Measures Registry User Guide: Physical Activity Environment

Jordan Carlson, PhD • Kelsey Dean, MS, RD, LD, CCRP • James Sallis, PhD

NATIONAL COLLABORATIVE ON CHILDHOOD OBESITY RESEARCH

Suggested citation:

Carlson, J. Dean, K. Sallis, J. Measures Registry User Guide: Physical Activity Environment. Washington (DC): National Collaborative on Childhood Obesity Research, January 2017. http://nccor.org/tools-mruserguides/wp-content/uploads/2017/NCCOR_MR_User_Guide_Physical_Activity-FINAL.pdf.

NCCOR
National Collaborative on Childhood Obesity Research

Measures Registry User Guide: Physical Activity Environment

Table of Contents

Acknowledgments

NCCOR gratefully recognizes The JPB Foundation for funding the development of the Measures Registry User Guides. NCCOR also extends its sincere thanks to the NCCOR Steering Committee, NCCOR Members, and the following individuals for their contributions to the Guides.

Authors

Individual Diet

- Sharon Kirkpatrick, PhD, MHSc, RD
- Amanda Raffoul, MSc

Food Environment

- Leslie Lytle, PhD
- Allison Myers, PhD, MPH

Individual Physical Activity

- Gregory Welk, PhD
- James Morrow, PhD, FACSM, FNAK
- Pedro Saint-Maurice, PhD

Physical Activity Environment

- Jordan Carlson, PhD
- Kelsey Dean, MS, RD, LD, CCRP
- James Sallis, PhD

Reviewers

Food and Nutrition Expert Panel

- Alice Ammerman, DrPH, RD
- Carol Boushey, PhD, MPH, RD
- Karen Webb, PhD, MPH
- Gail Woodward-Lopez, MPH, RD

Physical Activity Expert Panel

- Genevieve Dunton, PhD, MPH
- Patty Freedson, PhD
- Brian Saelens, PhD

Measures Registry User Guide Project Team

NCCOR Members

- Rachel Ballard, MD, MPH
- David Berrigan, PhD, MPH (co-lead)
- Stephanie George, PhD, MPH
- Jill Reedy, PhD, MPH, RD (co-lead)

NCCOR Coordinating Center

- LaVerne Canady, MPA
- Adee Kennedy, MS, MPH
- Todd Phillips, MS
- Anne Rodgers
- Amanda Samuels, MS, MPH
- Namita Vaidya, MPH

We would also like to thank Seung Hee Lee-Kwan, PhD, MS; Latetia Freeman Moore, PhD, MSPH; Sohyun Park, PhD; Jesus Soares, ScD, MSc; and Tina Kauh, PhD, for reviewing the final draft of the Guides.

1

Introduction

SECTION 1

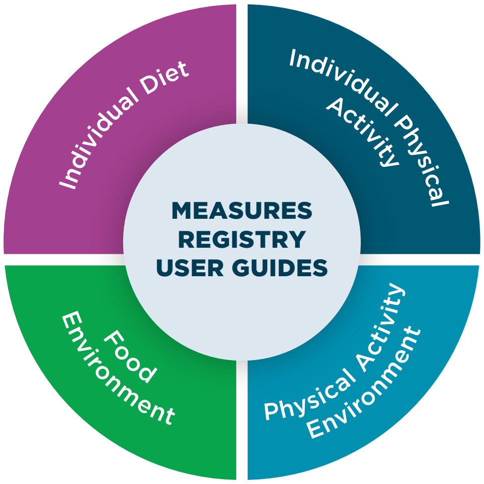
Introduction

Measurement is a fundamental component of all forms of research and it is certainly true for research on childhood obesity. A top priority for the National Collaborative on Childhood Obesity Research (NCCOR) is to encourage consistent use of high-quality, comparable measures and research methods across childhood obesity prevention and research.

NCCOR's Measures Registry—a free, online repository of articles about measures—helps achieve this aim. It is widely recognized as a key resource that gives researchers and practitioners access to detailed information on measures in one easy-to-search location. The Registry's measures focus on four domains that can influence childhood obesity on a population level:

- Individual Diet
- Food Environment
- Individual Physical Activity
- Physical Activity Environment

Figure 1: NCCOR Measures Registry User Guides



Even with this resource, however, it can be challenging for users to choose the most appropriate measures for their work. To address this need, NCCOR began the Measures Registry User Guides project in 2015. Organized by the same four domains as the Measures Registry, the User Guides are designed to provide an overview of measurement, describe general principles of measurement selection, present case studies that walk users through the process of using the Measures Registry to select appropriate measures, and direct researchers and practitioners to additional resources and sources of useful information (Figure 1). The User Guides will help move the field forward by fostering more consistent use of measures, which will allow for standardization, meta-analyses, and synthesis.

Overview of the Physical Activity Environment Measures Registry User Guide

The overall goal of this User Guide is to help users of the NCCOR Measures Registry make informed decisions when selecting, processing, and interpreting measurement tools for physical activity environments. This Guide is not intended to be a comprehensive summary of all measures, an evaluation of the measures, or a compilation of research using the measures. Instead, it fills a different niche by emphasizing the measurement issues that should be considered when selecting and using physical activity environment measures for research and practice purposes. This User Guide offers examples and tips for navigating the Measures Registry.

Organization of this User Guide

This Guide provides an orientation to physical activity environment assessment methods, by setting, and discusses considerations for selecting and using measures. It is designed to be useful for both researchers and practitioners, and includes case studies that show how both audiences can apply these considerations in practice.

In addition to this Introduction, this User Guide includes the following sections:

- Section 2. Assessing and Defining Physical Activity Environments provides a rationale for assessing physical activity environments and defines the key physical activity environment settings. Understanding the nature of these environments and the existing evidence will help users identify the most appropriate measures for the settings they wish to study.
- Section 3. Key Concepts in Physical Activity Environment Assessment describes the various methods of physical activity environment measurement across settings and other key concepts to consider when selecting environmental measures.
- Section 4. Evaluating Existing Measures provides an overview of the key measurement properties to consider when selecting environmental measures, including terminology, distinction between reliability and validity, single- vs. multi-item measures, response scales, and sensitivity to change.
- Section 5. Examples of Measures with Reliability and/or Validity Evidence provides examples of commonly used measurement tools with relatively extensive evidence of reliability and/or validity for assessing environments in various settings.
- Section 6. Selecting Measures outlines the process of selecting appropriate measurement tools for the given study population and research or evaluation aims. Additional considerations, such as resources required for data collection and analysis, are discussed, as are suggestions for using the Measures Registry.
- Section 7. Collecting and Reporting Data outlines methods and resources for successful and reliable data collection, including identifying local expertise, training staff, and deriving variables from the raw data.

NCCOR: WORKING TOGETHER TO REVERSE CHILDHOOD OBESITY

NCCOR is a partnership of the four leading funders of childhood obesity research: The Centers for Disease Control and Prevention (CDC), the National Institutes of Health (NIH), the Robert Wood Johnson Foundation (RWJF), and the U.S. Department of Agriculture (USDA). These four leaders joined forces in 2008 to continually assess the needs in childhood obesity research, develop joint projects to address gaps and make strategic advancements, and work together to generate fresh and synergetic ideas to reduce childhood obesity. For more information about NCCOR, visit www.nccor.org.

- Section 8. Case Studies of Selecting Measures use hypothetical study designs to illustrate decision making about measures based on the information in this Guide. Both practice- and research-based examples are given, as well as selection considerations depending on the project purpose, study population, and intended audience of the study.
- Section 9. Next Steps in Physical Activity Environment Assessment highlights gaps in physical activity environment research and makes recommendations to facilitate continued advances in this field.
- Section 10. Conclusion
- Section 11. Additional Resources on Physical Activity Environment Measurement highlights additional resources that can supplement the information in this Guide.
- References

2

Assessing and Defining Physical Activity Environments

Many factors influence whether or not a person engages in physical activity or meets the physical activity guideline of 150 minutes per week for adults and 60 minutes per day for youth. A vast body of research has shown that the built environment is a key determinant of physical activity, and the rationale and evidence behind this work are presented in this section.

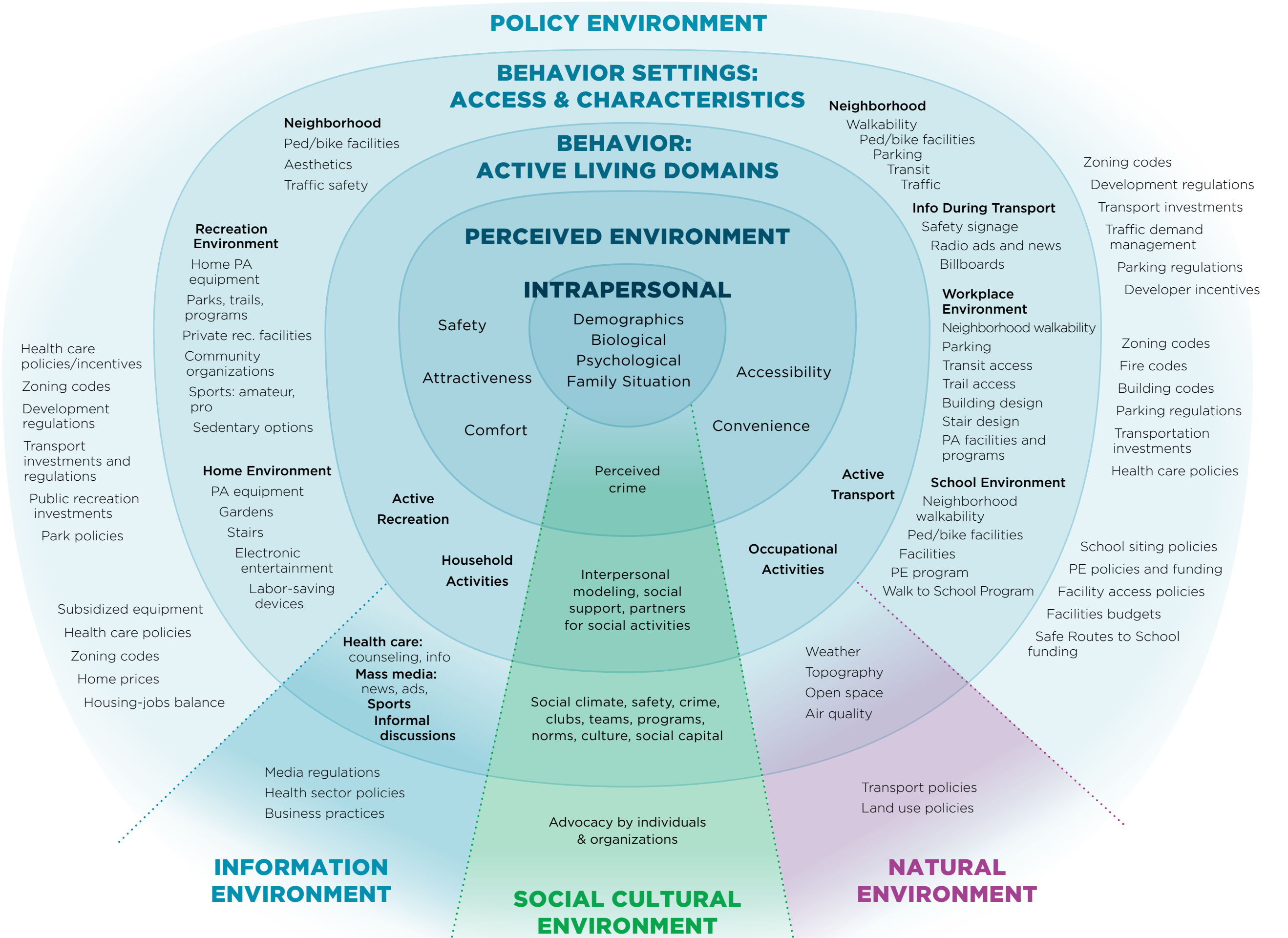
Why Study the Physical Activity Environment?

