Childhood Overweight and the Built Environment: Making Technology Part of the Solution rather than Part of the Problem

By
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The changing nature of how children engage with their physical environment is one factor in the dramatic increase in childhood overweight. Children today are engaging much less with the world outside their homes in terms of physical activity and much more in terms of eating. Technological innovations in media have contributed to these changes, keeping children inside and sedentary during more of their playtime and exposing them to highly coordinated advertising campaigns. But researchers are increasingly looking to technology for solutions to understand how children interact with their built environments and to make changes that promote healthy living. This article reviews many of these innovations, including the use of geospatial technologies, accelerometers, electronic food and travel diaries, and video games to promote physical activity and healthy eating. It also explores some of the other possibilities for harnessing the potential of technology to combat the childhood overweight epidemic.

Keywords: childhood overweight; childhood obesity; built environment; geographic information systems; GIS; global positioning systems; GPS; technology

The idea that children used to eat a made-from-scratch dinner at home with their families before running outside to play may have taken on mythic power in the context of the current childhood overweight epidemic. But fifty years ago, who would have imagined the obesegenic environments we would create for them, in part with the help of technology? Who would have imagined that, at the extreme, our children would be sitting in the backseat of climate-controlled minivans watching movies on personal DVD players while eating take-out

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fast-food meals featuring the same animated characters they are watching on their screens?

The changing nature of how children engage with their environment is one factor in the dramatic increase in childhood overweight. Children today are engaging much less with the world outside their homes in terms of physical activity and much more in terms of eating. Technological innovations, including the Internet, sophisticated video games, and the many at-home television and movie options, have contributed to these changes. As a result, children spend on average nearly four hours a day watching television, DVDs, and prerecorded shows and playing video games. Over the course of a week, their exposure to media (including music) is equivalent to a full-time job (Rideout, Roberts, and Foehr 2005). The American Medical Association suggested that for some children—perhaps more than 5 million—extensive use of video games may constitute an addiction (Associated Press 2007).

In addition to keeping children inside and sedentary during more of their playtime, these media expose them to highly coordinated advertising campaigns, many of which target children (Gantz et al. 2007; Kelly 2005). Gantz et al. (2007) estimated that children ages eight to twelve see approximately seventy-six hundred television food ads a year, and two out of three parents say their children have asked them to buy foods that they have seen advertised on television (Rideout 2004). Children and adults, alike, have responded to aggressive food marketing and the convenience of eating out. The proportion of calories Americans of all ages consume from foods obtained away from home increased from 18 percent in 1974 to 32 percent in 1996 to about half of all calories in 2004 (Stewart, Blisard, and Jolliffe 2006; Lin, Frazão, and Guthrie 1999).

At the same time researchers document these trends, they are increasingly looking to technology to better understand how children interact with their built environments and to make changes that promote healthy living. This article reviews many of these innovations, including the use of geospatial technologies such as geographic information systems (GIS) and global positioning systems (GPS), accelerometers, electronic food and travel diaries, digital audio players, Web sites, and cell phones. First, it explores the idea of the built environment, reviews the research on the influence of the built environment on physical activity and eating, and considers the technological changes that have made children more sedentary. After describing many of the innovative uses of technology to address the problem of childhood overweight, it offers an agenda for making technology—and children—a bigger part of the solution.

What Is the "Built Environment"?

"Built environment" is used here to describe everything that children encounter when they step outside their door in their immediate neighborhood area. It is based on a spatial conception of environment that imagines that children

spend much of their time near their homes. Previous research has defined the built environment to include physical structures, parks, recreation facilities, transportation infrastructure, and, more generally, land use patterns and urban design (Sallis and Glanz 2006; Transportation Research Board 2005; Handy et al. 2002; Frank, Engelke, and Schmid 2003). The availability of food, from fast-food restaurants and convenience stores to supermarkets, and the prevalence of outdoor advertising have also been considered part of the built environment (Sallis and Glanz 2006; Roux 2003).

Increased attention to the impact of the built environment signals a common theoretical orientation toward ecological thinking more than a standardized operational definition. Researchers increasingly conceptualize obesity as a multilevel problem, referring to factors beyond the individual that affect health as "neighborhood influences" (Booth, Pinkston, and Poston 2005), "residential environment" (Roux 2003), "macroenvironment" (King et al. 2002), and "structural mechanisms" (Cohen, Scribner, and Farley 2000). "Built environment" and "environment" are not always synonymous, as some researchers have broken this larger concept of environment into components. For example, Cohen, Scribner, and Farley (2000) have identified four different factors that potentially affect health: availability of healthful (e.g., fruits and vegetables) and harmful (e.g., gun and alcohol) products, physical structures, social structures, and cultural and media messages. The modifier "built" may imply something more specific than the broad concept used here, which incorporates physical, social, media, and access factors, but referring to the "built environment" is a helpful reminder that we humans are complicit in all of its ill health effects.

What Do We Know about the Impact of the Built Environment?

Physical Activity

A growing body of research, much of it sponsored by Robert Wood Johnson Foundation's Active Living by Design Program and published in a series of special journal issues, provides evidence of a link between the built environment and physical activity (Robert Wood Johnson Foundation 2007). This includes dozens of studies about land use, urban design, zoning, sprawl, smart growth, transit-oriented development, new urbanism, walkability, and access to and use of parks and trails. Several experts in the fields of planning, transportation, physical activity, and health have systematically reviewed this literature (Sallis and Glanz 2006; Transportation Research Board 2005; Heath, Hebert, and Lancaster 2006; Handy et al. 2002). Recognizing that there are some inconsistent findings, they conclude that (1) areas with mixed land use, greater residential and commercial densities, grid street networks, and sidewalks are associated with more walking, biking, and public transportation usage; and (2) children with access to parks,

recreation facilities, and programs are more physically active than children without access.

