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Development and deployment of the Computer Assisted Neighborhood Visual Assessment System (CANVAS) to measure health-related neighborhood conditions

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ABSTRACT

Public health research has shown that neighborhood conditions are associated with health behaviors and outcomes. Systematic neighborhood audits have helped researchers measure neighborhood conditions that they deem theoretically relevant but not available in existing administrative data. Systematic audits, however, are expensive to conduct and rarely comparable across geographic regions. We describe the development of an online application, the Computer Assisted Neighborhood Visual Assessment System (CANVAS), that uses Google Street View to conduct virtual audits of neighborhood environments. We use this system to assess the inter-rater reliability of 187 items related to walkability and physical disorder on a national sample of 150 street segments in the United States. We find that many items are reliably measured across auditors using CANVAS and that agreement between auditors appears to be uncorrelated with neighborhood demographic characteristics. Based on our results we conclude that Google Street View and CANVAS offer opportunities to develop greater comparability across neighborhood audit studies.

As research investigating the influence of neighborhood conditions on individual outcomes proliferates, the need for methods to efficiently measure theoretically relevant aspects of neighborhood environments has increased (Cummins et al., 2005; Brownson et al., 2009; Saelens and Glanz, 2009). Systematic audits of neighborhood environments represent one of the most adaptable tools available to measure neighborhood features reliably (Pikora et al., 2002; Reiss, 1971; Sampson and Raudenbush, 1999). The adaptability of neighborhood audits (also called systematic social observations) comes from the fact that researchers define pertinent aspects to measure based on theories about how neighborhoods affect health.

Researchers' ability to define their own measures provides a unique advantage of neighborhood audits compared to the georeferencing of existing administrative data that are collected for purposes other than research. Administrative sources often do not contain measures of neighborhood features thought to affect health or the measures do not correspond well to neighborhood features thought to affect health. Using neighborhood audits, researchers create an instrument containing items they deem relevant to observe, train auditors how to observe those items, and then record observations of those items in neighborhoods across their study area. The systematic nature of the data collection allows researchers to use standard statistical techniques to construct scales and model potential influences of neighborhood attributes on individual outcomes (Mujahid et al., 2007; Raudenbush and Sampson, 1999). Systematic neighborhood audits have been used in several fields including criminology (Perkins et al., 1990; Reiss, 1971; Taylor et al., 1984), sociology (Raudenbush and Sampson, 1999; Sampson and Raudenbush, 1999), urban design and planning (Ewing et al., 2006), and public health (Clifton et al., 2007; Pikora et al., 2002).

Most neighborhood audits have been conducted with raters visiting streets in person, an expensive undertaking that limits the use of neighborhood audits and hinders the generalizability

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of studies beyond relatively small geographic areas. Consequently, most systematic neighborhood audits have been limited to areas no larger than a single city or metropolitan area, frequently those in which the researchers reside. An early adaptation to overcome the problem of sending raters to the field used video cameras mounted to trucks that tape-recorded while being driven down Chicago streets (Sampson and Raudenbush, 1999; Raudenbush and Sampson, 1999; Earls et al., 1995). Auditors then coded neighborhood conditions by viewing the videos. Video recording improved reliability because auditors coded streets in a central facility and reduced costs by eliminating travel time of auditors to streets (Carter et al., 1995). At the same time, video recording presented logistical obstacles including equipment malfunction and correctly identifying segments to ensure ratings were assigned to the appropriate location (Carter et al., 1995).

One of the most promising advances in neighborhood research has been the validation of neighborhood audits using Google Street View, which provides still imagery free of charge for streets in much of the United States. Recent studies have shown that “virtual audits” done using Google Street View have acceptable levels of concurrent validity and inter-rater reliability while eliminating geographic constraints imposed by travel costs and field logistics (Anguelov et al., 2010; Badland et al., 2010; Clarke et al., 2010; Curtis et al., 2010; Odgers et al., 2012; Rundle et al., 2011; Vargo et al., 2011; Wilson et al., 2012).

