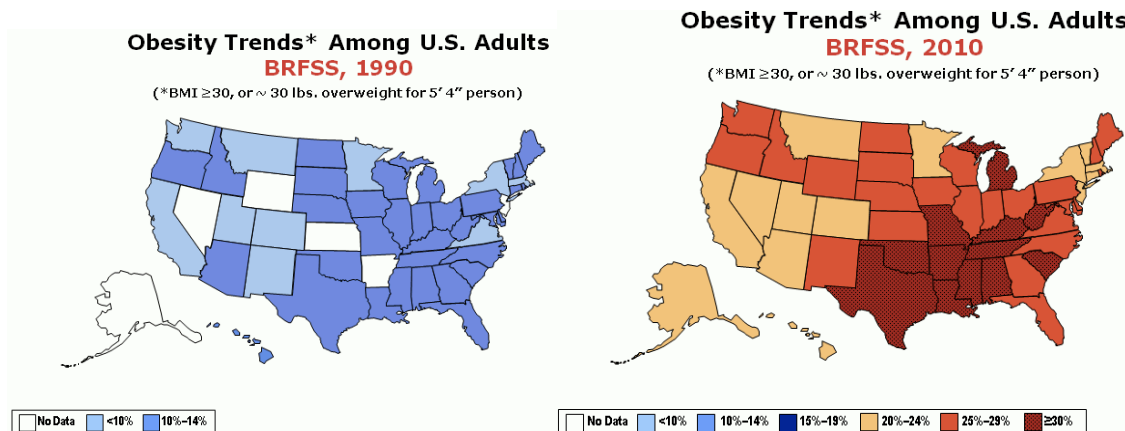


Using Geographic Information Systems to Improve Community Initiatives Regarding Obesity in the United States

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December 2, 2013

Introduction

Obesity has become an epidemic in the United States over the past 20 years. Body Mass Index (BMI) measures obesity, which is a commonly used formula to classify overweight and obesity in adults. BMI is defined as the person's weight in kilograms divided by the square of their height in meters. (CDC.gov). The most recent national data (2010) from the Center of Disease Control on obesity prevalence among U.S. adults, adolescents, and children show that 35.7% of adults and 17% of children and adolescents are obese. (CDC.gov). The U.S. Centers for Disease Control and Prevention also released a report that estimated 42% of Americans will be obese by the year 2030. That translates to an additional 32 million Americans who will become obese in the next 17 years. The cost of this increase would manifest approximately \$550 billion worth of health care costs from obesity-related illness. Below are two maps from the CDC showing the change in obesity trends from 1990 to 2010. (CDC.gov).



One reason for this significant increase in the obesity rate in the United States is the amount of time that people spend using computers, watching television, and playing video games. According to the Milken Institute in California, there is a direct link between spikes in the usage of new information and communications technology and the dramatic rise in obesity in 27 countries between 1988 and 2009. (Chatterjee 2012). Worldwide obesity has doubled since 1980 and in countries like the United States it continues to increase as Americans continue to sit in front of their computers and televisions. The World Health Organization reports that as of 2010, over 200 million men and nearly 300 million women were obese. (who.org).

In the past two decades, there has been a transition toward a knowledge/information-based society that has led to changes in the work environment and at-home lifestyle. This 'information-based society' has shifted employment patterns toward service-sector jobs that require long hours sitting in front of a computer. This has been exacerbated by urbanization, which has led people to take public transportation or drive rather than walk. There are also environmental factors that are contributing to the rise in obesity in America including: work schedules, oversized food portions, food advertising, cost of healthy food, increase of computer/television/technology use (remaining sedentary), lack of neighborhood sidewalks and area parks, lack of access to healthy foods, and lack of access to recreation for physical activity. (Chatterjee 2012).

It is clear that obesity isn't going away any time soon in the United States. Over the years it has been getting exponentially worse because of sedentary lifestyle, unhealthy food intake, and a decrease in the need for physical activity due

to changing technologies and the suburban sprawl. This paper will focus on using geographical information systems to improve community initiatives regarding obesity in the United States.

The Built Environment

In recent years, public health researchers have greatly benefited from the emergence of Geographic Information Systems (GIS) technology. The role the 'built environment' has played in explaining the spatial pattern of obesity has received a considerable amount of attention from public health professionals. The built environment is comprised of land use, urban design, and transportation systems. GIS technology allows professionals to integrate spatial information from a range of different sources into a single framework, and to use data to develop specific measures for the built environment. (Thornton 2011).

Research has shown that certain features of the built environment have influenced and affected individual's mental and physical health as well as health behaviors. (Booth 2005). Researchers have evaluated whether certain characteristics of the food environment including access to convenient stores, fast food restaurants, and supermarkets are related to Body Mass Index (BMI). Other traits of the built environment that influence obesity through the support of physical activity include transport infrastructure, street connectivity, and the location of recreational facilities. (Thornton 2011).