Food Access

A smaller and less coordinated, but still substantial, collection of research has shown that food access, in the form of supermarkets, fast-food restaurants, and convenience stores, varies considerably by neighborhood. Low-income and ethnic minority neighborhoods have fewer supermarkets and less access to fresh fruit, produce, and other healthy foods (Zenk et al. 2005; Rose and Richards 2004; Horowitz et al. 2004; Morland et al. 2002) and greater access to fast-food restaurants (Lewis et al. 2005; Block, Scribner, and DeSalvo 2004) and alcohol outlets (Morland et al. 2002). Fewer studies have linked food access to eating behavior, but several studies have shown that the availability of healthful products predicts healthier eating (Laraia et al. 2004; Rose and Richards 2004; Morland, Wing, and Roux 2002; Cheadle et al. 1993).

Outdoor Ads, Crime, and Safety

Outdoor advertising has received even less attention from researchers, but the results are similar: areas with racial minorities and low-income populations have more ads for alcohol and tobacco (Kwate and Lee 2007; Hackbarth et al. 2001).[1] One study documented a link between exposure to outdoor alcohol ads and alcohol intentions among youth (Pasch et al. 2007). Studies on the impact of neighborhood safety on physical activity and weight status have produced less consistent results, but some have shown that parent perceptions of crime and traffic safety influence physical activity levels and weight status of their children, most likely indirectly as their concerns about children keep them inside and thus more sedentary (Lumeng et al. 2006; Timperio et al. 2005).

Racial and Income Disparities

Racial and income disparities characterize all of these issues—physical activity, eating, food access, outdoor advertising, and crime—as well as overweight among children and adults (Day 2006; Kumanyika and Grier 2006; Taylor et al. 2006). Researchers hypothesize that differences in environment caused by residential segregation account for much of the disparity (Kawachi and Berkman 2003). In addition to being exposed to more fast-food restaurants and convenience stores (Lewis et al. 2005; Block, Scribner, and DeSalvo 2004), fewer supermarkets and healthy food options (Zenk et al. 2005; Rose and Richards 2004; Horowitz et al. 2004; Morland et al. 2002), and having less access to physical activity settings (Powell, Slater, and Chaloupka 2004), ethnic minorities and low-income children watch more television and movies than their white peers (Rideout et al. 2000; Kumanyika and Grier 2006). Research has also shown that

television shows targeting black audiences have more food commercials (Tirodkar and Jain 2003) and are more likely to promote candy, soda, and fast food than general audience programs (Henderson and Kelly 2005).

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Limitations of Previous Research

Researchers are quick to point out the many limitations of this body of research on physical activity and eating, including the fact that none of it documents a definitive causal link between the built environment and weight status (Sallis and Glanz 2006; Transportation Research Board 2005). Most of the research on the built environment has not focused on children (Krizek, Birnbaum, and Levinson 2004) or racial minorities (Kumanyika and Grier 2006). Most studies have not used random assignment or natural experiments, making it impossible to determine the impact of neighborhood self-selection (Sallis and Glanz 2006; Roux 2003). Most studies have been cross-sectional, while exposure and access are hypothesized to matter over time (Transportation Research Board 2005; Roux 2003). Little research has been conducted to determine how individual characteristics, other than gender, mediate the impact of the environment (Lewis et al. 2002; Miller, Stewart, and Brown 2002) and how children actually spend their time (Krizek, Birnbaum, and Levinson 2004). Despite increasing use of GIS and attention to physical environment, researchers give little attention to the influence of geographic scale (Roux 2003; Heath, Hebert, and Lancaster 2006). "Scale" refers to the size of the geographic area that influences behavior. For example, does violent crime within a census tract, zip code, or neighborhood affect residents, or does it need to occur on the block where people live in order to matter? The list of limitations goes on and on, but to summarize, more research on children, including racial minorities, is needed to

determine (1) how they interact with their environments over time; (2) the choices they are making about food, travel, and physical activity; and (3) how those choices affect their weight status.

How Is Technology Part of the Problem?

Access to Media Technologies

New technologies offer children an increasing array of entertainment options that involve staying indoors and being sedentary. Children today have unprecedented access to technology. For half of all children, the TV is on in their household "most of the time," and for children in two-thirds of all households, it is usually on during meals. Two-thirds of children ages eight to eighteen have a TV in their bedroom (Rideout, Roberts, and Foehr 2005). What experts are calling "screen time"—time spent in front of video games, computers, and TV—fills much of the time between school and sleep.

New Media Content and Formats

The content of that screen time is transforming rapidly, with video games evolving from the crude Atari Pac-Man of the 1980s to EA Sports's lifelike Madden NFL Football. The average cost of producing a video game jumped from $40,000 in the early 1990s to $10 million in 2004 because of three-dimensional graphics, artificial intelligence, and sound effects that make games more sophisticated and entertaining (Crandall and Sidak 2006). Today, children can play video games anywhere—in the car, during worship services, while shopping with parents—thanks to a plethora of mobile options including Nintendo's GameBoy Advance line, which offers five hundred different game options (Liz 2004).

What children watch on television and how they watch has also changed, as the number of channels and movie options has mushroomed. Over the past fifteen years, the percentage of U.S. households with cable television has increased from 60 to 85 percent (Dietz and Strasburger 1991; Cabletelevision Advertising Bureau 2006), and 55 percent of children have access to premium cable channels (Rideout, Roberts, and Foehr 2005). Digital video recorders (DVRs) such as TiVo allow users to record programs based on their preferences and watch at their convenience, while high-definition and plasma TV sets continue to improve the experience—and cost—of watching TV.

