance to grocery stores; both of these factors increased the likelihood that children have higher BMIs, the study's measure of risk of overweight.

Some studies have also been carried out in adults. A study in the state of Washington examined the association between census tract and obesity [29]. Two strengths of the research was the large sample, 59757 adults and weights and lengths were actual measurements. The built environment was not directly assessed. Instead, the authors evaluated the social and economic (identified as proxy variables) factors associated with obesity. Results indicate that home values and college education, but not household income, were significantly, negatively related to obesity. One could speculate that higher income census tracts/home values were less likely to have a low density of fast food outlets. Given the research design, however, this conclusion would be speculative.

Some recent systematic reviews of available studies have helped synthesize the disparate results across individual studies. Cobb et al. [30] conducted a search of literature using PubMed. Of the 5,853 studies identified, only 71 had a suitable research design and overall quality to be included in the review. Of the 71 studies, 47 focused on adults and 22 on children. The majority of studies found a null effect of the food environment on overweight and obesity. In essence, there was no statistically significant association – positive or negative – between the built environment and obesity. The authors of this review note that the null results could be due to the fact that few of the studies were longitudinal; in addition, the studies could not resolve the bias that may occur by

individuals self-selecting to live in a particular area. There were some significant trends in a minority of studies; Supermarket availability in ten studies was negatively associated with obesity and for grocery stores in 5 studies positively associated with obesity. These disparate findings could relate to the availability of "healthy" food. The authors did not have the data to confirm this but it could be likely that large supermarkets have a greater availability of healthful foods and at a lower price.

Fraser et al. [31] conducted a review of fast food outlets and obesity. Only 33 studies were included in the paper thus limiting the generalizability of findings. Also the study used a very narrow definition of fast food outlets as only national chains were included. One main result highlighted by the review is that fast food availability was associated with a lower consumption of fruits and vegetables. The authors intimate that this may indicate a lower quality diet nutritionally and might contribute to higher rates of obesity.

Some equally ambiguous findings are reported from a study by Williams et al. [32]. Thirty studies were included in the review. The main purpose of this review was to assess the influence of the food environment near schools on food consumption and /or food purchases. The only notable finding is that there was a slight effect of food outlets located near schools and body weight. The authors, however, are very tepid in their conclusion of this finding and suggest that it is equally plausible that some unmeasured variable is responsible for this association.

Physical activity environment

A number of reviews have been conducted on the relationship between the built environment, physical activity and overweight/obesity. The factors predicting levels of physical activity vary across age groups and thus it is important to disaggregate among children, adults and the elderly [4,33].

A framework for analyzing the individual factors associated with physical activity was developed by Pikora et al. [33]; these authors hypothesized that there are four major domains that affect physical activity; these include functional, safety, aesthetic, and destination variables. Curiously the primary studies summarized in this paper rarely include an analysis of each element.

A review by Ding et al. [34] looked at the association between environment attributes and physical activity, differentiating between children and teens. Methods of measurements made a huge difference in results. For both children and adolescents, objectively measured environmental attributes (as opposed to self-reported or perceived) and reported physical activity showed a significant association. One hundred and three papers were included in the review; 50% of the results pointed to a significant association between the built environment and levels of physical activity in the expected direction. The neighborhood environment-physical activity associations in this review were much weaker when the environmental characteristics were measured by participants' perceptions. The authors reported that the most consistent association involved pedestrian safety structures – traffic lights, crosswalks – and physical activity.

A similar review with fewer studies was conducted by Feng et al. [35]. The authors do note that most of the measures were subjective and thus did not include the rigor of detail found in the Ding et al. review [34]. The most consistent predictors of physical activity in youth were (1) the father's level of physical activity (2) time the subjects spent outside (3) school-related physical activities.