The Institute of Medicine,[1] Centers for Disease Control and Prevention,[2] National Physical Activity Plan,[3] American Heart Association,[4,5] and World Health Organization[6] all recommend interventions to change physical activity environments as a way to increase physical activity and reduce obesity in populations. The U.S. Surgeon General also emphasized the critical role of environments in the title and theme of the 2016 report *Step it Up! The Surgeon General's Call to Action on Walking and Walkable Communities*.[7] It is intuitive that some places are better than others for physical activity, but intensive study, mainly in the 21st century, has defined many environmental features that hold promise for increasing physical activity.

Many groups in communities across the United States and worldwide are working to create more activity-friendly environments. The goal of most of these efforts is to make it easier, safer, and more comfortable for people to choose to be physically active in their daily lives. It has become clear that different types of environments can be designed to facilitate different purposes, or domains, of physical activity. Well-designed parks, playgrounds, school grounds, trails, recreation centers, and health clubs can support leisure-time physical activity. Neighborhoods designed so people can walk to nearby destinations, along with safe facilities for pedestrians and bicyclists, can increase walking and bicycling for transportation. Buildings sited with access to public transit and multi-use trails, on-site walking paths, and designed with attractive stairs can encourage physical activity to, around, and in buildings. These environments are designed and managed by sectors of society outside of public health and medicine, including city planning, transportation, parks and recreation, architecture, landscape architecture, education, and private enterprise. Thus, researchers, practicing professionals, and policy makers in all of these sectors may be interested in measuring physical activity-related features of environments and be potential users of the physical activity environment measures in NCCOR's Measures Registry.

Theoretical models that guide research and practice and that are widely used in the childhood obesity field include the built environment as an important factor in influencing behavior. In particular, ecological models of behavior (Figure 2) are based on the idea that behavior is influenced by a range of factors at the individual (psychology, biology), social and cultural (norms, values, interactions), environmental (social and built), and policy (laws, regulations, practices) levels. The most effective interventions are expected to be those that operate at multiple levels.[8] For example, Safe Routes to School policies in transportation agencies can provide funding to improve sidewalks and street crossings near schools (environment level), support walking school buses and better enforcement of speed limits (social level), and deliver education programs to encourage walking and bicycling to school (individual level). A variety of measures are needed to evaluate the environmental, social, and individual changes produced by such multi-level interventions.

Figure 2: Ecological Model of Active Living



Source: Sallis, 2006[9]

Physical Activity Can Be Supported in Diverse Environments

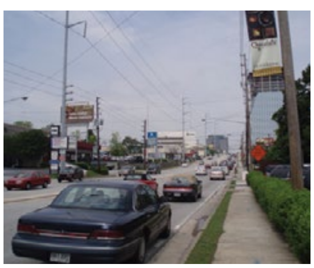
Multiple settings play an important role in overall physical activity, and many public health intervention recommendations are location-specific (e.g., school-based physical activity, home-based screen time, neighborhood walking).[10-12] In youth, key physical activity settings include neighborhoods, parks and recreation areas, schools, and homes.[13-18] Within each of these settings, the built environment can support or not support physical activity. Some environmental features have differential impacts on youth vs. adult physical activity, as highlighted in Section 3. In general, neighborhood community design factors that support physical activity include greater residential density, a mix of residential and commercial land uses, and access to schools, parks, and recreation facilities.[19-22] Neighborhood transportation system factors that support physical activity include street connectivity, cul-de-sacs (particularly as play areas for youth), bicycle infrastructure networks, and access to transit. Neighborhood streetscape features that support physical activity include safe street crossings, sidewalks, traffic speed bumps, and features that protect pedestrians from vehicles. Figure 3 contrasts commercial shopping areas that are designed around automobiles versus those designed with pedestrians in mind.[19,23] Schools that support physical activity typically have safe outdoor play spaces as well as comprehensive school physical activity programs that include ample physical education, recess, classroom activity, and before- and after-school activity.[24,25] Homes that support physical activity are those in which youth have ample access to play spaces and equipment and limited access to sedentary environments.[26-29] Measures exist for assessing environments in each of these settings, though some environments do not have good coverage from existing measures, as outlined in Section 5.

Evidence on Environments and Physical Activity

The literature on social and built environments as they relate to physical activity has grown rapidly, made possible by a sustained output of new measures, as documented in the NCCOR Measures Registry. Most of the evidence about environments and physical activity is cross-sectional, and though the studies and their findings have many inconsistencies, some findings show good agreement.[30] Among adults, walkability variables are supported as correlates of walking for transportation, and proximity to recreation facilities and neighborhood aesthetics are correlates of leisure-time physical activity. Total physical activity is related to recreation facilities, transportation facilities, and aesthetics. Similar associations have been found with children and adolescents, though less consistently. It is not possible to draw conclusions for older adults due to a paucity of studies. More prospective studies in adults and older adults are available now, also with inconsistent findings.[31] Critiques of physical activity and built environment research note that self-selection—the idea that people who like to walk choose residential areas that are walkable, for example—limits evidence of causality. However, several studies have assessed self-selection and neighborhood preferences and concluded that associations between built environment and physical activity are sometimes attenuated but remain significant after accounting for self-selection.[32,33] The large and long-term RESIDE study of people who relocated residences in Australia showed that changes in neighborhood environments were related to changes in physical activity (e.g., Hooper, 2014; Knuiman, 2014).[34,35] Studies evaluating "natural experiments," such as park improvements,[36] bicycle facilities,[37,38] and Safe Routes to School interventions,[39,40] have shown promising results that improve evidence of causality.

Recently, interest has been growing in how built environments are related to sedentary behavior, including both total sitting time and more specific measures, such as sitting at work and screen time at home. The most consistent environmental correlate of screen time among children is having a television in the bedroom.[41] A few studies of neighborhood walkability and sitting have been conducted, but results have been inconsistent.[42]

Figure 3: Commercial Shopping Areas Designed for Automobiles (Low-Walkable) vs. Pedestrians (High-Walkable)



Poor microscale design for pedestrians. Atlanta, GA.

Automobile-oriented road and shopping area. Anywhere, USA.

Pedestrian-only street. Boston, MA.

Streetscape with pedestrian improvements, such as curb extensions and street trees. Near Miami, FL.

Multiple Users Have Multiple Uses for Physical Activity Environment Measures

Researchers can use environmental measures to advance knowledge about environmental correlates (cross-sectional studies) and determinants (prospective studies) to explore equity in access to physical activity opportunities across socioeconomic classes and geographic areas, to document and evaluate environmental changes in intervention studies, and to evaluate the effect of policies designed to change built environments, such as Complete Streets, Vision Zero, and Safe Routes to School. Practitioners in many fields can use environmental measures to assess baseline conditions as part of planning processes and to evaluate their interventions. Policy makers can use environmental data to determine the need for community improvements, to target interventions and investments where they are needed most, and to assess the outcomes. Community groups can use environmental measures to provide data to support their advocacy for community enhancements. Information regarding how to select appropriate physical activity environment measures for each of these uses is presented in Section 6.

3

Key Concepts in Physical Activity Environment Assessment

The built environment can be measured at different levels, using different methods, and in various settings relevant to physical activity. Descriptions of these levels, methods, settings, and other key concepts are presented in this section. The main focus is on measures of environmental characteristics themselves. Related measures of how often a specific setting (e.g., park) is used, and measures of physical activity in a specific setting, such as a park, are discussed later in this section. Some measurement tools capture both environment characteristics and physical activity in the setting.

Levels of Built Environment Attributes

Physical activity environments are complex and can be measured at multiple levels that vary somewhat by the specific settings.

Macro-scale Attributes

"Macro-scale" attributes describe the layout of communities and include the concept of walkability. Walkability refers to the combination of mixed land use, moderate-to-high residential density, and high street connectivity that allows people to walk from home to common destinations, such as shops and schools. Proximity of parks, trails, bicycle networks (e.g., lanes, trails), and public transit can be considered macro-level attributes as well. Geographic information systems (GIS) are often used to capture these attributes when data are available; self-report measures also can assess these variables.

Micro-scale Attributes

“Micro-scale” attributes indicate the design of a setting and can affect the experience of being active or inactive in a given place. Streetscape attributes include presence, quality, and amenities of sidewalks; characteristics of street crossings, such as crosswalks and pedestrian signals; transportation variables, such as transit stops and signage, travel lanes, and speed limits; and aesthetic features of buildings and landscaping. Other micro-scale variables include activity zones and equipment for physical activity in parks and school yards; design of public spaces; characteristics of trail design; and attributes of buildings, including stairs. Micro-scale features are usually measured by direct observation (i.e., audits) and self-report, because they are not often available in GIS.

Social Attributes

A third level of measurement is mostly focused on social dimensions of the environment. Social environments are not well-defined, but commonly studied variables include people in the environment and evidence of people's behavior. Examples are indicators of social disorder such as graffiti, litter, and abandoned buildings; people walking or children playing; maintenance of park or playground equipment; crime; traffic density and speed; and programming and supervision in recreation areas. Social indicators are usually measured by direct observation or self-report.

Methods of Environmental Assessment

Environmental assessment tools fall into three categories based on their methodology and data collection procedures (see Table 1). Within the Measures Registry, specific measures falling within each of these methods of assessment can be isolated using the check boxes under the “Measure Type” subheading. The Measurement Types are:

- **GIS:** GIS-based measures, which involve archival data sets that are layered and analyzed within GIS software.
- **Environmental Observation:** Observational measures, which are obtained using systematic observational methods (audits).
- **Questionnaire:** Self- or proxy-reports of environmental features, which can be administered by paper-and-pencil questionnaire, computer or online survey, or interview.

Additionally, the Measures Registry includes Electronic Monitor, Record or Log, and Other as modalities of environmental measures. The Electronic Monitor section includes studies that used Global Positioning Systems (GPS) to assess participants' locations. The Record or Log and Other sections include some observational audit measures as well as direct observation measures of physical activity within specific settings (e.g., System for Observing Play and Recreation in Communities [SOPARC]). These measurement types are not covered in detail here because they are described in the Measures Registry User Guide: Individual Physical Activity.

DEFINITIONS OF WALKABILITY

Walkability is a relatively new concept that has been defined in several ways. Definitions from the transportation field often focus on macro-level variables that create an opportunity to walk to destinations,[43] whereas other definitions capture macro-scale, micro-scale, and even social features. In the 2016 Surgeon General's Call to Action on Walking and Walkable Communities, a walkable community was broadly defined as a community where it is safe and easy to walk and where pedestrian activity is encouraged.[7,44]

GIS-based Measures

GIS is a software system (rather than a measure itself) used for integrating and analyzing spatial and geographic data. GIS-based environmental measures are typically derived from existing databases, and these data sources are continuously evolving. Data collected through observations and questionnaires also can be integrated into GIS if they are spatially specific. Data in GIS need to have spatial reference, such as parcel or road database shapefiles. Existing databases are available from multiple sources, such as regional transportation planning agencies, local municipalities, and ongoing surveillance surveys (e.g., American Community Survey, U.S. Census). From this existing information, built environment measures that could be related to physical activity are computed.[45,46] For example, road network spatial databases (i.e., shapefiles) can be obtained from many regional transportation planning agencies or local municipalities and used to calculate the number of street intersections within a defined neighborhood or area. The GIS measures in the Measures Registry are simply variable computations performed in GIS that have been used in physical activity research. Many of the publications listed in the “Results” view of the Measures Registry include multiple GIS-derived variables (see Section 6 for suggested process for using the Measures Registry).