What children play on video game consoles and watch on TV and how they play and watch has changed considerably, but the greatest revolution has taken place with the Internet. In particular, online communities that allow visitors to customize sites and interact with other people have drawn in adults and children in unprecedented numbers. Social networking sites such as MySpace and Facebook attract children as early as middle school by allowing them to customize their own site with photographs, videos, and information about their

friends. YouTube allows visitors to post their homemade videos in an accessible format, creating new opportunities for everything from *Saturday Night Live* skits (Steinberg 2007) to presidential debates (Seelye 2007). MySpace, MySpace email, Facebook, and YouTube all ranked among the top eleven Web sites in 2006, representing nearly 12 percent of all Internet usage (Hitwise 2007).

Beyond video games, TV, and computers, children and adults increasingly walk around with high-tech digital audio players and cell phones. Between 2001 and 2007, Apple sold 100 million iPods, by far the most popular of the MP3 players (Apple 2007b). Cell phones feature flash cameras, camcorders, GPS, text-messaging, e-mail, Internet access, video games, and music downloads. "Family plans" and cell phones designed for children encourage adults and children, alike, to consider personal phones indispensable. Most of these technologies can be integrated. For example, Apple depends upon its iTunes Store Web site to generate revenue when iPod users download individual songs, and Apple TV will allow users to view anything on their computer through their TV sets, including the full catalog of YouTube videos (Apple 2007a). This new environment is leading companies to merge their boardrooms as well as their technology. Fox Interactive Media Corporation, which oversees all Internet operations for Fox News Corporation, paid $580 million in 2005 for MySpace (*Sidney Morning Herald* 2005). Apple and Google have also hinted at a merger (Markoff 2006). Rather than competing head to head to increase their market share, these corporations are finding it more effective to join forces.

Advertising

Children have their greatest exposure to advertising through broadcast and cable television, and much of what they see advertised is food. U.S. food manufacturers spend 75 percent of their advertising budgets and U.S. fast-food restaurants spend 95 percent of their advertising budgets on television (Gallo 1999). Fast-food restaurants regularly partner with movies aimed at children and advertise special promotions on TV. In the summer of 2007, McDonald's Happy Meals featured toys from Sony Animation's "Surfs Up" along with collector glasses, Swamp Sludge McFlurry, and Minty Mudbath Shake for DreamWorks' "Shrek's Treketh to Adventure." The movie industry does not stop with promotions for fast-food restaurants. In addition to McDonalds, DreamWorks listed Frito-Lay Cheetos (cheese curls that turn your mouth green), Sierra Mist diet soda, Yoplait Yogurt (yogurt tubes with swamp riddles), Sargento cheese, Nestle ice cream (sludge fudge and swamp pops), M&M candies (ogre-sized peanut butter and chocolate candies), Kellogg's, and Kraft macaroni & cheese as *Shrek III* partners (DreamWorks 2007). Many food manufacturers also partner with toy companies, feature video games and kids' clubs on their Web sites, and sell advertising directly in movies through product placement (Story and French 2004).

While television is the most ubiquitous form of advertising for children, outdoor advertising has become increasingly creative in how it uses technology. Outdoor advertising is a $6.8 billion industry (Outdoor Advertising Association of

America 2007a) and includes everything from billboards to street furniture, bus shelters, and bus and building wraps. Digital billboards represent a small proportion of all billboards (approximately 500 out of 450,000 billboard in the United States), but technological innovations are making new forms of advertising possible, including real-time updates of anything from lottery jackpots to mortgage interest rates (Outdoor Advertising Association of America, Inc. 2007a) and billboards featuring digital ink that requires less energy and cost than conventional digital billboards (Outdoor Advertising Association of America 2007b).

Cities across the United States have buses wrapped in vinyl advertisements, and the outdoor advertising industry is threatening to wrap buildings and other large outdoor features with ads on the model of Times Square. Nomad Worldwide, a leader in ad wraps, boasted that it sees a "world of blank canvasses" and has "proven that any surface can be conquered—billboards, scaffolding, wallscapes, barricades, building wraps, and construction sites" (Nomad 2007). While these building wraps do not all feature unhealthy foods, an unlicensed building wrap in downtown Philadelphia that generated significant attention from advocates and the media featured a Dunkin' Donuts ad (Slobodzian 2007).

Summary of the Problem

The time children spend indoors is increasingly consumed by media technology, from television to computer games and the Internet. Increasingly sophisticated computer, television, and audio options keep them sedentary during much of their free time while exposing them to coordinated advertising campaigns disproportionately promoting unhealthy foods. Many of these technologies are now portable, meaning that media technologies can also occupy time spent away from home. High-tech outdoor advertising is relatively new, but the possibilities for "wrapping" all aspects of our built environment, including things that move, like busses, seem endless and promise even more exposure to unhealthy foods. When children and families do spend time out of the home, it is increasingly to purchase fast-food meals and snacks. While not the sole cause of the childhood overweight epidemic, the increasing role of media technology in the lives of children explains, in part, how the equation between physical activity and food consumption has become so out of balance.

How Can Technology Be Part of the Solution?

While children spend much of their time with these various technologies, most research on children's physical activity and eating still relies on paper-and-pencil measures for observing children and surveying communities. This low-tech approach may provide a more appropriate choice in many situations, saving researchers money and time and potentially providing as good if not better data than high-tech options. But all of the technological improvements in the past ten years provide limitless opportunities for researchers to advance our understanding of

how children interact with the built environment and how to intervene to reduce childhood overweight. The Robert Wood Johnson Foundation's Active Living by Design and Healthy Eating Programs and the National Institutes of Health's Improving Diet and Physical Activity Assessment initiative have provided significant funding for researchers to create new or adapt existing instruments for handheld personal digital assistants (PDAs) and tablet PCs and to incorporate GIS and GPS.