For many people, their built environment can either facilitate or hinder healthy eating, physical activity, and a proactive lifestyle. Areas with little recreational facilities, unsafe neighborhoods, hilly or uneven terrain, rural and small

populations with no 'downtown' aspect, no sidewalks, or insufficient lighting can impede physical activity. With the growth of the suburban crawl in the United States during the past 30 years, many neighborhoods have been designed specifically for vehicles with no regards to pedestrians or bicyclists. In areas with high connectivity for pedestrians, walking and biking are encouraged and serve as a main form of transportation. Also, the location of fast-food restaurants, convenience stores, and bars serving unhealthy foods that are high in fat and calories hinder good nutrition choices for those living in that specific area. (Norman 2013).

The tools available within a GIS enable specific spatial measures to be created. GIS has the potential to contribute in developing more precise measures of the built environment. (Duncan 2012). There are different methods involved when assessing the built environment. Indirect methods include GIS data, census data, street data, and can be accessed fairly easily. Intermediate methods are a little more involved and include regional land use data, databases, aerial photography, and perceived environment measures completed by residents. Direct methods are the most involved and require much more time and work because of the in-person interaction that must take place to observe environmental characteristics. (Booth 2005).

Accessibility and Proximity

When discussing the built environment, accessibility is key in determining features distributed across space but also by mobility factors such as public transportation and car ownership. In a study done by Strategies for Metro Atlanta's Regional Transportation and Air Quality (SMARTRAQ) between 2000 and 2002,

10,878 participants from the 13-county Atlanta region were surveyed regarding their daily travel routines. The study was interested in time spent in a car and distance walked through a 2-day travel diary. Distance walked and car time were calculated using GIS software, ARCINFO, Custom Visual Basic Programming, and a street network. For each trip recorded in the travel diary, the origin and destination were recorded on the street network. The results of the final analysis showed that with each kilometer walked, there was a 4.8 percent reduction in the odds of being obese. Time spent in a car or on public transit was positively associated with obesity and showed that an additional 60 minutes per day in the car converted to an additional 6 percent odds of being obese. (Frank 2004).

This study also showed the extreme differences between the 13 counties in the Atlanta region. Accessibility to restaurants, greenspace, supermarkets, and recreational facilities varied greatly between neighborhoods and Atlanta suburbs. Entire counties were not able to capture the unique experiences by each individual in the study because the connectivity, land mix, walkability, and density factors were different for each area. Evidence shows that the physical design of the places where people work and live can drastically affect their overall travel and physical activity choices, as well as eating habits. (Frank 2004).

Proximity is an important indicator of accessibility and is used to determine which feature (tennis court) is closest to a particular point (home). Proximity is important because accessibility is increased when features are closer and in turn influence their contribution to healthy behaviors. A positive connection has been acknowledged between proximity to supermarkets and healthy living. Least-cost

analysis is considered the best measurement of proximity because it considers the person would use the shortest/quickest travel route. (Frank 2004). GIS technology has become so advanced it can account for more sophisticated measures of travel time that incorporate factors such as traffic signals, traffic delays, traffic density, and topography; making it easier for people to navigate through traffic during their daily routines. (Ghirardelli 2010).

Socioeconomic factors also play a role in accessibility to certain amenities, grocery stores, and recreational facilities. Research shows that socioeconomic status (SES) at the neighborhood level is related to physical activity, obesity, and other health-related behaviors. The National Institutes of Health and the Robert-Wood Johnson Foundation are researching the positive correlation between access to community facilities and physical activity levels. (Gordon-Larsen 2006). This increased focus on the recreational opportunities available in different neighborhoods and communities has drawn attention to the features and locations of parks and the association between park access, physical activity, and the risk of obesity. (Cutts, 2009).

In much of the research being done there is one key question that has been neglected: whether the social context of the neighborhood, specifically negative characteristics influence access to parks and recreational facilities. (Weiss 2011). GIS software has enabled a considerable expansion of research on disparities in recreational opportunities and their suggestions for obesity. By focusing exclusively on the characteristics of parks, such as size, facilities, quality, and spatial

dimensions; researchers have overlooked other neighborhood factors likely to influence whether nearby resident utilize the available space.

Physical proximity to a park or rec facility may provide the potential for park usage, but underlying factors such as high crime rates and hazardous traffic may decrease park benefits and usage. It is important to consider both neighborhood disamenities and spatial access when thinking about socioeconomic and ethnic disparities in park access and the role of parks in the promotion of health. (Weiss 2011). A study done in New York City looked at how adjustments for spatial variation in characteristics such as traffic, crime, and noxious land uses measured disparities in access to NYC parks. This study helped explain the illogical finding that Hispanics and Blacks have higher rates of obesity in New York City even with having more access to recreational facilities and parks than Caucasians in other areas. (Weiss 2011).