Advantages of GIS-based measures are that they rely on (relatively) objective data and are easy to derive for large samples by someone with GIS software expertise. Disadvantages of GIS-based measures are that they are limited to community design (land use) and transportation system information. Data often do not exist for home, school, streetscape, and micro-level (i.e., interior) parks and recreation features. However, data collected in these settings can be integrated into GIS. Using GIS-based measures can be difficult. GIS-based projects often require collaboration with geographers or transportation or public affairs experts. Although GIS-based data on traffic, crime, sidewalks, and crossings exist in some areas, data can vary in quality, completeness, recency, and availability across jurisdictions. The way that data, such as crime data, are recorded across jurisdictions also can vary, making it difficult to compare and pool data across geographic areas. The quality of available GIS data should not be assumed.

Observational Measures

Observational measures, or audit tools, involve systematic observation of an environment, typically by trained research staff or community stakeholders. Good audits tools are accompanied by a manual with well-defined construct definitions and observer training procedures that result in acceptable inter-rater reliability. Audits exist for assessing micro-level streetscape, home, school, park, and recreation center features. In neighborhoods, audits can provide useful information that is not captured in GIS databases, such as availability of crosswalks and duration of pedestrian crossing signals. Audits can be favored over self-reported measures because the former provide more objective, detailed, and place-specific data than self-reported participant or informant perceptions.

Observational measures require substantial time and resources because trained observers must visit each environment being assessed. Although evidence is accumulating to support the validity of conducting observations remotely, such as through Google Earth and Google Streetview,[47-49] these methods still require significant time and resources and extensive training of coders. Another limitation of audits is that they have poorer validity for capturing transient and subjective constructs, such as aesthetics or social disorder, because they are typically only conducted at one point in time. Audit measures must be processed and scored, which is a burden on users, and some measures do not have well-developed scoring procedures.

Audit tools serve several important purposes outside of research. They can be used to engage and educate community members about the impacts of environments on health. These tools are also useful for conducting needs assessments to inform local decision making and advocacy. Audit tools can point to specific environmental changes to target, including more modifiable micro-level features (e.g., sidewalk quality) than can be identified through GIS-based measures, which capture constructs that can take decades to change (e.g., street layout). For example, audits are often used by community advocacy groups to identify needed sidewalk and street-crossing improvements.

Questionnaires and Environment Perceptions

Questionnaires are commonly used in physical activity environment assessment and include participant-report and proxy-report tools. Proxy-reports involve the questionnaire being completed by someone other than the participant themselves, such as a parent, key informant, or school staff member. Most questionnaires in the Measures Registry ask participants to report on objective facts, such as presence of sidewalks, proximity to parks, and physical activity equipment in parks, schools, or homes. Objective indicators of aesthetics can even be reported, such as amount of greenery, views, and how well buildings are maintained. Some questionnaires ask participants to evaluate the quality of environments. Examples include perceived safety from traffic, attractiveness of parks, and comfort level while walking in the neighborhood. Self-report questionnaires are the only way to assess perceptive evaluations of the environment, which often do not align with objective measures of the environment.[50] One reason for the misalignment is when a participant's level of awareness of the environment does not reflect actuality (e.g., distance, access to amenities/facilities). Another reason for misalignment relates to the value placed on the environmental attribute, such as safety or aesthetics, which can differ across participants rating the same environment.

Questionnaires range in length, with some using single items and others using multi-item scales to capture various constructs. They frequently use Likert response scales, such as 4- or 5-point scales, with response options ranging from "strongly disagree" to "strongly agree." Tools that capture the presence or absence of environmental attributes often use tallies or checklists of available resources. Tools that capture value-based perceptions of environmental attributes, such as safety and aesthetics, typically use Likert response scales (e.g., agree vs. disagree). The Neighborhood Environment Walkability Scale (NEWS) is an example of a questionnaire whose scales include reporting of both objective features and evaluative perceptions,[51] whereas the sedentary environment module of the Physical and Nutritional Home Environment Inventory is an example of a tally/checklist that can be completed with a good level of objectivity.[52]

Questionnaires are commonly used because meaningful environmental information can be captured with few resources and little burden to the researcher or practitioner. Questionnaires are useful for capturing information that is difficult to assess when GIS and audit data do not exist or are difficult to capture. Evidence from perceived environment measures has shown that perceptions often have small associations with objective measures, yet the former are important for understanding physical activity over and above objective environment characteristics.[53-55] Thus, many studies find it beneficial to include both perceived and objective environment measures. Limitations to questionnaires include participant burden, the potential for low response rates, and floor or ceiling effects. Floor or ceiling effects can occur when the majority of participants respond at the bottom or top of the response scale and thus result in limited variability and power for detecting associations.

Proximity, Accessibility, and Quality of Environmental Attributes

Distinguishing between measures of proximity, accessibility, and quality is important when assessing environments. Proximity refers to the presence, absence, or distance to an environmental feature. For example, having a greater number of parks in the neighborhood and a shorter distance to the nearest park have been associated positively with physical activity in youth.[19,56] Accessibility refers to the ease of getting to the feature. For example, a park could be nearby, but a highway or dangerous intersection between the neighborhood and the park reduces accessibility. Accessibility can be affected by the street network, with a connected grid allowing direct access and a disconnected suburban-style network creating a long, indirect pathway. Quality involves rating existing features on attributes such as aesthetics, appeal, condition, ease of use, or safety. The Environmental Assessment of Public Recreation Spaces (EAPRS) tool, for example, can be used to capture ease of access, cleanliness, colorfulness, condition, and comfort of park facilities.[57] Similarly, the school audit tool by Jones et al. covers quality attributes such as aesthetics, design, maintenance, and suitability for physical activity of the external grounds of the school.[58] GIS-based measures are mainly used to assess proximity through the mixture of land uses in community design and accessibility through the connectivity of the transportation system. Many audit tools and questionnaires capture proximity, accessibility, and quality.

Measurements Using Specific Environments and Physical Activity in Specific Environments

Researchers and practitioners sometimes desire to assess people's use of specific environments (e.g., whether or how often a park is used), or physical activity levels within specific settings (e.g., how much activity occurs in parks). This information can be used to better understand where physical activity occurs, how exposure to different environments may influence physical activity, or how characteristics of a setting are related to physical activity in that setting. Although measures of use of specific environments and physical activity in specific environments are not directly part of environmental assessment, they are sometimes assessed in conjunction with environmental variables. Specific measures that fall under this category are presented at the end of Section 5, and examples include questionnaires, observational measures, and GPS.

Considerations for Youth

The Measures Registry includes measures relevant for both youth and adults. The "Age" subheading can be used to narrow the number of measures in the "Results" view based on age group. The following factors should be considered when selecting a measure that is specifically relevant for youth.

Environmental Correlates Unique to Youth

Youth-specific measures and evidence should be considered when youth are the focus of study. Some evidence suggests that the community design and transportation environments sometimes have differential associations with physical activity in youth versus adults. For example, greater intersection density and street connectivity have been fairly consistently positively related to walking for transport purposes in adults and youth.[19,59,60] However, presence of cul-de-sacs, a street design feature indicative of lower street connectivity, has been positively related to recreational physical activity in youth, likely because these features serve as important low-traffic play areas for youth.[19,27,61-64] Recreation environments also may be more important for understanding physical activity in youth versus adults.[19,27,61,63] School environments are clearly more important for youth than for adult physical activity.[65] Less is known about differences in the importance of environmental attributes in other settings between youth and adults, but in addition to consideration of study purpose, the study population should be kept in mind when selecting appropriate measures.

Self-reporting in Youth

Although self-reports have seen vast use in adults, they are used less commonly in children. This is because young children have difficulty with comprehension and/or may not have sufficient knowledge of their environments. No specific age cutpoint has been established for when self-reports become appropriate, but self-reports of young adolescents can produce comparable results to parent reports.[66] When assessing environments in younger children, questionnaires can be completed by parents or other proxy reporters.

4

Evaluating Existing Measures

A tool's measurement properties should always be considered when evaluating the acceptability of a measure. The most important properties to consider, namely the tool's reliability and validity, as well as other relevant measurement properties, are described in this section. Each measure and publication in the Measures Registry includes a tab that provides detailed information on the measure's reliability and validity, when available.

Reliability and Validity

Reliability refers to the consistency with which something is measured, whereas validity refers to the accuracy with which the measure captures the construct to be measured. Validity can be further broken down into criterion validity, which is when the tool is compared to a gold standard measure of the same construct (i.e., truth), and construct validity, which is when the tool is positively correlated with a measure of a theoretically-related construct. For example, we expect neighborhood walkability to be positively correlated with physical activity, especially active transportation. The types of reliability and validity that are relevant to built environment assessment differ across the methods of assessment. Acceptable measures would ideally have evidence of both reliability and validity, although in environmental research it can be difficult (e.g., with GIS) or unnecessary (e.g., with direct observation and environmental perceptions) to assess criterion validity because of the lack of gold standard comparison measures. Thus, many environmental measures rely on evidence of reliability (i.e., do raters agree with each other and is the same respondent consistent over time), face validity (i.e., is the measure perceived by experts as consistent with the concept it is intended to measure), and construct validity (e.g., is the measure related as expected to physical activity) to evaluate their quality or utility.

GIS-based Measures

A primary component comprising reliable GIS-based measures is that variable computations should be replicable by multiple analysts (see Section 7 for more detail on variable computations).[67,68] Few existing measures provide this evidence, but this type of inter-rater reliability can be maximized by using well-defined variables and a detailed scoring protocol. Another key component of reliability of GIS-based measures is temporal match, which refers to the match between the time period when the GIS data were collected and the time period when other variables (e.g., participant physical activity) were collected. Ideally, the GIS and participant variables would be collected within one year of one another. Although GIS variables can be stable over multiple years, some areas can change rapidly, such as those undergoing redevelopment, so local knowledge of the area is useful. A poor temporal match would make GIS variables that change rapidly less useful for explaining physical activity. Criterion validity in GIS-based measures is primarily affected by the completeness and accuracy of the GIS databases used. Unfortunately, it is often impossible to know whether errors exist in public geodatabases, and evidence is lacking on how data incompleteness and inaccuracies affect physical activity research. It is important to investigate the quality of the data source when possible; for example, by directly observing a small sample of GIS variables to determine accuracy. Construct validity is important and relevant to GIS-based measures, with the key consideration being that variables used should have evidence or rationale for associations with physical activity. Evidence of construct validity can be found in reviews of built environment and physical activity research.[19,30,59]

Observational Measures

Inter-rater reliability is the most commonly assessed measurement property of observational measures and is a critical component in determining a tool's quality. Inter-rater reliability involves multiple raters completing the audit tool for the same locations independently and comparing their responses for discrepancies. This is typically done for a sample of at least 30 to 40 instances of the environment being captured (e.g., street segments). Key metrics to consider include percent absolute agreement, Kappa for use with yes/no checklist audits and categorical data,[69] and intraclass correlation coefficients (ICCs) for use with continuous responses (e.g., 1-5 Likert scales).[70] Commonly used thresholds to represent good percent agreement are ≥80 percent, and for Kappas and ICCs ≥0.80; Kappa and ICC values between 0.60 and 0.80 are often considered acceptable.[69] It is important to note that a measure cannot have acceptable validity if it does not have acceptable inter-rater reliability.[71] Criterion validity testing of observational measures is not typically necessary because direct observation is considered a gold standard objective method. Construct validity is commonly assessed for observational audits, and tools or constructs that have shown associations with participants' physical activity are interpreted to have good construct validity.