Technology for Measuring the Built Environment

Geospatial technologies including GIS and GPS are increasingly used by researchers to model the built environment. Because exposure is generally conceptualized to relate to physical proximity (Austin et al. 2005; Pasch et al. 2007), knowing what resources and conditions exist near where children spend time is critical to understanding their exposure. GPS is the favored tool for field data collection because location information can be acquired anywhere (in theory) using satellites, while GIS depends upon pregenerated map layers of features like buildings, streets, and administrative areas.

GIS has been used extensively in research on the impact of the built environment on childhood overweight. Most research has used vector GIS to represent basic physical infrastructure such as roads, sidewalks, and transit lines, or administrative units such as census tracts and zip codes to display demographic information, but GIS is capable of providing much higher levels of spatial analyses than simple visual overlays. The Twin Cities Walking Study, which integrates paper-and-pencil survey data with extensive and well-documented GIS data, provides one example of the more sophisticated modeling GIS makes possible (Forsyth 2007; Forsyth et al. 2006). The study uses GIS measures of road networking that incorporate direction and speed rather than just simple street centerline files provided by the U.S. Census Bureau that only show street locations, names, and classifications. The study also uses GIS to calculate area and dissimilarity indexes to determine land use mix rather than simply showing color-coded land use maps.

In addition to vector GIS, the Twin Cities Walking Study uses raster GIS, which represent map layers using regularly shaped cells to denote a continuous surface and provide more flexibility in analyzing data. Using raster GIS, it is also possible to calculate slope and viewsheds, two factors that may be related to the walkability of a neighborhood (Forsyth 2007; Forsyth et al. 2006). Raster GIS has also been used to create continuous measures of environmental conditions that are not dependent upon aggregations of administrative units like census tracts. Hillier et al. (2003) computed kernel densities of housing code violations, housing demolitions, and tax delinquent properties using raster GIS.

Examples of using GPS to measure the built environment are rarer. In developing the Path Environment Audit Tool (PEAT), Troped et al. (2006) used GPS to map paths and trails in eastern Massachusetts. Students at California State Polytechnic University used GPS with handheld computers and digital cameras

to map assets in San Jose's poorest neighborhoods (Ulrich 2005). Digital and disposable cameras provide tools for documenting neighborhood conditions. In the Health of Philadelphia Photo-Documentation Project (Cannuscio and Asch 2006), researchers gave students and community members disposable cameras to document elements of their neighborhood that facilitate or create barriers to health. Cell phones are increasingly equipped with digital cameras that allow for convenient—if not high-quality—photographs in the field. Digital cameras provide another option. A study of outdoor advertising in Austin, Los Angeles, and Philadelphia (Hillier et al. n.d.) used digital cameras and GPS devices to record the location and content of outdoor advertisements. Data showing the location of outdoor ads and photographs of the ads can then be displayed along with other map layers, as shown in Figure 1. New digital GPS cameras integrate the functionality of handheld GPS with digital cameras, making it possible to stamp photographs with location information (Ellison 2006).

Handheld computers, referred to as "pocket PCs," and PDAs are also being used in neighborhood assessments. The Physical Activity Resource Assessment (PARA) instrument for inventorying physical activity resources in an urban setting was originally designed for paper and pencil, but a handheld computer version is in development (Lee et al. 2005). In addition to survey instruments, PDAs can be used with GIS to facilitate field data collection. A study of the location of corner stores and other places where children purchase food on the way to and from school used PDAs equipped with GIS software (Fitzgerald 2005).

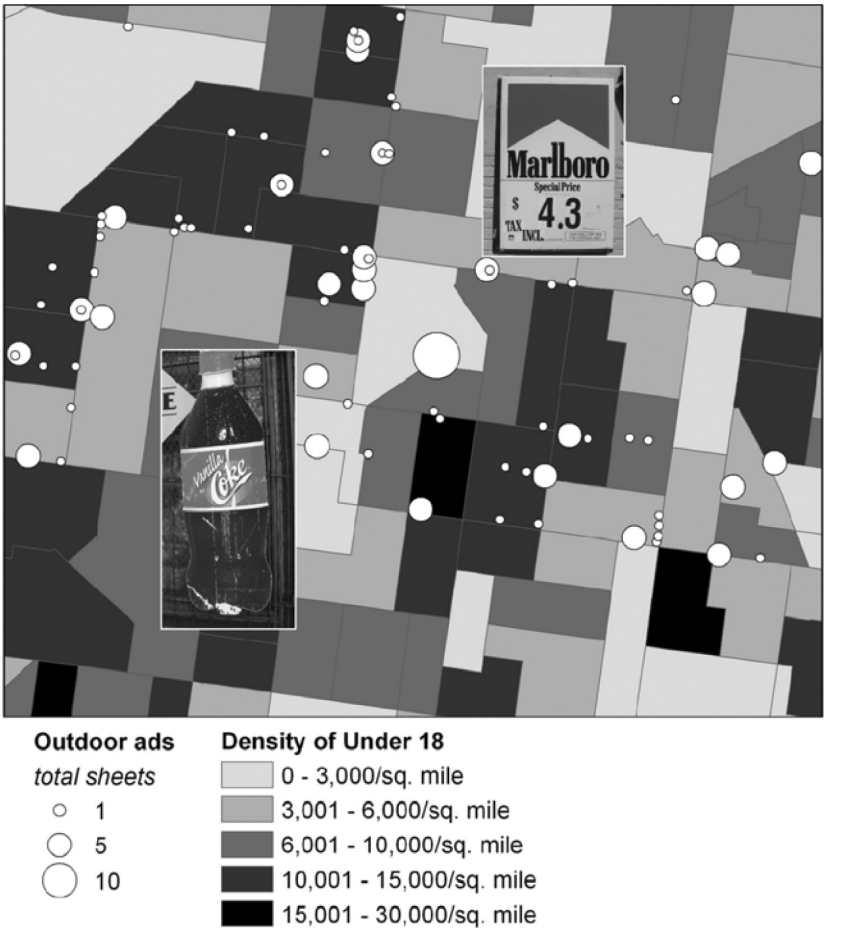
Technology for Measuring Physical Activity

Numerous researchers have also developed tools that use new technologies to measure physical activity with funding from the Robert Wood Johnson Foundation's Active Living Program (Robert Wood Johnson Foundation 2007). The System for Observing Play and Recreation in Communities (SOPARC), created to determine the number of people in parks and the types of activities in which they are engaged, was also developed originally as a paper-and-pencil instrument, but the newest version will use PDAs to record information (McKenzie et al. 2006).