The promise of systematic neighborhood audits rests not only with ensuring valid and reliable data *within* a study, but also ensuring valid and reliable data that can be compared *across* studies. To date, the inconsistency of measurement across sites has meant that neighborhood audits have not lived up to their promise (Brownson et al., 2009). Google Street View audits are uniquely capable of overcoming inconsistency because of Google Street View’s large geographic reach, consistent method of image acquisition, and existing integration with geographic information systems. The tool described in this paper, the Computer Assisted Neighborhood Visual Assessment System, or CANVAS, is an online application with an efficient and user-friendly interface built around Google Street View that allows researchers to deploy audits and manage data collection using Street View. The primary contribution of CANVAS is that it supports the development of large-scale, generalizable studies of neighborhood effects by improving the efficiency and quality of data collection using the secondary data offered by Google Street View. In this paper we describe the development and features of the CANVAS software and report the results of a virtual field test that measured walkability and physical disorder on a nationwide sample of street segments. We assessed rating times, inter-rater reliability, and potential measurement bias on 187 items.

1. Methods

1.1. *Development of the Computer Assisted Neighborhood Visual Assessment System*

Here we describe the Computer-Assisted Neighborhood Visual Assessment System (CANVAS) web-based software application, including a summary of the technical specifications and design features for study managers. Three priorities guided the design and implementation of CANVAS. The first was to reduce measurement error due to controllable factors such as auditors rating the wrong street, misinterpretation of the question wording, or inconsistent application of rating instructions. The second was to create a system that allows study managers with limited technical knowledge to deploy and oversee data collection. The last was to develop a standard set of data collection protocols and items covering a variety of domains for use by researchers.

We developed an initial prototype for CANVAS using a combination of Google Forms, a simple computer gateway interface (CGI), and the Google Maps application programming interface (API). High school interns used this prototype to rate streets in New York City during the summer of 2009. This prototype served as a proof of concept, but revealed the necessity of an integrated web framework for efficient and reliable data collection. The CANVAS application was built using version 1.4 of the Django web framework (Django Software Foundation, 2012) with a MySQL version 5.1 database (MySQL AB, 2005). Compared with the prototype, CANVAS improved the integration of the interfaces for auditors and study manager and allowed programming of item skip patterns, grouping of related questions into modules, and inclusion of on-screen help for auditors. The authors and four interns – three undergraduates and one graduate student – tested and critiqued the usability of the new version of CANVAS both for data collection and for study administration. Revisions based on these critiques were incorporated into CANVAS and the system was used in the data collection reported below.

1.2. *Items rated*

Items included in CANVAS were adapted from several existing audit instruments. We began by incorporating the full inventory of items in three existing audits, the Irvine-Minnesota Inventory (Day et al., 2006), the Pedestrian Environment Data Scan (PEDS, Clifton et al., 2007), and the Maryland Inventory of Urban Design Qualities (MIUDQ, Ewing et al., 2005, 2006). We also incorporated select items related to physical disorder from two other inventories, the systematic social observation of the Project on Human Development in Chicago Neighborhoods (Carter et al., 1995; Sampson and Raudenbush, 1999) and the New York Housing and Vacancy Survey (U.S. Bureau of the Census, 2011). We edited the list to reduce redundancy as well as items not measureable using imagery (e.g., noise).

In addition to the items measuring features of the neighborhood environment, we developed a series of items to evaluate image quality and the prevalence of obstructions blocking views of the sidewalk. The goal of this module was to assess aspects of street imagery that might affect reliability. Unlike neighborhood audit measures, this module had no in-person analog and so had not previously been pilot tested. This module included the zoom level at which the auditor first perceived pixelation, the camera technology used [‘bright’ (high-resolution) or ‘dark’ (low-resolution)] (Anguelov et al., 2010), and the legibility of street signs on the segment (clear/blurry/unreadable), as well as the total length of the segment in “steps” (mouse clicks needed to advance along the entire segment) and the number of those steps for which the view was obstructed.

The resulting inventory contained 187 items. To increase the efficiency of rating, we included skip patterns so that auditors would not be required to spend time entering redundant results. For example, auditors were asked if there were any commercial uses on the block; if they answered “no,” then they were not asked to rate whether specific kinds of commercial land use were present. This reduced auditor burden and increased rating speed.

1.2.1. *Study deployment interface*

The CANVAS study deployment interface allows researchers to designate the street locations to be audited, designate the audit items to be rated, and assign street segments to auditors. Locations can be identified in either ‘manual-confirm’ mode or ‘auto-select’ mode. In manual-confirm mode, study directors upload a CSV file listing pairs of longitude and latitude values representing the start