Questionnaires

The primary measurement property needed to support questionnaires is test-retest reliability, which involves administering the tool to the same participants at two time points, such as two weeks apart. Similar to inter-rater reliability, percent agreement, Kappa statistics, and ICCs are used to interpret reliability.

Criterion validity can be assessed for presence or absence and tally-based report measures by comparing a participant's responses to the same tool completed by a researcher using an observational audit, but this is not commonly done. Criterion validity is not typically assessed for perceptive evaluation report measures because evaluations are subjective and do not have a gold standard comparison. Similar to observational measures, construct validity should be established by testing associations with physical activity. Users also should note whether the measurement properties were established in a similar population as the user intends to study. When using a questionnaire in a new population or comparing across populations, the measure would ideally have evidence of invariance across subgroups (e.g., the measure performs similarly in men and women).[72]

Single Items, Scales, and Indices

Measure developers have used a variety of methods to reduce measures with many items to a small number of scales and indices. However, there is a trade-off between greater feasibility but lower reliability and validity of shorter scales or single-item indicators. Both indices and scales can be used to reduce a large number of variables to a small number of useful metrics. Although the terms "scale" and "index" are sometimes used interchangeably, they have differences. Scales comprise inter-related items capturing a narrow (usually unobservable) construct, typically a perception or attitude. One advantage of scales is that they often improve reliability over single items. In contrast, items comprising an index do not need to be inter-related and often capture a broad concept. Environmental measures typically assess a wide range of features, but consensus is growing that no single feature is the most important for physical activity. One advantage of indices is that they can be used to investigate additive effects of single items or features, particularly when composed of a sum of dichotomous items. A growing number of studies show that multi-item indices are most strongly related to physical activity outcomes.[60,64]

GIS-based Measures

Walkability indices, which involve a composite score derived from multiple environmental attributes, are commonly used in GIS-based measures. Such indices can be computed by summing dichotomous (e.g., yes = 1, no = 0) variables across a number of environmental attributes. For example, a neighborhood that has connected streets (1), access to shops and restaurants (1), and low residential density (0) would have a score of 2 on an index ranging from 0-3. When creating indices from continuous variables representing different units of measurement, a common procedure is to transform each indicator or attribute score into a standardized z-score based on the sample mean and then take a sum or average across the z-scores to derive the index (e.g., Frank's walkability index).[43] These indices are advantageous because they can reduce a large number of variables to a manageable number of metrics and represent the combination of attributes sometimes viewed as more important than any single attribute. Another reason to use scales and indices is that environmental variables often are correlated with each other. Because components of walkability can be inter-correlated, it is sometimes not possible to include all components in the same analytic model. Running models with one walkability component at a time will underestimate associations with outcomes, but the multi-component index should yield a more accurate estimate of the association of the pattern of the built environment with the outcome. Limitations of walkability indices are that one variable may be unknowingly driving an association, and the metrics are difficult to interpret outside of the area or region used to generate the standardized scores. Thus, single variable attributes with easily interpretable metrics (e.g., number of intersections per square km, used to capture street connectivity) are sometimes more desirable for planning and decision making than are indices.

Observational Measures

Indices lend themselves well for use in observational assessment, given that many features are rated dichotomously (e.g., presence or absence), but indices are unfortunately underused in this area. The Microscale Audit of Pedestrian Streetscapes (MAPS) is an example of an observational tool that uses indices.[64] Indices can be used in observational measures in the same manner as in GIS-based measures and should be considered by users.

Questionnaires

Many questionnaires include multiple scales to group items according to specific attributes. For example, a perceived safety from traffic scale may include items covering perceptions of sidewalks, street crossings, traffic volume, and traffic speed, each rated on a Likert response scale. This type of data reduction simplifies analyses and can improve reliability properties of the measure. A disadvantage of scales is that multiple items are needed to assess each construct, so measures assessing multiple constructs can become lengthy. Some tools, such as the Physical Activity Neighborhood Environment Scale (PANES),[73] use one or two items to assess a construct and cover multiple constructs. Such tools can have acceptable measurement properties and should be considered when survey length is a concern, but in general, reliability properties are most favorable when multiple items are used to assess each construct.

Other Measurement Issues

Response Scales

Response scales are used in both questionnaires and observational measures. Response scales in environmental assessment tools typically include anywhere from 2 (e.g., yes/no) to 10 or even more response options. Likert-type response scales can include three or more response options, with all or some options including anchor points, such as “none,” “some,” and “many” or “strongly agree” and “strongly disagree.” Anchors need to be balanced so that the intervals between every two sequential numbers are roughly equivalent. Response scales that include an odd number of response options often include a “neutral” or middle category, which can be problematic if responses will later be dichotomized (e.g., agree vs. disagree). An advantage of continuous response scales is that they typically result in greater variability and thus provide more power for detecting associations than dichotomous response scales. However, dichotomous response scales such as yes/no and agree/disagree are more easily interpretable and sometimes sufficient.

Stability vs. Sensitivity to Change

Measures that have good inter-rater or test-retest reliability focus on environmental attributes that are stable and show little change over short time periods. Although these traits are beneficial for establishing reliable measures, such tools may have limited use for assessing changes over time, such as evaluating interventions. GIS-based measures, in particular, have low sensitivity to change or have not yet been evaluated for sensitivity to change because macro-level community design features can require several years or even decades to change. For example, changes to increase population density or mixed land use within a neighborhood dominated by single-family homes would require significant policy changes and extensive redevelopment.

Although most observational measures and reports are generally not designed specifically to capture constructs that change over time, some may be useful for assessing changes over somewhat longer periods of time (e.g., ≥1 year) or when interventions target the constructs being assessed. For example, a cross-walk audit tool could be useful for capturing changes if an intervention specifically targets cross-walk improvements. If the user’s goal is to assess changes over time, special consideration is needed when identifying appropriate measures. Development of a new measure or new items for an existing measure may be needed to evaluate changes in the specific variables targeted by interventions. In some situations, it may be beneficial to use mixed-methods (i.e., both qualitative and quantitative data) to capture environmental changes. For example, a key informant with knowledge of the area and/or environmental changes could be interviewed to provide additional information on the environmental changes and the process by which they were achieved.

5

Examples of Measures with Reliability and/or Validity Evidence

SECTION 5

This section highlights a sample of physical activity environment measures included in the Measures Registry for each setting and method that have evidence for reliability and/or validity. It is important to note that this information is not based on a systematic review, and other measures not listed here also have strong measurement properties. Table 1 lists examples of physical activity environment measures by method and setting.

GIS-based Measures

Community Design and Transportation System

GIS-based community design variables with evidence of construct validity include residential density, land use mix, and access to parks and recreation facilities. Transportation variables include street connectivity and access to transit. Walkability indices with evidence of construct validity include those by Cervero and Kockelman,[74] Ewing et al.,[75] and Frank et al.[76] The latter index involves a summation of z-score variables, whereas the other two indices are computed using principal components analysis. Brownson et al. provide a detailed list of GIS-based variables and associated data sources.[68] Walk Score is an example of an index with evidence of validity, but it is unique in that walkability scores are provided on a publicly available website free of charge. The user simply types in an address, and a Walk Score ranging from zero to 100 is provided. The Walk Score takes into account distance to amenities such as schools, parks, businesses, and other common destinations, as well as measures of street connectivity and residential density.[77] The Walk Score creators have made an effort to align their algorithm with academic research, and several studies have found that Walk Score correlates well with measures of street connectivity, residential density, density of retail destinations, and access to other destinations.[78-80] However, limited evidence exists regarding associations between Walk Score and physical activity, and validity of other metrics provided by Walk Score, such as Bike Score, Transit Score, and Crime Grade.

Observational Measures

Streetscapes

Streetscape audit tools with evidence of reliability and validity include the Microscale Audit of Pedestrian Streetscapes (MAPS),[81] Systematic Pedestrian and Cycling Environment Scan (SPACES),[82] Irvine-Minnesota Inventory (IMI),[83] and Pedestrian Environment Data Scan (PEDS).[84] MAPS includes a comprehensive scoring system, a limitation of other tools,[81] as well as a short version designed for practitioners.[85] Some streetscape audit tools were designed for specific settings, such as around schools (e.g., Texas Childhood Obesity Prevention Policy Evaluation School Environmental Audit Tool),[86] and worksites (e.g., Workplace Walkability Audit),[87] and in street alleys (e.g., Systematic Pedestrian and Cycling Environmental Scan for Alleys [SPACES for alleys]).[88]

Trails, Parks, and Recreation

The Path Environment Audit Tool (PEAT) has evidence of reliability and validity for assessing trails.[89] Park assessment tools with evidence of reliability and validity include the Environmental Assessment of Public Recreation Spaces (EAPRS)[57] and Community Park Audit Tool (CPAT).[90] Both are comprehensive, but CPAT may be more feasible for use by practitioners. The Physical Activity Resource Assessment (PARA) can be used to assess trails, parks, and recreation areas, and has the advantage of being brief and easy to complete.[91] A more comprehensive tool for assessing recreation environments is the Recreation Facility Audit Tool (REFAT), which was adapted from the PARA and has evidence of construct validity.[92]

Table 1: Examples of Commonly Used Built Environment Measures with Evidence of Reliability and/or Validity

	METHOD OF ASSESSMENT		
SETTING	**GIS**	**OBSERVATION**	**QUESTIONNAIRE**
Community design Transportation system	Indices developed by Cervero and Kockelman, Ewing et al., Frank et al., and Walk Score		Neighborhood Environment Walkability Scale (NEWS) Neighborhood Physical Activity Questionnaire (NPAQ) Physical Activity Neighborhood Environment Scale (PANES)
Streetscapes	(Microscale features are not often available in public databases, so few GIS measures have been developed. However, data from observational measures can be entered into GIS. The same issues apply to the settings below.)	Irvine-Minnesota Inventory (IMI) Microscale Audit of Pedestrian Streetscapes (MAPS) Pedestrian Environment Data Scan (PEDS) Systematic Pedestrian and Cycling Environment Scan (SPACES)	St. Louis Environmental Instruments
Trails Parks Recreation		Community Park Audit Tool (CPAT) Environmental Assessment of Public Recreation Spaces (EAPRS) Path Environment Audit Tool (PEAT) Physical Activity Resource Assessment (PARA) Recreation Facility Audit Tool (REFAT)	Physical Activity Neighborhood Environment Scale (PANES) Research on Urban Trail Environments (ROUTES)*
Schools and child care		Environment and Policy Assessment and Observation (EPAO) Audit Tool for Primary School Environments	ActiveWhere? School Physical Activity Nutrition and Physical Activity Self-Assessment for Child Care (NAP SACC) School Physical Activity Policy Assessment (S-PAPA)*
Homes		Home-Inventory Describing Eating and Activity Development (Home IDEA) for Preschoolers Healthy Homes Survey	Mapping Home and Neighborhood Environments Home Physical Activity Environment Survey
Workplaces Other buildings		Audit of Physical Activity Resources for Seniors (APARS) Checklist of Health Promotion Environments at Worksites (CHEW) Environmental Assessment Tool (EAT)	Office Environment and Sitting Scale Worksite and Energy Balance Survey (WEBS) Worksite Supportive Environments for Active Living Survey (SEALS)*
Rural		Rural Active Living Assessment (RALA)	Rural Active Living Assessment (RALA) Rural Active Living Perceived Environmental Support Scale (RALPESS)

Schools and Child Care

A comprehensive school environment audit tool with evidence of reliability and validity was developed by Jones et al.[58] Audit tools also exist for the childcare environment, such as the Environment and Policy Assessment and Observation (EPAO).[93]

Homes

Home audit tools with evidence of reliability include the Home Food and Activity Assessment[94] and Healthy Homes Survey.[95] The latter is unique because it can be conducted through a telephone survey, and involves a parent doing an audit of his or her home.