While GPS can be used to identify resources and conditions within the built environment, it also holds promise for measuring physical activity. A 1997 study (Schultz and Chambaz 1997) concluded that GPS could be used to record information about physical activity in a nonintrusive and continuous manner anywhere outside because satellite readings are available worldwide. More recently, Rodriguez, Brown, and Troped (2005) used GPS in conjunction with accelerometers to track the locations where study participants were physically active. SOPARC will also use GPS to validate self-reported and observed physical activity (McKenzie et al. 2006).

Other technology has been used to measure physical activity and movement. In the Trial of Activity for Adolescent Girls (TAAG), study participants attached

FIGURE 1
MAPPING OUTDOOR ADS WITH DIGITAL PHOTOGRAPHS AND DEMOGRAPHIC DATA



accelerometers to belts around their waist to measure moderate to vigorous physical activity at thirty-second intervals. Results showed that girls who lived closer to their schools engaged in more physical activity (Cohen et al. 2006). Another study used accelerometers, self-reported television watching, and GIS data to determine that neighborhood characteristics influence boys' physical activity more than girls' physical activity (Roemmich et al. 2007). In a very different type of study, Lindsey et al. (2006) used infrared monitors to measure traffic along multiple trail locations to determine aggregate, rather than individual, activity levels.

Technology for Measuring Eating and Travel Behavior

Even more than physical activity measures, measures of eating have relied on paper-and-pencil surveys. New tools that utilize technology are emerging, however. The National Cancer Institute is developing a Web-based instrument for self-administered twenty-four-hour food recalls called Automated Self-Administered 24-Hour Recall (ASA24) (National Cancer Institute 2007). Together with researchers at the University of Pennsylvania, the author hopes to develop Food and Environment Diaries for Urban Places (FED-UP), a video-game-like food and travel diary that students would complete online using a map interface (Hillier and Volpe n.d.). Children would be asked to collect information during their trip to and from school, using cell phone text-messaging and digital photography to record what they purchase and eat. This information would be transmitted wirelessly to their online account. GPS devices would be used to record the paths children take to and from school or to verify self-reported travel behavior. Children would then review and complete the records of their daily trips online.

Instruments like ASA24 and FED-UP hold the potential of capturing much more detailed self-reported data than traditional food frequencies and food recalls, with images to help identify specific products and portion sizes. By making these instruments available online, study participants can input data regularly without need for an interviewer. FED-UP would have the additional benefit of recording spatial information about where children purchase and consume food and understanding how children interact with their environment. In a pilot study, we used a customized GIS created using ArcPad software for handheld computers to record the route that students reported taking (Hillier and Volpe n.d.). As Figure 2 demonstrates, this data on routes can be mapped with information about crime, housing, land use, and demographics using GIS.

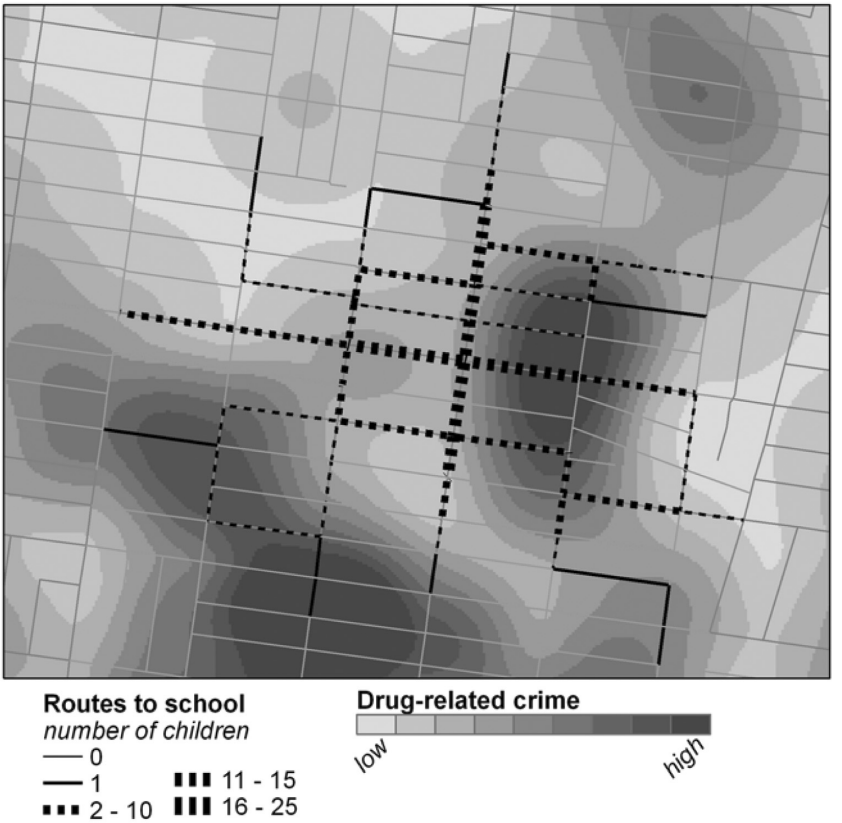
Several applications for mapping routes on the Internet have been developed using Google Maps, including Gmaps Pedometer and walkrunjog.net, and could be adapted for travel diary research. The Space-Time Adolescent Risk Study (STAR) (Wiebe 2006) of young adult gunshot victims is using a combination of Internet mapping, GIS, and tablet PCs (laptop computers with screens that lie flat and can be "drawn" on with a stylus) to allow gunshot victims to show where they were leading up to their shooting.

