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Using Google Earth to conduct a neighborhood audit: Reliability of a virtual audit instrument

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ABSTRACT

Over the last two decades, the impact of community characteristics on the physical and mental health of residents has emerged as an important frontier of research in population health and health disparities. However, the development and evaluation of measures to capture community characteristics is still at a relatively early stage. The purpose of this work was to assess the reliability of a neighborhood audit instrument administered in the city of Chicago using Google Street View by comparing these "virtual" data to those obtained from an identical instrument administered "in-person". We find that a virtual audit instrument can provide reliable indicators of recreational facilities, the local food environment, and general land use. However, caution should be exercised when trying to gather more finely detailed observations. Using the internet to conduct a neighborhood audit has the potential to significantly reduce the costs of collecting data objectively and unobtrusively.

1. Introduction

1.1. Characterizing neighborhoods in health research

Over the last two decades, the impact of community characteristics on the physical and mental health of residents has emerged as an important frontier of research in population health and health disparities (Diez Roux, 2001; 2004; O'Campo, 2003; Sampson et al., 2002). The measurement of community characteristics is evolving, but strategies typically fall under one of three categories of measurement: secondary analysis of archival data sources, perceived (self-reported) responses in a community survey, and objective audit instruments (Brownson et al., 2009). Using secondary data from administrative sources (e.g. decennial census), both to define neighborhoods and as an aggregate measure of neighborhood characteristics, researchers have examined the relationship between various health outcomes and factors such as population density (Lopez, 2004), land use diversity (Clarke and George, 2005; Cervero and Duncan, 2003), and block size (Boer et al., 2007). These archival data are often enhanced using geographic information systems (GIS) to incorporate data on characteristics such as traffic volume (Tonne et al., 2007), street connectivity (McGinn et al., 2007), the availability of food (Bader et al., 2010), and recreational facilities (Diez Roux, Evenson et al., 2007) within local neighborhoods.

Tapping individuals' perceptions of their environments is another common measurement strategy (e.g. Moore et al., 2008), particularly in the research on physical activity and the built environment (Brownson et al., 2009). However, subjective reports from respondents are subject to same-source bias (e.g. those in poor health are more likely to report poorer neighborhood conditions) (Echeverría et al., 2008), and conflicting findings can arise when using both subjective and archival measures (McGinn et al., 2007). As an alternative, direct observation of neighborhood characteristics using an audit instrument relies on more objective measurement to capture many of the comprehensive and detailed environmental characteristics relevant for health (Clifton et al., 2007; Clarke et al., 2008; Schaefer-McDaniel et al., 2010). While driving or walking through small-area respondent-centered neighborhoods, researchers observe and document neighborhood features using a standardized instrument (e.g. Pikora et al., 2002). The direct observational method known as systematic social observation (SSO) is a measurement strategy used in the social sciences (Reiss, 1971; Raudenbush and Sampson, 1999; Sampson and Raudenbush, 1999) whereby survey interviewers or raters systematically rate each respondent's neighborhood block (e.g. condition of the street, presence of litter, and heavy traffic) during the survey period. However, these in-person audits are highly resource intensive and costly, making them prohibitive for many studies.

The development and evaluation of measures to capture community characteristics are still at a relatively early stage (Brownson et al., 2009; Sallis, 2009), and only a few studies have

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explicitly compared measurement properties across different strategies (e.g. Bader et al., 2010). The purpose of this work was to assess the reliability of a neighborhood audit instrument administered using the internet by comparing these "virtual" data to those obtained from an identical instrument administered "in-person". Using the internet to conduct a neighborhood audit has the potential to significantly reduce the costs of collecting data "objectively and unobtrusively" (Brownson et al., 2009). Our objective in this work is to ascertain the reliability of this method by capitalizing on existing data that were collected as part of a study on neighborhoods and health in the city of Chicago.

1.2. Using the internet for a neighborhood audit

Recently, there has been dramatic growth in internet capacities for observing and characterizing small area neighborhoods. Google Earth (Google Inc., 2005) is a free, internet-based software that displays satellite images of the earth's surface at a resolution of 15 m or higher. Google Street View is a relatively new technology featured in Google Earth that provides 360° horizontal and 290° vertical panoramic views at the street level (based on images taken at approximately 10 or 20 m intervals) from a height of about 2.5 m. Thus, Google Street View gives the viewer the feeling of virtually being on the street and the capacity to virtually walk down that street. Street View was launched on May 25, 2007, in several major US cities, and has been expanding to include coverage throughout the world.