Workplaces and Other Buildings

Physical activity environment assessment tools for worksites have been reviewed by Hipp et al.[96] The Checklist of Health Promotion Environments at Worksites (CHEW)[97] and Environmental Assessment Tool (EAT)[98] are comprehensive tools for assessing worksites that have evidence for reliability and validity. Evidence of reliability and validity also exists for tools that assess specific building types, such as congregate living facilities for older adults (Audit of Physical Activity Resources for Seniors [APARS]).[99]

Rural

The Rural Active Living Assessment (RALA) includes a street segment audit tool that has evidence of reliability and validity.[100]

Questionnaires

Community Design, Transportation System, and Streetscapes

Several report tools are commonly used and have evidence of reliability and validity for assessing neighborhood walkability factors. These include the Neighborhood Environment Walkability Scale (NEWS),[51] an abbreviated NEWS,[101] St. Louis Environmental Instrument,[102] and Neighborhood Physical Activity Questionnaire (NPAQ).[103] The Physical Activity Neighborhood Environment Scale (PANES) has acceptable reliability and validity properties but differs from the aforementioned tools because it is brief (17 items).[73]

Trails, Parks, and Recreation

Trails, parks, and recreation environments are typically assessed using audit tools. Slater et al. developed an adolescent questionnaire for assessing park environments.[104,105] For trails, the Research on Urban Trail Environments (ROUTES) trail use report tool includes items assessing trail environment characteristics.[106]

Schools

The ActiveWhere? study developed and evaluated reliability and validity for a set of questions on the availability of several physical activity-related school facilities.[107] The School Physical Activity Policy Assessment (S-PAPA) is a detailed report tool with reliability and validity that is primarily used for assessing school physical activity practices and policies, but also includes a small number of questions on the physical environment.[108] For assessing child care environments, the Nutrition and Physical Activity Self-Assessment for Child Care (NAP SACC) has evidence of reliability and validity.[109]

Homes

Report tools developed by Hume at al.[110,111] and Rosenberg et al.[112] have evidence of reliability and validity for assessing home environments related to youth physical activity and sedentary behaviors.

Workplaces and Other Buildings

The Worksite and Energy Balance Survey (WEBS) includes 72 items on physical activity as well as nutrition environments in the worksite and has evidence for reliability and validity.[113] A briefer tool with evidence of reliability and validity is the Worksite Supportive Environments for Active Living Survey (SEALS).[114] Also with evidence of reliability and validity, the Office Environment and Sitting Scale specifically assesses the sitting environment in the worksite.[115]

Rural

The Rural Active Living Assessment (RALA) includes interview questions that are completed by community members or key informants. The questions cover availability of recreation facilities, programs, and policies, and have evidence of reliability and validity.[100] Also with evidence of reliability and validity, the Rural Active Living Perceived Environmental Support Scale (RALPESS) can be used to assess participants' perceptions of their environment. The tool covers: (1) church facilities, (2) town center connectivity, (3) indoor areas, (4) around the home/neighborhood, (5) town center physical activity resources, (6) school grounds, and (7) outdoor areas.[116]

Assessing Use of Specific Environments and Physical Activity in Specific Environments

Questionnaires and Observational Measures

Tools measuring use of specific environments are not presented in the Measures Registry. Examples of questionnaires to measure these constructs can be found on Dr. James Sallis' website. Counting users, pedestrians, and/or bicyclists within specific environments can provide an objective way of assessing use of environments, and counting can be done manually or with automated devices.[117] Many cities and counties use automated counters to track pedestrian and bicycle traffic, and some parks track users in a similar manner. Issues to consider with manual counting include when and how frequently to collect assessments. Both manual and automated counting strategies may need to take into account non-independence (i.e., people being counted at multiple sites).

Commonly used tools for assessing physical activity in specific environments include the observational audit tools System for Observing Play and Recreation in Communities (SOPARC)[118] and System for Observing Play and Leisure Activity in Youth (SOPLAY).[119] These tools include checklists of environmental features to describe the environments being captured, and can be found in the Measures Registry.

GPS

Several studies have used person-worn GPS tracking devices in physical activity research[120] to capture the environments that an individual encounters across the day rather than simply the environment around a specific origin (e.g., home neighborhood). These methods allow investigation of the environments in which physical activity occurs as well as how exposure to various spatial contexts may influence physical activity. Several tools exist for making the use of GPS data in built environment research feasible (e.g., PALMS).[121]

Gaps and Limitations of Existing Measures

As is apparent in Table 1, few to no strong measures exist for some methods and settings (e.g., home audits, park self-report measures). In some settings multiple measures exist, making it difficult to choose (e.g., streetscape audit and report tools). Several existing measures with evidence for reliability and validity are lengthy and require complex training and/or scoring procedures because they were designed for research. Such tools may not fit the needs of practitioners because of their cost, complexity, and/or user burden. Much progress still needs to be made before both research- and practice-quality tools exist for all methods and settings.

6

Selecting Measures

This section describes the various purposes for using built environment measures, how users can identify and refine their purpose, and key selection considerations for each project purpose. This section also suggests processes for using and searching for measures within the Measures Registry.

Defining Project Purpose

Physical activity environment projects can have a wide variety of purposes and objectives, as highlighted in the Behavioral Epidemiology Framework presented in Figure 4. The figure distinguishes five project purposes: Basic, Epidemiology (or Health Outcomes), Surveillance, Theory and Correlates, and Intervention. The majority of projects in the practice domain fall under Surveillance and Intervention Research. Environmental research fits within each of the five levels, but has less of a role in Basic Research. As outlined in Section 2, physical activity environment research is guided by ecological models that suggest that physical activity is influenced by factors from multiple levels.[8] Although many study purposes are multi-level, this section specifically focuses on selecting measures at the environmental level.

Once the study purpose is refined using the Behavioral Epidemiology Framework, clearly defined project objectives can be identified to facilitate selecting appropriate environmental assessment tools. Objectives should be SMART: Specific, Measureable, Achievable, Realistic, and Time-bound.[123] The primary objectives of conducting environmental assessments include:

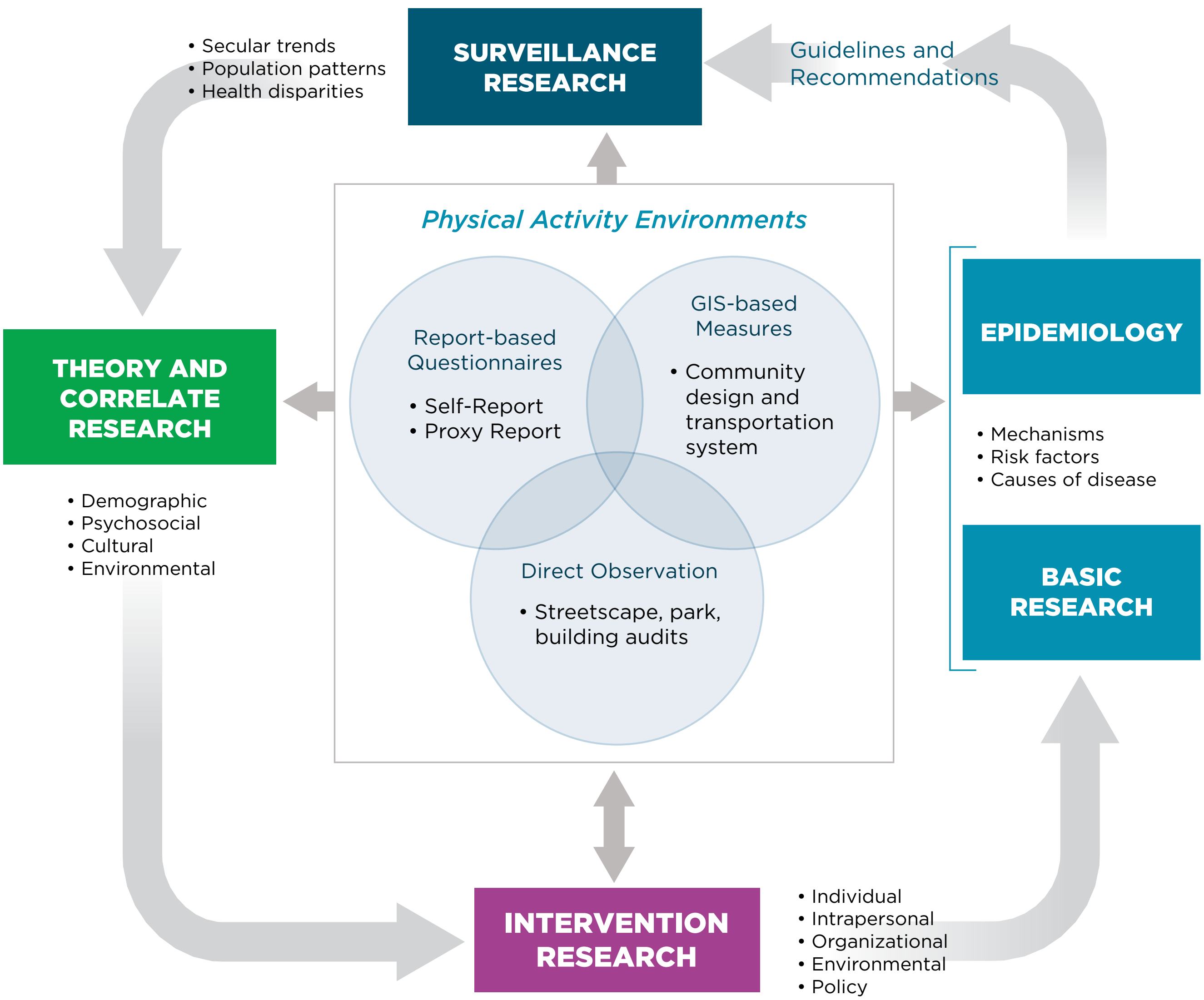
- To conduct periodic measures for public health planning purposes and assessing trends over time (i.e., surveillance).
- To observe associations between environmental attributes and physical activity, sedentary behavior, or health (i.e., observational/correlates study)
- To conduct intervention research or evaluation involving one or more of the following:
  - » To educate and/or engage community members in advocacy around environments and health (i.e., community engagement)
  - » To identify areas and/or attributes in need of improvement (i.e., needs assessment); can also include assessment of disparities in physical activity environmental attributes
  - » To evaluate whether and how environmental attributes change over time or as the result of an intervention (i.e., evaluation)

Whether grounded in research or practice, most projects fall into one or more of these three purposes. An example of a multiple-purpose project is when an investigator may conduct a physical activity intervention and wants to use built environment assessment to 1) engage participants in advocacy efforts, and 2) evaluate whether environmental improvements occur. Correlates research also can be combined with health outcomes research, for example when physical activity is investigated as a mediator of the link between the built environment and health outcomes.

Considerations in Selecting Measures

Once the project purpose is defined using SMART objectives, multiple factors should be considered in selecting the most appropriate tool(s) for environmental assessment. These factors include the setting of interest, comprehensiveness, reliability and validity, relevance to population being studied, resources and expertise required, and flexibility and adaptability to local needs.