Smart card technology provides another tool. Data acquired by supermarkets when purchases are scanned and linked to customer accounts can be analyzed at the individual or aggregate level to understand food behavior (Bucklin and Gupta 1999). The same technology has been used to determine (Lambert et al. 2005) and limit (Snyder 2006) what children eat in school cafeterias.

Technology for Improving the Built Environment

Policy makers, software companies, and government officials have found ways to use technology to reshape the built environment. For example, GIS and spatial modeling are being used to design healthier and more livable communities

FIGURE 2
HYPOTHETICAL ROUTES TO SCHOOL WITH CONCENTRATION OF CRIME



consistent with the research findings about walkability and mixed land use. CommunityViz integrates GIS technology with 3D modeling to analyze the impact of development choices (Placeways 2007). The integration of GIS with agent-based modeling, a technique for modeling complex behaviors with multiple interactions (Bonabeau 2002), also holds promise for predicting the impact of certain built environment changes on children's behavior.

Public safety efforts rely heavily on GIS and other high-tech approaches to fighting crime and reducing vehicular accidents. The New York City Police Department popularized CompStat, a GIS-intensive accountability management system for geographically targeting delivery of police services (Walsh 2001). Red-light cameras that automatically photograph the license plate of vehicles that

enter an intersection after a traffic light turns red are significantly reducing the number of vehicles running red lights, which is a major cause of motor vehicle and pedestrian accidents (Retting, Ferguson, and Farmer 2007; Federal Highway Administration and National Highway Traffic Safety Administration 2005). Research has shown that parent perceptions of crime and traffic safety influence their children's levels of physical activity (Lumeng et al. 2006; Timperio et al. 2005), so reducing crime and traffic accidents may reduce parent concerns and increase physical activity among children.

Policy makers, software companies, and government officials have found ways to use technology to reshape the built environment. For example, GIS and spatial modeling are also being used to design healthier and more livable communities consistent with the research findings about walkability and mixed land use.

Technology for Improving Eating

New technologies have also been adapted to educate children and adults to change their eating habits. At least two computer games have been developed to encourage healthy eating—Squire's Quest (Baranowski et al. 2003) and the United States Department of Agriculture's MyPyramid Blast-Off Game (U.S. Department of Agriculture 2007). The development budgets for these projects pale in comparison with the millions of dollars that for-profit companies invest in new games, but they represent early efforts to engage children through familiar technology. Digital audio players, online videos, wikis, blogs, "mosh-pits," and other Web2.0 applications are being used by health professionals for clinical education and sharing of health resources (*Journal of the American Medical Association* 2007; Maag 2006; Trier 2007; Skiba 2007; Boulos, Maramba, and Wheeler 2006; Cebeci and Tekdal 2006). All of these hold promise for educating children and parents about healthy living as well as teaching researchers about best practices.

Cellular telephones provide an additional technology with potential for changing behavior. Phones designed for children like Verizon's Migo and the Disney phone allow parents to use the built-in GPS to monitor where their children are,

restrict phone numbers dialed and received, and pre-program emergency numbers or "family alert" test messages for young children. In addition to reducing parent concerns about children being outside the home, this technology could be used to send children reminders about healthy eating and physical activity or track their travel and food consumption.

Technology for Improving Physical Activity

In addition to these educational applications, a number of new technologically based games have emerged that hold promise for reengaging children in physical activity and the outdoors. Geocaching, played primarily by adults, involves a series of clues such as GPS coordinates for finding "caches," usually watertight boxes with a logbook and small objects for trading. Players post information about new hunts on an official game Web site that by June 2007 included information about more than four hundred thousand "caches" (Groundspeak 2007). This treasure hunt game could be adapted for children in urban communities, having them move through parks, travel to child-friendly institutions, and learn about GPS technology.

Cell phones can also be used to promote physical activity. Recently, they have been used to provide information during self-guided walking tours. The Cross/Walks project in Philadelphia provides prerecorded messages about the history of the Fabric Row section of South Philadelphia that can be accessed by cell phone (Iverson 2007). Tours like these could be designed by children for children, incorporating historical content as well as commentary on personal landmarks, creating an outdoor version of MySpace.

New "activity-promoting" video games also hold promise for converting sedentary screen time to active screen time (Lanningham-Foster et al. 2006). These include Nintendo's Wii, a game console featuring a wireless controller that can detect motion (Nintendo 2007) and Sony Eye Toy, which uses a USB camera to incorporate images and movements of the player into the game (Sony Computer Entertainment 2007). Dance Dance Revolution (DDR), a Japanese invention with the motto "Where exercise gets fun," uses arrows to instruct players to step on one of four places on a dance pad in rhythm with a song (DDRgame.com 2007). DDR began as an arcade game, but dance pads that plug into the television are now available, as well as a "practice pad" that does not use technology but can be used outside (DDRgame.com 2007). A future outdoor version for parks, school playgrounds, or even sidewalks that uses digital audio players, cell phone displays, or PDAs to instruct the dancer might revolutionize recess, outdoor play, and trips to and from school (Lanningham-Foster et al. 2006). Table 1 compares these different technologies used to measure and improve eating behavior and physical activity.