There has been evidence that fear of crime and other safety concerns may discourage residents from participating in outdoor activities. These safety factors may lead potential users to avoid parks and recreation centers all together while pursuing other activities in their spare time. (Hill 2012). Research using GIS gauging access to parks has greatly improved our understanding of the availability of physical activity and recreational opportunities in urban areas. In order to fully recognize the benefits that GIS can offer for tracking health disparities it is important to tackle a number of methodological and conceptual issues as mentioned above. (Hill 2012).

Density

Density is the measure of the “intensity of exposure to features of the built environment and may be an important determinant of health behaviors as it relates to the accessibility of potentially health promoting and health damaging environmental characteristics.” (Thornton 2011). Density may be expressed in several ways: count of features within a zip code, relative number of features per population or per geographic area. It is most accurately represented by relative number of features per population or geographic area.

The growth in consumption of fast-food and convenience store food is an important contributor to the rising occurrence of obesity in children and adolescents. The clustering of these types of restaurants around schools is indicative of student’s high exposure to unhealthy food environments, which affects their dietary behavior. (Day 2011). A study done in New Zealand in 2008 showed that there was a high degree of spatial clustering of convenience stores and fast-food chains within 1.5 km of schools. It has been proven that high densities of fast-food promote unhealthy eating habits for students, thus increasing their risk for being overweight or obese at a young age. (Day 2011). When children and adolescents live in an area that is saturated with chain restaurants and convenience stores offering no healthy food options, they pick up unhealthy eating habits because unhealthy food is their only option within the area of their home and school. So many cities and towns in the United States are inundated with fast-food chains, making supermarkets scarce and moving further away from the city center. After income, education level, age, gender, etc. are factored in; people are constantly

exposed to unhealthy eating environments with no other viable options. (Ghirardelli 2010).

With local government administering the locations of these food retailers, and planning regulations as well as consumer demand, some neighborhoods and school zones have no choice in the matter as it is. The spatial distribution of schools, fast-food restaurants, convenient stores, and land use constraints pose challenges in analyzing such spatial phenomenon. GIS mapping provides a cost-effective and quick way to examine neighborhood differences without sending researchers in to survey the area. The accuracy of GIS data is sometimes limited by misclassification of data and the variable nature of businesses. (Ghirardelli 2010).

While fast-food restaurants set the tone for unhealthy neighborhoods, grocery stores set the tone for healthy neighborhoods. Access to food sources is especially important to consider in low-income areas where less people have access to a personal vehicle. If there is a low-density of supermarkets in an area, residents with little financial means are forced to buy whatever they can access and afford (which ends up being off the Dollar Menu at the closest fast-food shop). Legislators, health leaders, and community members need to understand the repercussions of having a high density of unhealthy food options in one area versus having a grocery store with healthier choices available because it is directly affecting the health of local residents. (Ghirardelli 2010).

Walkability

Walkability is composed of four main components: safety, functionality, aesthetics, and destination. Each of these components has sub-components that can

be created and tracked within GIS. An example of this is connectivity being a key feature of functionality. In recent studies, residents living in areas considered more 'walkable' or connected have been linked to increased levels of physical activity and a lower BMI. Levels of walking may be improved through greater land mix and higher pedestrian network connectivity. While some measures of walkability like walking paths or traffic control can be monitored through GIS, other measures like litter or graffiti (which can deter someone from walking in a certain area) need a closer observation by an actual person. (Norman 2013).

Walkability is a concept that is more understood and practiced in European countries opposed to the United States. In Sweden, Norway, and Denmark people walk everywhere all year round because their homes are in city center and all of the shopping is in city center. Pedestrian walkways are more common than roads for cars and the entire traffic system runs differently. In Sweden there are no stoplights; traffic is constantly moving by way of roundabouts, which keep the flow of cars going smoothly. During the dead of winter there will be hundreds of bicycles parked around town with a foot of snow on them, their owners are shopping or running errands around town. The weather is not a deterrent for people to get out and about for their daily routines. Extreme cold is dealt with by dressing in layers and keeping warm, it is not used as an excuse to stay in. Walkability is a way of life in many countries; cities have built their entire road systems, businesses, homes, and lifestyles around this concept.