Other studies have been conducted on adults. One of the few studies to evaluate both the food environment and walkability was conducted by Rundle et al. [36] in New York City providing data on 13,102 adults. The results indicate that the density of BMI and healthy food outlets, described as supermarkets, fruit vegetable markets, natural food stores, were inversely related to BMI. This positive effect on decreasing the risk for a higher BMI remained after controlling for the neighborhood's walkability score.

Cerin et al. [37] analyzed the relationship between aspects of neighborhood design, food options and weight status. The number of convenience stores and in-store healthy food choices were related to the probability of walking. In turn, the likelihood of walking was, in turn, related to a lower risk of overweight and obesity.

This relationship is better reflected in data provided by Sallis et al. [2]; in this review authors noted that the likelihood of having greater than five bouts of moderate to vigorous physical activity increases as the number of recreation facilities increase per block; conversely, the likelihood of being overweight decreases as the number of recreation facilities increase.

One of the few reviews of studies on the physical activity of older adults was conducted by Haselwandter et al. [38]. The authors note that physical activity declines precipitously after the age of 65. The review finds that there are key factors in the built environment that influence physical activity in the elderly; these include personal security, presence of street lights, wide sidewalks,

Results from studies on physical activity suggest more consistent findings than those relating to the food environment. The rigor of findings is influenced significantly by the method of measurement, with objectively measured physical activity providing more confidence on the consistency of results [22,39].

Discussion

This review provides a critical appraisal of the association between the built environment and overweight and obesity. The central hypothesis that was posited was that the built environment can have positive or negative effects on overweight and obesity. The key to the direction of this effect will be driven by the specific manner in which elements of the built environment are implemented. The food and physical activity environments were the main components of the built environment which were analyzed in this paper.

Very few studies have included an analysis of both the food environment and physical activity environment simultaneously. Hence in the results section research was discussed within the food or physical activity arenas. Better elucidation of the effects of the built environment – both food

and physical activity - is needed in order to better inform public policy.

In addition, many of the systematic reviews identified a large number of studies which distilled down to a much smaller number of acceptable papers due to lack of quality and/or detail needed for the analysis.

The relationship between the built environment and overweight and obesity is more complex than conceptualized three decades ago. This complexity is reflected in the multiple links shown in Figure 1.

There are mixed results for the association between the built environment and overweight and obesity. The major hypotheses in the published literature are that changes in diet (increased calories) and reduced physical activity have contributed to the burgeoning rates of overweight and obesity. A major limitation in the studies reviewed, however, is that diet is not measured directly. Metrics for the food environment which are typically employed include proximity to various types of food outlets. There are some assumptions embedded in this approach. First, many studies have tested the theory that existence of fast food outlets in a defined geographical area may have a positive effect on increasing overweight and obesity. Results here are mixed, with the majority of studies reviewed in this paper showing a null effect or no statistically significant relationship between body weight and fast food outlets.

Second the limited geographic focus of many of the studies precludes making any overall conclusions. For example, most of the studies were limited to either the residential or school geographical areas. The total food environment is not measured and may be a key reason for the lack of effect of the food environment and obesity.

For physical activity it is important to disaggregate the data by age group: Children, adults and the elderly. The literature suggests this is important since the drivers of physical activity patterns vary by age group.

For adults, emerging evidence shows a direct association between community design and residents' levels of physical activity. The likelihood of obesity declines with increases in mixed land use, but rises with increases in time spent in a car per day. For example, every 30 additional minutes spent in a car was linked with a 3% increase in the risk of obesity [2]. Taking into account multiple outcomes [such as residential density, land use mix, and commuting time] will likely help to explain the variation within individual outcome measures such as body mass index.

For the elderly, factors such as street lights, cleaner streets, walking groups, fewer unleashed dogs, weather and bicycle paths were drivers of physical activity.

For children, key factors relating to physical activity levels include community safety, physical activity in schools, after school care, participation in sports and proximity to a playground.

Conclusion

The body of evidence in this paper would suggest that the built environment can have positive or negative effects on overweight and obesity. Attention to changes in the built environment can be a powerful weapon for promoting healthy lifestyles.

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