The highly detailed imagery available in Google Street View raises the possibility of conducting a "virtual" neighborhood audit. Despite the widespread availability of visual data on community and built environments, few studies have utilized such electronic images on the internet to characterize neighborhood environments (Curtis et al., 2010; Doyle et al., 1998). In this paper we assess the level of agreement between street level characteristics documented by trained raters using SSO as part of a community-based survey in the city of Chicago, and data collected with an identical instrument using Google Street View. This is a case study that draws on existing data collected "in-person" in 2002, and collects comparable data using Google Street View when it became available 4–5 years later. While we would ideally like to have had more contemporaneous measurement occasions, cost considerations prohibited the collection of data solely for this purpose. Rather, this is an opportunistic study that draws on existing data to conduct a case study in Chicago, offering initial insight into the reliability of a virtual method. We hope this is a first step in considering the utility of this method and that other researchers will replicate such analyses in other settings with better temporal alignment of data.

2. Methods

2.1. Data

Data obtained from the Chicago Community Adult Health Study (CCAHS), which was conducted in 2002 through face-to-face interviews with a multi-stage probability sample of 3105 adults aged 18 and over, living in the city of Chicago, and stratified into 343 neighborhood clusters previously defined by the Project on Human Development in Chicago Neighborhoods (Sampson et al., 1997). CCAHS was specifically designed to examine the effects of neighborhoods on health and observational data were collected on the block around each sampled residence through the method of systematic social observation. Corresponding with each face-to-face interview, survey raters completed a standardized instrument for rating the block where the respondent lived. On the cover page of the instrument is a diagram of a typical city block on which the rater fills in the names of the streets s/he is coding (Fig. 1). Each side of one of these streets is referred to as a block face, and a typical city block contains eight block faces. Each rater walked around the entire block two times while recording observations—the first time walking along the "inside" block faces and the second along the "outside" block faces. Inter-rater reliability of this method was demonstrated using a subsample of 80 blocks in a pilot study conducted in 2001 where two raters made separate, independent observations of the same block at the same time. Observed agreement ranged from 0.78 to 1.00 (κ=0.27–0.91). Agreement tended to be higher for objective indicators (e.g. presence of high-rise housing; κ=0.84) and lower for observations requiring a qualitative judgment (e.g. quality of street conditions; κ=0.27).

Using this standardized instrument, observational data were collected on multiple neighborhood characteristics that have been shown to be related to health (see Table 1), including land use (e.g. housing type, commercial, institutional, industrial), recreational facilities (e.g. parks, playgrounds), food environment (e.g. supermarkets, fast food, restaurants, liquor stores), neighborhood physical and social disorder (e.g. garbage, litter, broken glass, graffiti, signs advertising alcohol), as well as built environment characteristics (e.g. presence of trees, quality of street conditions). Some questions are asked at the level of the block face, meaning that the rater must code each side of the same street separately (e.g. presence of graffiti on buildings, signs or walls). Other questions were asked at the street level where one observation was made for the entire street (e.g. condition of the street). For our purposes we focus on characteristics at the street level, aggregating the block face characteristics up to the street level where necessary.

For comparison, we used an identical instrument on a subset of 60 of these residential blocks (244 streets) to conduct a virtual SSO using Google Earth. These blocks were selected from a random sample of all blocks in the study and were spatially distributed throughout the city of Chicago (Fig. 2), with somewhat greater density on the north side of the city. Using the Street View images for the city of Chicago, a trained rater did a virtual walk around the block where respondents lived and documented observed characteristics using the identical standardized SSO instrument. Google Street View images for the city of Chicago were dated around 2007 (about four to five years after the in-person SSO data were collected).

2.2. Analyses

We examine the inter-source reliability of street-level characteristics observed in the virtual compared to the in-person neighborhood audit. Agreement between observed characteristics using the in-person SSO and the virtual SSO was assessed using the Kappa coefficient (Cohen, 1960). The Kappa statistic adjusts for the amount of agreement that could be expected to occur by chance alone (Landis and Koch, 1977), and ranges from 1.0 (representing perfect agreement) to 0 (representing agreement corresponding to that expected by chance). However, due to the sensitivity of the Kappa statistic to the underlying prevalence of the characteristic (Feinstein and Cicchetti, 1990), we also report the observed agreement between the in-person and virtual SSO data. All analyses were conducted in SAS Version 9.2 for Windows.

3. Results

Observed agreement and Kappa statistics (with 95% confidence intervals) for the SSO data are presented in Table 1. Levels of