Figure 4: Behavioral Epidemiology Framework



Welk, 2002. The figure was adapted to feature physical activity environment measures.[122]

Setting of Interest

Selecting the setting of interest is often evident once the project objectives are finalized. A researcher should select the setting(s) that affect the population being studied or the setting in which the intervention is taking place. In youth, this often involves homes, schools, neighborhoods, parks, and recreation settings. Because it is often not feasible to assess all of these settings, settings should be prioritized based on their relevance (e.g., where youth spend a large amount of time), availability of partners (e.g., where partners work and/or have influence), and/or potential for intervention. However, because it is uncommon for a single measure to cover multiple settings, multiple measures may be needed to adequately account for the variance in youth's overall physical activity.

A practitioner or researcher should select the settings that have potential for being affected by policy or environmental changes. For example, a needs assessment could be conducted on streetscape characteristics around schools seeking or receiving Safe Routes to School funding.[124] When using environmental assessment for community engagement, the involvement of community members could inform which setting(s) to target.

Comprehensiveness

Comprehensiveness is an examination of whether a measure or set of measures sufficiently assesses the aspects of the physical activity environment that need to be assessed. For example, if the aim of a project is to examine changes in the neighborhood built environment following the installation of a new bike/pedestrian trail, measures of the quality of as well as the access to (e.g., pedestrian features linking the trail to existing neighborhood) the bike/pedestrian trail could be examined. Comprehensiveness of measures includes the number of settings as well as the number of attributes or constructs within each setting being selected. Comprehensiveness should be balanced with project goals, feasibility, resources required, and measurement properties (e.g., reliability and validity). However, comprehensiveness is not necessarily the equivalent of length. Long measures can include multiple inter-related items representing single constructs (e.g., multi-item scales) and brief measures can cover multiple constructs using one to two items per construct.

Reliability and Validity

Having evidence of acceptable measurement properties is important for both research- and practice-based projects. Tools with poor reliability and/or validity limit the ability to detect differences among groups, changes over time, or associations between environmental attributes and health outcomes. Reliability and validity are less important when environmental assessment is used for community engagement, but if the results of the assessments will be used for a needs assessment or to target environmental changes, it is important that the tool have acceptable measurement properties. Visit the "Validity" and "Reliability" tabs for each measure in the Measures Registry, where results are presented when available.

Relevance to the Population Being Studied

It is important to note that reliability and validity can differ across geographic areas and participant populations, the latter being particularly relevant for self-report measures. A tool validated in urban areas or with a predominantly white non-Hispanic sample may not be reliable or valid for use in other geographic areas, cultures, or samples. Similarly, a measure's utility is specific to the purpose of the project. A tool may have acceptable validity for observational research but have poor sensitivity for detecting environmental changes over time, often because the response categories are very broad or there are no items to assess the planned intervention. Thus, users should consider whether the tool was designed and evaluated in a similar geographic area and/or population and for a similar purpose as the user intends. A majority of the measures in the Measures Registry have not been tested in multiple geographic areas and/or populations, particularly diverse populations in terms of race/ethnicity and socioeconomic status.

Rural and international environments are two key areas where environmental assessment tools diverge, particularly those related to community design. A strength of the NCCOR Measures Registry is that rural measures are separated from urban/metropolitan measures so they can be easily identified. When applying a questionnaire or audit tool to another country, adaptations are often needed, and GIS-derived data and relevant variables can vary drastically across countries[125] due to regional and historical differences in community design.

Resources and Expertise Required

The practicality of using any environmental assessment tool comes down to its complexity and cost for data collection and management. The "How To Use" tab in the Measures Registry provides useful information about resources needed to administer the measure, when available. GIS expertise is specialized and costly, and not all GIS technicians will have expertise in the variables related to physical activity. Accessing GIS data from multiple sources and deriving variables are complex and time-consuming activities. However, GIS-based methods are advantageous in large samples of individuals from few geographic regions because the cost is primarily based on the number of jurisdictions and variables rather than number of people. Audits, on the other hand, carry a per-person or per-environment (e.g., school, neighborhood) cost, making them less feasible for use in large studies. Audits require expertise in training in observational methods, ongoing attention to quality control, and management of complex data. The primary limitation to questionnaires is participant burden. Knowledge and careful consideration of the study participants and the time required to complete all study questionnaires will inform the selection of appropriate questionnaires. Data management demands are least complex with questionnaires.

Complexity and cost also vary within each method of assessment. Data collection, training, and scoring guides greatly reduce the complexity and cost of using GIS, audit, and questionnaire tools. The quality and comprehensiveness of the guides should be assessed before a measure is selected. Measure developers may or may not be able to answer questions or provide assistance, so thorough documentation is highly desirable. Smartphone and tablet applications can significantly reduce data management burden with audits and questionnaires as long as they have been fully vetted.

Flexibility and Adaptability

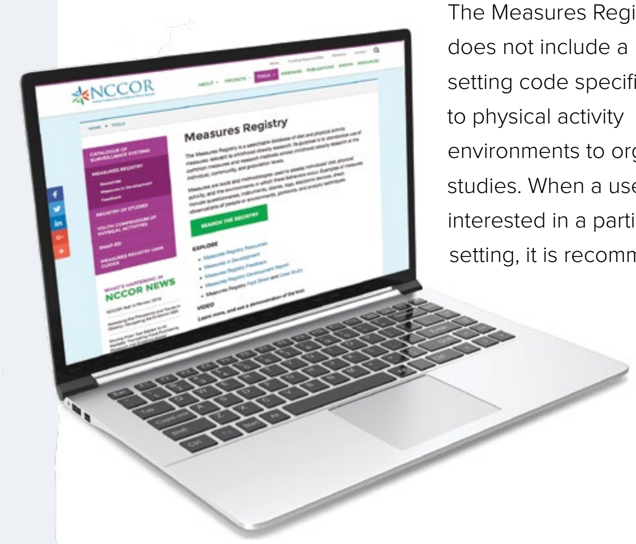
It is important to choose a flexible measure in situations where the tool may need to be adapted or tailored to specific populations or settings. New items in audit tools and questionnaires should be pilot tested for inter-rater or test-retest reliability when possible. Tools that use smartphone or tablet applications or require complex scoring algorithms may be less flexible because of difficulties in making software or scoring modifications. GIS-based measures can be flexible; for example, a variable can be computed multiple ways, and the options will be determined by the datasets available.

Suggested Process for Using the Measures Registry

The following section outlines the main steps that users can follow to use the Measures Registry to select the most appropriate measures for a designated purpose.

Searching and Filtering Results

The Measures Registry can be accessed from the NCCOR home page, under the "Tools" tab. The physical activity environment measures in the Measures Registry are organized by "Measure Type" (i.e., measurement method), "Ages" covered, and "Context" (i.e., urban or rural). The check boxes within each category can be used to narrow the results field. Once the user selects the desired measure type and context, a list of measures fitting those criteria is displayed. When a measure has been evaluated (i.e., tested for reliability or validity), the Registry will most likely include the measurement development or evaluation publication. If multiple measurement evaluation publications exist for a given measure, the Registry will typically include each of the publications. If a measure development or evaluation publication does not exist, the Registry will include the first paper published using the measure, typically a physical activity correlates study. Many of the publications in the Registry are not measure development or evaluation studies.



The Measures Registry does not include a setting code specific to physical activity environments to organize studies. When a user is interested in a particular setting, it is recommended to use the search function. Entering keywords such as "home environment" or "school" into the search box results in a list of publications that included those keywords in the title or abstract. The search function can be used in combination with the category check boxes to further refine the search, such as limiting the search to a specific setting and measurement method.

Navigating the Information Tabs Within Each Publication

Clicking on a publication's title will open a link with more detailed information about the measurement tool. It is recommended that each tab be viewed in detail while keeping in mind the selection considerations outlined above. The "At A Glance" tab includes helpful information when available, such as the length, constructs covered, and how to obtain the measure. The "Study Design" tab reports the characteristics of the sample used to develop and evaluate the measure, so users can consider whether the tool is appropriate for the population they intend to study. The "How To Use" tab includes information on how the tool is administered and whether data collection and/or analysis protocols exist. In circumstances where the Measures Registry does not include a link to the measure or protocols, the user should contact the authors of the study. Finally, the "Validity" and "Reliability" tabs include specific results from the publication on the tool's measurement properties. If a tool has multiple publications in the Measures Registry, the user should view the tabs for each publication.

7

Collecting and Reporting Data

Several factors should be considered in the planning and implementation of data collection, as well as when analyzing and reporting data.

Data collection considerations are detailed in this section, organized by measurement method, and followed by general statistical considerations when working with environmental data. Many users will benefit from consulting an expert in the field of physical activity environment assessment or someone with experience using a specific tool.

GIS-based Measurement Considerations

Several considerations are important when determining whether to use GIS-based measurements in a study or project, and these are described below.

Needed Expertise

Although GIS software such as ArcGIS is user-friendly, the level of data processing and analyses involved in built environment assessments often requires GIS expertise. Fortunately, GIS experts can be found through local universities and government departments. GIS is commonly used in Geography, Public Affairs, City and Transportation Planning, and Health Departments. GIS is used with a wide variety of data, so project staff should make sure a GIS expert is recruited whose skills and interests are relevant to the study or project.

Access to Databases

One challenge of GIS-based environmental assessment is that GIS databases can be difficult to obtain. Local Metropolitan Planning Organization's (MPO) websites are the best places to start when searching for GIS databases because many MPOs maintain a fairly large collection of GIS data for their region, such as road networks, parcels, and land use shapefiles. Other sources of GIS data include local municipalities, which often will share their GIS databases, sometimes for a fee. GIS data can also be obtained or purchased from sources such as ESRI[126] and the U.S. Census.[127] It is also possible to add an original audit or survey data into GIS.

Variable Computations

After determining geographic coordinates (e.g., for building addresses or from GPS) and obtaining the necessary geodatabases, built environment variables need to be created. Creating interpretable and useful built environment variables requires careful thought and multi-step computations involving multiple indicators and intermediary variables. Net residential density, for example, involves dividing the number of residential housing units by the sum land area across all residential parcels. Intersection density involves the sum number of intersections divided by the total land area. Mixed land use variables can be more complicated to compute. The International Physical Activity and Environment Network created a detailed protocol covering computations of numerous GIS-related built environment variables. This protocol serves as an excellent resource for those working on GIS-based built environment assessments and is publicly available online.[128] A similar resource has been created mainly for application in the United States.[67,129]

It is important to note that GIS variables can be computed in various ways and differ across studies. This should be taken into account when comparing findings across studies and selecting computations. Appropriate computations are those with the strongest evidence in relation to physical activity, relevance to the population being studied, and ability to be compared across geographic areas.

Buffer Size, Type, and Origin

GIS-based (e.g., community design) built environment assessments for physical activity have traditionally captured the spatial context around people's homes. This method involves creating spatial boundaries around people's homes in GIS to represent the environmental context believed to influence physical activity. The primary approaches to creating the spatial boundaries are: (1) radial/Euclidean buffers, which involve drawing a straight line from the home for a specified distance (e.g., 1 km) and using the line as the radius to create a circle, and (2) street network-based buffers, where a line is drawn a given distance from the home through the street network. Street-network buffers are believed to better represent opportunities for walking and are generally supported in previous studies, though results have been similar across buffer types.[130,131]

Buffer size also is important to consider, and the selection may vary based on the population of interest. For example, smaller buffer sizes, around 500 meters, are more appropriate for younger children with limited mobility freedom, whereas larger buffers, around 1 kilometer, better represent an adolescent's walking space. Although the home neighborhood is almost always the origin of the buffer, evidence is accumulating suggesting that community design aspects outside of one's home neighborhood, such as the school[132] and work[133] "neighborhoods," also are important. Some studies have used GPS to determine all of the locations/geographic coordinates a person encounters and calculated GIS-based physical activity environment variables from this information.[134,135] This dynamic approach allows a comprehensive assessment of environmental exposures but may be limited by data availability.