Because of the suburban sprawl in America it has been hard for cities to keep walkability as a priority for residents. Some towns/cities have done a great job with

making the downtown area more 'walkable' with restaurants, shopping, cultural activities, sporting events, etc. In the last 20 years, Knoxville has done an amazing job of revitalizing the downtown area, making it more accessible to pedestrians for shopping and activities. Parking garages were built to keep cars on the outside of city center, as well as streets being turned into pedestrian walkways. GIS can help government officials and urban planning committees evaluate and improve walkability standards for downtown areas. Not only can GIS map out problem areas, it can also reveal higher standards for urban planning in correlation with healthier lifestyles (Cutts 2009).

Walkability includes multiple aspects of the environment that affect health and wellness. Studies show links to inactivity/sedentary lifestyle and obesity. This problem will only continue to worsen if we continue to sit in our cars and at our desks and neglect to use our legs. Researchers must work closely with legislators and policy makers to implement changes to the physical environments that are limiting people from being healthy. (Glicksman 2013). GIS incorporates the ability to integrate research findings into city planning while helping those involved understand and relate in a way that is meaningful to them.

Social Media and GIS

In the last decade social media has exploded on the technology front. Mobile devices continue to rapidly increase in the global economy. GIS is now being used with location-based social media on mobile phones, allowing researchers to explore connections between health, people, and places. One advantage of using GIS in conjunction with location-based mobile apps is that it produces real-time,

quantitative data collected on the consumption, recreation, and physical activity patterns of urban residents all around the world. Facebook, Twitter, and Foursquare all use location-based mobile apps in hopes of monitoring consumer behavior and changes and trends in the market. (Ben-Harush 2012).

GIS gives researchers the ability to collect and map real-time, objective data involving leisure, consumption, physical activity, and recreation patterns among urban communities and has immediate consequences for a variety of research disciplines including health promotion, social marketing, urban design and public health inequalities. One great thing about location-based mobile apps and GIS is that it connects people to places and automatically generates the relation. With location tracking features, it utilizes the self-reporting method without the user feeling like they are reporting anything. People use Facebook, Twitter, Instagram, and Foursquare to check in to the gym, the movies, restaurants, and sporting events which makes collecting data to track food consumption and physical activity straightforward since the mobile app is doing all the tracking. (Ben-Harush 2012).

The possibilities seem endless when it comes to GIS and social media teaming up to track and capture latitude and longitude points regarding user's location during activities in these locations, and modes of transport. The data is able to be superimposed onto sophisticated GIS such as Google Maps, allowing us to get a glimpse of how urban populations are using their environments in relation to their health. (Ben-Harush 2012).

How Can GIS Help?

Computerized geographic information systems (GIS) can help to analyze trends associated with obesity and ultimately could become a vital tool in prevention efforts, according to series of studies published in the *American Journal of Preventive Medicine*. Developing the GIS-based environmental assessment method suggests it could be applied in multiple study areas," the study's authors wrote. "The environmental measures employed objectively assessed GIS data to create a novel study design and recruitment scheme that allowed examination of the separate and interactive effects of both physical activity and nutrition measures of built environment, which are believed to represent the most important dimensions of obesogenic environments for youth." (Day 2011).

Robert Wood Johnson Foundation Research and Evaluation Officer Celeste Marie Torio, Ph.D., explained that GIS helps such efforts by creating a "visual representation" of connections between people and their environments. "It models complex reality by breaking it down to layers of information, represented by points, lines, areas and images, covering a wide range of geography," Torio said. "GIS essentially allows for the simultaneous examination of multiple variables and their complex interactions across a variety of contexts." (Gordon-Larsen 2006). Torio added that despite such potential, GIS use is only in its early stages. "Looking toward the future," she said, "GIS may help enhance our understanding of how the multitude of factors and their interactions influence childhood obesity, and help us reverse this epidemic." (Gordon-Larsen 2006).

Conclusion

GIS captures, displays, and analyzes data based on geographic references. It allows users to pile on multiple layers and types of information: location-specific data about health, crime, income, education, and more. It also allows us to visualize and analyze that data in multiple ways. The result: images that convey more information and make more powerful arguments than words often can. With GIS, seeing is truly believing. A proven technology, GIS facilitates the measurement, management, mapping, and analysis of the real world.

GIS is not a cure-all, but the integrative nature of GIS and its linkage with spatial statistical analysis offers an important means of better understanding and dealing with some of the most pressing problems of our time and providing valuable tools for researchers and policymakers alike. Not surprisingly, as GIS has matured (the ready availability of geospatial data, enhanced visualization tools, and advanced spatial analysis methods) there has been an explosion of interest in the application and use of spatial concepts and methods in health-related research.

Legislators and urban planners need to focus on community design, its influence on public health, and how public policy can improve public health through thoughtful design decisions. All of this is possible because of the capabilities of GIS. Geographic information system mapping can help communities visualize the health of their neighborhoods and identify opportunities for improvement in the future.

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