The challenges involved in capitalizing on these new technologies for research, education, reshaping the built environment, and engaging children in physical activity and healthy eating are considerable. Developing new technologies or even adapting existing ones pose significant costs relating to hardware acquisitions and training. Obtaining consistent readings from GPS in different weather and built

(text continues on page 76)

TABLE 1
COMPARISON OF TECHNOLOGIES

Technology	Examples	Use	Availability	Strengths	Limitations	Cost
Geospatial						
Geographic information systems (GIS)	Twin Cities Walking Study (Forsyth et al. 2006); Food and Exercise Diaries for Urban Places (FED-UP) (Hillier and Volpe n.d.)	Measure built environment and travel behavior	Widely available at academic institutions and government agencies; more limited use in nonprofits	Can be applied to many different data types; highlights spatial relationships	Difficult to model movement or change over time; requires training to use	Some open source (free) software, but $500 or more for most popular software; PC needed
Global positioning systems (GPS)	Path Environment Audit Tool (PEAT) (Troped et al. 2006); Trial of Activity for Adolescent Girls (TAAG) (Cohen et al. 2006)	Measure built environment, travel behavior; encourage physical activity (GPS treasure-hunting games)	Widely available in wrist or hand-held versions, in cell phones, and car navigation systems	Identifies location without street address	May not work in all conditions (weather, tall buildings); requires training	$100 or more
GPS cameras	No published studies	Measure built environment and eating behavior	New technology not widely available	Stamps photographs with location information (for mapping)	May not work in all conditions (weather, tall buildings); requires training	$800 or more
Online interactive mapping	Space-Time Adolescent Risk Study (STAR) (Wiebe 2006); FED-UP (Hillier and Volpe n.d.)	Measure travel and eating behavior	Wherever Internet is available	Widespread access; ease of use; can be adapted for different applications	Not designed for research; may require customization	Free unless customization required

(continued)

TABLE 1 (CONTINUED)

Technology	Examples	Use	Availability	Strengths	Limitations	Cost
Photography						
Disposable cameras	Health of Philadelphia Photo-Documentation Project (Cannuscio and Asch 2006)	Measure built environment, food behavior, and physical activity	Widespread; available at drug stores, convenience stores, etc.	Inexpensive; easy to use; good for fieldwork if loss of or damage to camera is concern	Image quality may not be comparable to more expensive cameras	Less than $10 plus film-processing fees
Digital cameras	Five-City Billboard Study (Hillier et al. n.d.)	Measure built environment, food behavior, and physical activity	Widely available	Easy to use; generate high-quality images in digital format	Require charged batteries; ease of use may encourage taking too many photos	$200 or more (varies widely)
Red-light cameras	Roosevelt Blvd., Philadelphia (Gambardello 2007)	Promote traffic safety	Limited to dangerous intersections in certain cities	Reduce red-light running and increase pedestrian and vehicular safety	Expensive to install	$50,000 or more
Digital audio recordings						
MP3 downloads	*Journal of the American Medical Association* (2007); nursing education (Maag 2006)	Education and training for professionals or children	More common for commercial music than educational material	Convenient to listen to; MP3 players are very common	Limited control over setting in which recording is heard	None if software for recording and digital audio player for listening are available
Podcasts	(Boulos, Maramba, and Wheeler 2006)	Education and training for professionals or children	More common for nonresearch uses	Convenient to listen to or watch; can incorporate audio and video	Limited control over setting in which recording is heard	None if software for recording and digital audio player for listening are available

Cellular phones						
Telephone calls	Cross/Walks: Weaving Fabric Row (Iverson 2007)	Promote physical activity through narrated walking tours	Limited examples of tours but near universal access to cell phone service in urban areas	Widespread access to cell phones and cell phone service; ease of use	Cell phone service not reliable	$35/month or more plus cost of phone
Text messages	FED-UP (Hillier and Volpe n.d.)	Measure travel and food behavior	Nonresearch usage is widespread	Widespread access to cell phones and cell phone service; ease of use	Depends upon self-report; can only capture a limited amount of information	Available with most cell phone services; requires cell phone and cell phone service
Digital photographs	FED-UP (Hillier and Volpe n.d.)	Measure travel and food behavior	Nonresearch usage is widespread	Convenience; ease of use; widespread access	Poor-quality images	Available with most cell phone services; requires cell phone and cell phone service
Monitors of movement and consumption						
Accelerometers	TAAG (Cohen et al. 2006; Roemmich et al. 2007)	Measure physical activity	Used widely in research	Provide reliable and valid measures of movement; do not depend on self-report	Data recorded is difficult to interpret	$100 or more

(continued)

TABLE 1 (**CONTINUED**)

Technology	Examples	Use	Availability	Strengths	Limitations	Cost
Infrared monitors	Trail monitoring (Lindsey et al. 2006)	Measure physical activity	Used widely for nonresearch applications	Measure movement without needing people or cameras; nonintrusive	Provides no data about who is moving	$200 or more
Smart cards	Supermarket scanner data (Bucklin and Gupta 1999); school cafeterias (Lambert et al. 2005; Snyder 2006)	Measure eating behavior; promote healthy eating	Widely used in supermarkets	Widely available; convenient; easy to use	Privacy issues	Cards are inexpensive but scanning system required
Computers						
Educational computer games	Squires Quest (Baranowski et al. 2003); MyPyramid Blastoff (U.S. Department of Agriculture 2007)	Promote healthy eating	Limited use in research setting	Fun for children	Expensive to develop; rarely as sophisticated and engaging as commercial products	Free to play; tens of thousands of dollars to develop
Physically active computer games	Dance Dance Revolution (DDRgame.com 2007); Wii (Nintendo 2007)	Promote physical activity	Used widely by children in arcades and at home	Fun for children	Commercial products developed to be entertaining rather than healthy	$30 or more; $250 or more for game console