Observation Measurement Considerations

As with GIS-based measures, users interested in working with observation measures should first consider the following issues.

Training

Conducting observational audits can require significant resources and training, particularly for detailed research-oriented tools. Good audit tools are accompanied by a user guide that includes information on training coders. The following training steps should be used when conducting observational audits for research or when high levels of accuracy are required.

1. Before beginning data collection, each coder should be trained by a "master trainer" who has been trained and certified by the tool developer(s) or another master trainer.
2. Initial coder training should involve going through the audit tool together in the field (e.g., while walking the route being coded) while the master trainer provides definitions, instructions, and explanations for each selected code.
3. Coders should be deployed to audit a small number of environments (e.g., five segments or two parks) that the trainer also has audited. Each coder's data should be compared to the trainer's gold standard data. Each coder should exhibit a high level of agreement (e.g., >80 percent or 85 percent) with the master trainer before being certified for data collection.
4. Project staff should continue to monitor inter-observer agreement on a small number of environments throughout data collection, then provide feedback and retraining as needed. Ongoing monitoring is needed to ensure high quality of data.

These procedures are ideal for research studies but may not be applicable to practice-based projects, such as those that engage community members in audits for educational purposes or to identify areas needing improvement. Whenever possible, community members should be trained to conduct the audits, and simple certification procedures should be implemented based ideally on agreement with the trainer or at least an assessment of inter-rater reliability.

Selection of Environment Samples for Auditing

Because it is rarely feasible to audit all streets in a community or all parks in a city, a systematic approach to sampling is needed. One approach is to select generalizable samples of the environment/setting of interest when using an audit tool. For example, when using a streetscape audit tool, the user must decide which and how many street segments and/or routes to assess. When using a park audit tool, the user must decide which and how many parks to audit. However, little research is available to guide this selection process.

Another approach is to select samples for a specific purpose. If the goal of the study is to examine the safety of streetscapes around schools, a random sample of schools can be drawn. If the goal is to assess disparities in park quality, then low- and high-income areas can be sampled, and parks within those areas can be assessed. If the goal is to link the built environment to participants' physical activity, the sample environments can be selected based on proximity to each participant's home. The environments can also be selected based on the nearest cluster of destinations (e.g., shops, restaurants) to represent the most likely walking path between the participant's home and these destinations. When the objective is to classify a neighborhood for activity-friendliness, a random sample of environments (e.g., parks, streets) can be selected to represent the neighborhood. Some evidence suggests that assessing between 25 percent and 50 percent of the street segments in the neighborhood may be sufficient to provide a representative estimate of the area.[136,137]

Use of Google Street View for Observational Audits

Google Street View is a feature of Google Maps that provides images from views along streets across the world. Several recent studies have investigated whether streetscape audits can be reliably and validity completed using Google Street View.[47,138,139] Each of these studies concluded that Google Street View is acceptable for such tasks. One important consideration when using Google Street View is to be cognizant of the date the images were collected. If the image is old, the environment could have changed, thus limiting the validity of the audit. Images can be taken during different seasons, so if an obstruction (e.g., tree foliage) appears in an image, the user could search for other (newer or older) images of the same area. Google Earth has been available since 2007, so several images have been captured for many areas across the world over this time span. A helpful guide for conducting streetscape audits using Google Street View was developed by Wilson and Kelly.[140]

Smartphone and Tablet Applications

Traditionally, observational audits have been completed using pen and paper. More recently, several audit tools have been incorporated into smartphone and tablet computer applications, such as the SOPARC Online App: System for Observing Play and Recreation in Communities (iSOPARC).[141] Advantages of applications are that data are recorded directly into the smartphone or tablet, skip-patterns can be automated, data can be transferred and stored on a secure server, and in some instances data can be scored automatically. Applications can be costly to build and maintain, but more are continuing to emerge in environmental assessment.

Photovoice

Photovoice has seen recent use in physical activity environment assessment and allows participants to capture photographs of their environment (e.g., Buman, 2013).[142] The photographs, sometimes paired with written or verbal narratives, can supplement quantitative measures by providing rich qualitative information on specific environment factors relevant to the participant. Photovoice has utility in intervention studies that engage community members. It can also be useful in needs assessment projects that aim to identify and advocate for specific environmental improvements.

Statistical Considerations

In additional to measures-related considerations, users will also need to consider several statistical issues.

Nested Data

Environmental assessment often involves nested (i.e., multi-level) data when multiple participants are included from each environment. Users of environmental assessment tools need to consider the unit of analysis in their data collection and analysis efforts. When personal characteristics are of interest, such as physical activity, the participant is the unit of analysis. For example, when data from a school environment tool (i.e., audit or self- or proxy-report) are compared to physical activity data from multiple children from that school, the design is considered nested. In this circumstance, the sample size and statistical power (i.e., ability to detect a true association) are driven primarily by the number of schools rather than the number of participants. An ideal design would include a large number of schools and a small number of randomly selected students (e.g., 20–30) per school. Assessing more students per school would only minimally improve power. When analyzing nested data, mixed-effects models must be used to account for the non-independence of participants within settings.[143] Most statistical packages are capable of handling these types of models (e.g., Singer, 1998).[144]

Standardized and Unstandardized Regression Coefficients

Unstandardized regression coefficients are interpreted as the change in the dependent variable for every 1-unit change in the independent variable. The unit of measurement is retained, so if the dependent variable is minutes of physical activity, for example, the unstandardized coefficient represents minutes of physical activity. For example, an unstandardized regression coefficient of B = -8.6 for the association between distance to the nearest park in kilometers (independent variable) and minutes per day of physical activity (dependent variable) means that for every additional one kilometer in distance to the nearest park, participants had 8.6 fewer minutes per day of physical activity. So a person living one kilometer from a park would have 8.6 fewer minutes per day of physical activity than a person living zero kilometers from a park, and a person living two kilometers from a park would have 17.2 fewer minutes per day of physical activity than a person living zero kilometers from a park. Thus, unstandardized regression coefficients are particularly useful when the unit of measurement is meaningful, such as a quantity of something (e.g., minutes of physical activity, number of parks, number of intersections per acre). Standardized regression coefficients involve standardizing the variances of the dependent and independent variables to 1, similar to creating z-scores. Standardized coefficients cannot be interpreted in the unit of measurement of either the dependent or independent variable, but are useful for comparing effect sizes across variables and statistical models. Both types of coefficients add value and are commonly used in environmental assessment, but unstandardized coefficients are most informative to decision making.

Multicollinearity

Independent variables with high correlations should be grouped into scales or indices to prevent multicollinearity, which violates the assumptions of multiple regression analysis. Investigators commonly use a threshold correlation of r = 0.7 or r = 0.8 to denote "high" correlations among independent variables. Highly correlated items can be combined into scales using factor analysis or by summing or averaging values across items. See Section 4 for more information on scales and indices.v

8

Case Studies of Selecting Measures

SECTION 8

Three case studies are provided below to walk users through the processing of selecting appropriate measures for their project. The case studies cover a wide range of research and practice project purposes and apply several of the selection considerations covered in Section 7.

Background

A local bicycle and pedestrian advocacy organization is working with the city planning department to improve environments around schools to support active living. The organization plans to apply for grant funding to support specific environmental improvements and would like the improvement targets to be identified through a community needs assessment. Their goal is to identify specific locations and types of improvements for which to seek funding.

Considerations

The organization is interested in environmental attributes that would be feasible to modify during the two-year grant period. They do not have much influence over home, school, and other building environments, but they have some influence over neighborhood and park environment modifications through their partnership with the city planning and parks departments.

The organization also wants to assess neighborhood and park environments, but not to use GIS-based measures because community design attributes available in GIS are at the macro-level and not easily changed (e.g., residential density and land use mix). The organization considers using self-reports but ultimately rejects that idea because (1) they do not have expertise in community surveys, and (2) audit tools are more specific with regard to identifying areas and attributes to target for improvement. Thus, both streetscapes and park audit tools appear to be well-suited for this project. Because the organization wishes to involve community members in the project, they need brief tools that will require little training, pinpoint modifiable features in need of improvement, and produce simple results metrics that can be easily communicated to the grant funder.

Measure Selection

In looking for a streetscape tool, the organization selects the Measures Registry filter options "Physical Activity Environment" and "Environmental Observation," and types "street" into the search field. Approximately 15 results are shown. Some results are immediately ruled out for various reasons (e.g., Google Street View tool, rural tool, senior tool). About 10 tools are compared using the "Compare" check box. The organization narrows the results to the tools that have the instrument available in the Registry, approximately five tools. Based on the content desired, the organization considers the Active Neighborhood Checklist,[145] Microscale Audit of Pedestrian Streetscapes-Mini (MAPS-Mini),[81,85] Pedestrian Environmental Quality Index (PEQI),[146] and Systematic Pedestrian and Cycling Environment Scan (SPACES).[82] PEQI is ruled out because little evidence for reliability and validity is available. SPACES is ruled out because it is too lengthy.

The organization uses the same search parameters to identify park audit tools, and "park" is typed into the search box. About 15 results are provided but some are immediately ruled out because they are not exclusively focused on parks and thus lack the detail the organization desires. Using the "Compare" check box, the organization narrows the candidates to the Bedimo-Rung Assessment Tool,[147] Environmental Assessment of Public Recreation Spaces (EAPRS),[57] Physical Activity Resource Assessment (PARA)[91] and Community Park Audit Tool (CPAT).[90] PARA is ruled out because it lacks the level of detail desired.

For the streetscape audit tool, the organization selects the Active Neighborhood Checklist because it is brief, includes a codebook and training materials, has been previously used by practitioners, and has evidence of reliability and validity.[145] They strategically select street blocks to audit near elementary schools to represent points of pedestrian access to each school. The CPAT park audit tool is selected because of its previous use by practitioners and evidence of reliability and validity. However, CPAT includes 140 items, and the organization is concerned about resources and time burden. Thus, they select a subset of items based on community input and published evidence of reliability and validity of the subscales.

CASE STUDY 2 INVESTIGATING HOW MULTIPLE KEY ENVIRONMENTS EXPLAIN CHILDREN'S PHYSICAL ACTIVITY

Background A project team is planning a large multi-region study to better understand how the transportation and recreation physical activity of children ages 6 to 10 years is related to the supportiveness of the various environments the children encounter on a regular basis.

Considerations The project team would like to assess several of the key environments where children spend their time. Based on previous studies, the team identifies the home, school, and neighborhood as key environments to include in their study.

Because of the large sample size needed and desire to cover multiple environments, the team needs to identify measures that do not pose a high data collection burden or cost. Although streetscape audit tools would inform this project, the team ultimately decides not to use audit tools because of the large amount of time required to travel to participants' neighborhoods and collect audit data (though observations using Google Street View would be an option in this circumstance).

For community design and transportation system measures, the project team considers GIS-based measures, given their relative ease in large samples, but they make sure to investigate the availability and comparability of GIS databases across the regions being considered for the study. For home, school, and streetscape environment measures, the team prefers proxy-report (e.g., parent report) when available because audits would be too costly, and the children are viewed as being too young to use self-report. Because this is a novel project, the team desires comprehensive measures with strong evidence of reliability and validity.