Personal digital assistants (PDAs)	System for Observing Play and Recreation in Communities (SOPARC) (McKenzie et al. 2006)	Measure the built environment	Used widely for personal and business use but not for research	Widely available; convenient size	Small screen and small processor limit functionality	$200 or more
Tablet PCs	STAR (Wiebe 2006)	Measure built environment and travel behavior	Limited usage outside of research	Ease of use; feels more like computer game than conventional PC	Much larger and more expensive than PDA	$2,000 or more
Internet						
Internet Web sites	Automated Self-Administered 24-Hour Recall (ASA24) (National Cancer Institute 2007)	Measure eating behavior	Wherever Internet connection is available	Accessibility; easy to use; can be customized	Expensive to develop interactive site	
Wikis	(Boulos, Maramba, and Wheeler 2006)	Education and training for professionals or children	Wherever Internet connection is available	Interactive	Limited control over content	Free or low cost
Blogs	(Boulos, Maramba, and Wheeler 2006)	Education and training for professionals or children	Wherever Internet connection is available	Easy to use	Limited control over content	Free or low cost

environment conditions, having reliable wireless Internet access, and interpreting data generated from accelerometers are among the known challenges. Establishing the reliability and validity of these new instruments requires attention beyond getting them to work. The current generation of researchers did not grow up with multipurpose cell phones or Web2.0 applications like blogs and wikis, so using them for research is often not instinctive. The ability of these new technologies to track and influence individual behavior also poses serious questions about human subjects, research ethics, and privacy. Clearly, applying technology more consistently and more effectively to combat childhood overweight requires much more than technical expertise.

An Agenda for Moving Forward

What researchers know about the role of the built environment on childhood overweight is fairly limited. Mixed-use and high-density areas with less crime and greater traffic safety where children have access to recreation facilities promote physical activity (Sallis and Glanz 2006; Transportation Research Bureau 2005; Heath, Hebert, and Lancaster 2006; Handy et al. 2002). Depending upon where they live, children have very different access to healthy foods (Zenk et al. 2005; Rose and Richards 2004; Horowitz et al. 2004; Morland et al. 2002). Media from TV to the Internet to computer games pervade their time, limiting their active and outdoor play and exposing them to messages promoting unhealthy foods (Rideout, Roberts, and Foehr 2005; Gantz et al. 2007; Kelly 2005). To date, technology has contributed more to this problem than to its solution, but many technological innovations and applications hold promise for reversing this pattern. So how do researchers and public health advocates ensure that this happens?

To date, technology has contributed more to this problem than to its solution, but many technological innovations and applications hold promise for reversing this pattern.

Making Children Part of the Solution

Part of the answer involves a conceptualization of childhood overweight that makes children active participants in developing solutions. We must meet children

where they are, and that means understanding why they are so interested in Wii, DDR, MySpace, YouTube, cell phones, text-messaging, and other technologies that distinguish their childhoods dramatically from previous generations. These technologies use sophisticated graphics and multimedia and allow children to participate and shape their own fun. What else do children like? What makes these things fun? How can the features of these new technologies that engage children be adapted for research, teaching, and promoting physical activity? Who better to ask than children?

Participatory research that includes children as agents of change and not passive research participants is one approach (Sloane et al. 2003; Hackbarth et al. 2001). Partnerships with schools must respect the pressure on teachers to meet curricular standards and improve test scores, but privately funded technological enrichment activities may be welcome through after-school programs, computer classes, health classes, or physical education programming. Such partnerships should also leave technological devices and software like GIS, GPS, and accelerometers with teachers for use with other projects, such as mapping school grounds and conducting science experiments. Social marketing provides another opportunity. Nintendo and EA Sports know what children like because they ask them and spend time learning about their preferences. The Food Trust, a Philadelphia-based nonprofit food research and advocacy group, used this approach to develop healthy snack foods as part of its Corner Store Campaign. The Food Trust hired a firm specializing in social marketing to work with children to design a new line of baked corn chips under the name "Slam Dunk" (Food Trust 2007).

Making Media Corporations Part of the Solution

The companies that create the most successful video games, cell phones, and Web sites must be viewed as potential allies in the fight against childhood overweight. The limited amount of funding available from private foundations and government institutes make it unlikely that most technological applications that researchers develop on their own will compete with $10 million video games (although YouTube and MySpace offer two examples of creative media that are relatively inexpensive). With some form of subsidy or public recognition, might a shoe company develop affordable shoes for children that have built-in pedometers and light up when personal activity goals are met? Which phone service might develop a cell phone scanner that allows children and adults to scan bar codes to determine how food items fit within individual dietary plans and federal nutrition guidelines? Which food company might develop a system for producing Web-based personal food reports that track smart card food purchases and suggest alternative foods? For example, the report might suggest 100 percent juice as a substitute for artificially sweetened beverages and provide coupons from manufacturers to try new products. It is unlikely that researchers and health advocates can develop and distribute new technologies like these on a large scale without the help of the entertainment industries.

Advocates must continue to file lawsuits and shame food companies like Kellogg's into changing the way they market to children (Martin 2007) or the beverage industry into changing how it serves children at school (Warner 2005). City planners and local governments must continue to use technology to design healthier communities. Legislators must continue to support laws that make it easier for supermarkets to locate in underserved areas (Clark 2004). But there are limits to our ability to eliminate health risks and reshape the environment in which children live. Ultimately, we need to help children make better choices over their life course, creating what King et al. (2002) described as "choice-enabling" environments. This means that all children need to have access to healthy foods and recreation; then we can focus on helping them to make good choices. They must see evidence that their choices can make a difference for themselves and for society, that childhood overweight is a problem, and that the problem is not intractable. Children will inherit this overweight epidemic, with all of its health and financial implications. We should enlist their help, including their interest and skills in technology, now.

Note

1. The tobacco industry voluntarily stopped advertising on billboards in 1999, but this only eliminated large-format outdoor ads.

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