Measure Selection The team searches the Measures Registry by selecting the filter options "Physical Activity Environment" and "GIS." Age category is not selected because of the relevance of GIS variables across age groups. Rather than using the "Compare" check box, the team views each of the approximately 25 results individually. Measures without evidence of construct validity, as indicated in the "Validity" tab, are ruled out. The remaining results are reviewed and examined for consensus (i.e., GIS variables that appear across multiple results).

More than 75 results are displayed when the team selects the "Physical Activity Environment" and "Questionnaire" check boxes, and type in "neighborhood." Results that have the instrument attached and that appear to meet their criteria based on title are compared using the "Compare" check box. Those without evidence of reliability and validity are ruled out. As the results narrow, the team views the tools for their comprehensiveness and frequency of use. Some of the candidate measures are entered into a scientific literature search engine to estimate frequency of use.

The team searches for home environment report tools using the search term "Home" and selecting the "Questionnaire" check box. In reviewing the approximately 50 results, only those with a link to the instrument are considered, and the project team has difficulty identifying physical environment tools that are specific to the home setting (most are related to the home neighborhood or parenting behaviors). Two potential candidates are identified and reviewed for more detail: the Healthy Home Survey[95] and Perceived Environment Survey on Safety, Aesthetics and Physical Activity.[111] The same process is used to search for school physical environment report tools, with similar difficulties. Many of the search results are for school neighborhoods, child care facilities, or school policies/practices, or lack a link to the instrument. The team expands their search to include observational audits. Very few candidates are identified from the Registry, suggesting a lack of assessment tools in this area.

The project team selects GIS-based residential density, land use mix, street connectivity, and park access for assessing community design and transportation system factors because of their consistent use in various publications in the Measures Registry and their associations with children's physical activity in previous studies. They consider GIS-based composite measures/indices, such as the walkability index by Frank et al.,[43] and choose the Cervero and Kockelman index[74] because of its level of detail and comprehensiveness, compared to the Frank index, which comprises only four variables.

The parent report Neighborhood Environment Walkability Survey (NEWS)[66] is selected because it covers features not available through GIS, such as sidewalk attributes and aesthetics, and has evidence of reliability and validity in relation to youth physical activity. The parent report tool developed by Hume et al.[111] is selected as the home environment report tool because of its strong measurement properties and previous use in research. The school environment audit tool developed by Jones et al.[58] is selected as the school environment report tool because of its level of detail, but it is first tested in a subsample to investigate its reliability and validity when completed by trained school key informants rather than using in-person audits.

CASE STUDY 3 EVALUATING CHANGES RESULTING FROM STREETSCAPE NEIGHBORHOOD RENOVATION PROJECTS

Background

A redevelopment grant is awarded to a city with special emphasis on pedestrian-oriented renovation projects through the city's main urban corridor. A project team would like to evaluate the extent to which the grant results in improvements in streetscape features known in previous studies to be associated with physical activity.

Considerations

The team chooses a pre-post design so that environmental changes can be captured across the one-year project. Because the renovation projects are focused on streetscape features, the team narrows in on streetscape report and audit tools. Although community member perceptions are important, audit tools are desirable because they provide a higher level of specificity than report tools. The constructs assessed need to have shown consistent relationships with physical activity in previous studies, so construct validity is especially important. The tool needs to be sensitive to change, particularly the changes being targeted by the renovation projects. Although most environmental assessment tools have not been evaluated for whether they can capture changes over short periods of time (e.g., one-year), the level of specificity provided by some audit tools is likely to be sensitive to the changes being targeted.

Measure Selection

The team selects the Measures Registry filter options "Physical Activity Environment" and "Environmental Observation," and types "street" into the search field. However, several relevant tools are left out when "street" is used in the search box, so this term is omitted. Simple checklist tools are ruled out because high detail and specificity are desired. A handful of relevant tools are selected based on their title and availability of the instrument. The candidates are compared using the "Compare" check box. The team considers the Irvine-Minnesota Inventory (IMI),[83] Microscale Audit of Pedestrian Streetscapes (MAPS),[64] and Pedestrian Environment Data Scan (PEDS)[84] because they are extensive instruments with similar content and have supporting evidence.

The IMI tool is selected because of its specificity, evidence of reliability and validity, and use in multiple previous studies. In reviewing previous publications using IMI, the team identifies several items and scales that (1) have consistent associations with walking for transportation and/or leisure across age groups, and (2) appear to have the ability of being affected over the one-year time frame of the grant.

9

Next Steps in Physical Activity Environment Assessment

Continued development in the field of measuring the physical activity environment would benefit from attention to several areas, including: (1) considering the level of variability obtained in food environmental measures, (2) moving beyond observational data and increasing the evaluation of longitudinal relationships and change over time, and (3) increasing attention paid to the expected associations between environmental measures and outcomes, and (4) continued efforts to promote use of common measures where possible.

Though several validated measures are available to choose from in most settings, some clear gaps remain. The bigger need identified by an expert working group[148] is for validated measures that are short enough to be feasible for use by practitioners. Interventions to improve physical activity environments are recommended by international[6,149] and national authoritative organizations,[2,7] and measures should be used to determine intervention needs and evaluate outcomes. Few brief, validated measures are available, but examples include MAPS-Mini for streetscapes, PARA for parks, and PANES for perceived neighborhood walkability.[73,85,91]

Some measures in the Measures Registry, particularly audit measures, have evidence of reliability, but evidence is still needed on whether the constructs are consistently associated with physical activity (i.e., construct validity). For measures with evidence of validity in one population subgroup, it would be useful to expand evidence by studying other age groups, income groups, and specific race and ethnicity subgroups to evaluate generalizability of effects. An important consideration is whether measures are sensitive to change, but very few have been evaluated for this ability. An important improvement for GIS measures is to document the procedures used to create variables, so the variables become more comparable. Some guides help with standardization of procedure,[67,128] but they depend on comparable, accurate, recent data being available. Thus, improvement in the quality and availability of physical activity-relevant data in GIS is a high priority. This will require collaboration with diverse government agencies such as transportation, city planning, and taxation, though crowd-sourcing of data is a possibility.

Continuing barriers to the use of physical activity environment measures are the burden and cost of data collection, complexity of data management, lack of clarity in scoring and interpreting results, and need for adapting measures. The Built Environment Assessment Training (BEAT) Think Tank has recommended several strategies for advancing the use environmental measures[148]:

- Develop simplified but validated measures to encourage more use by researchers and practitioners.
- Develop technological tools to simplify data collection, data management, scoring, and analysis.
- Improve scoring systems, with freely available syntax or software.
- Create guidelines for adaptation of existing measures and online access to various versions.
- Provide online training for data collection, data management, and interpretation of results.
- Encourage professional organizations to support the use of validated environmental measures and help the field develop consensus about definitions of constructs, preferred methods, and scoring.
- Incorporate training in environmental assessment in university courses in multiple departments.
- Use social media to support use and interpretation of environmental measures.

10

Conclusion

Many measures of physical activity environments have been developed over a relatively short time period. Options exist to measure almost all common physical activity settings, and measures are available in several modes, though not for all settings. Thus, available measures are likely to meet most needs for research and practice. Development of new measures and refinement of existing measures will continue, and this continued evolution is important for the field as new concepts are examined. However, the number and diversity of physical activity environmental measures in the Measures Registry can make it difficult to select appropriate measures and may discourage their use altogether. The goal of this User Guide, therefore, is to provide an overview of the field of physical activity environment measurement, offer general guidance about selecting measures to suit each user's needs, and make the Measures Registry a more user-friendly and valuable resource. This guidance should be applicable even as more measures are added to the Registry. We hope this User Guide encourages greater use of physical activity environment measures in research and practice.

11

Additional Resources on Physical Activity Environment Measurement

Several published resources that are useful in physical activity environment research can be used to supplement the information provided in this Guide:

- Step It Up! The Surgeon General's Call to Action to Promote Walking and Walkable Communities[7]
- Active Living Research (ALR) website,[150] which also contains a compilation of environment measures and supporting materials

ALR Briefs Specific to Measurement

- The Role of Self-Selection in Explaining the Effect of Built Environment on Active Travel[33]
- Counting Bicyclists and Pedestrians to Inform Transportation Planning[117]

Review Papers

- Measuring the Built Environment for Physical Activity: State of the Science[68]
- Assessing Perceptions of Environments for Active Living[50]

GIS protocols

- Built Environment and Physical Activity: GIS Templates and Variable Naming Conventions[128]
- Environment and Physical Activity GIS Protocols Manual [67, 129]

References

1. Koplan J, Liverman CT, Kraak VI. *Preventing childhood obesity: Health in the balance.* Cap Childhood Obesity, Balance Washington, DC: National Academies Press; 2005.

2. Heath GW, Brownson RC, Kruger J, et al. The effectiveness of urban design and land use and transport policies and practices to increase physical activity: Systematic review. J Phys Activ Health. 2006; 3(Suppl 1): S55-76.

3. National Physical Activity Plan. Available at: http://www.physicalactivityplan.org/. Accessed June 5, 2016.

4. Mozaffarian D, Afshin A, Benowitz NL, et al. Population approaches to improve diet, physical activity, and smoking habits: A scientific statement from the American Heart Association. Circulation. 2013; 126: 1514-63.

5. Pearson TA, Palaniappan LP, Artinian NT et al. American Heart Association Guide for Improving Cardiovascular Health at the Community Level, 2013 Update: A scientific statement for public health practitioners, healthcare providers, and health policy makers. Circulation. 2013; 127(16): 1730-53.

6. World Health Organization. Global strategy on diet, physical activity and health. 2004. Available at: http://www.who.int/dietphysicalactivity/strategy/eb11344/strategy_english_web.pdf. Accessed December 16, 2016.

7. United States Department of Health and Human Services. Surgeon General's Call to Action on Walking and Walkability. Available at: http://www.surgeongeneral.gov/library/calls/walking-and-walkable-communities/. Accessed June 5, 2016.

8. Sallis JF, Owen N. Ecological models of health behavior. In: Glanz K, Rimer B, Viswanath V, eds. *Health Behavior: Theory, Research & Practice.* 5th ed. San Francisco, CA: Jossey-Bass/Pfeiffer; 2015: p. 43-64.

9. Sallis JF, Cervero RB, Ascher W et al. An ecological approach to creating active living communities. Annu Rev Public Health. 2006; 27: 297-322.

10. U.S. Department of Health and Human Services. Physical activity guidelines for Americans. 2008. Available at: http://www.health.gov/paguidelines/pdf/paguide.pdf Accessed December 16, 2016.

11. Healthy People 2020. Physical activity. 2016. Available at: http://www.healthypeople.gov/2020/topics-objectives/topic/physical-activity. Accessed June 5, 2016.

12. Institute of Medicine (IOM). *Educating the student body: taking physical activity and physical education to school.* Washington (DC); 2013.

13. Grow HM, Saelens BE, Kerr J et al. Where are youth active? Roles of proximity, active transport, and built environment. Med Sci Sports Exerc. 2008; 40: 2071-9.

14. Kneeshaw-Price SH, Saelens BE, Sallis JF et al. Children's objective physical activity by location: Why the neighborhood matters. Pediatr Exerc Sci. 2013; 25: 468-86.

15. Rainham DG, Bates CJ, Blanchard CM et al. Spatial classification of youth physical activity patterns. Am J Prev Med. 2012; 42(5): e87-96.

16. Jones AP, Coombes EG, Griffin SJ et al. Environmental supportiveness for physical activity in English schoolchildren: A study using global positioning systems. Int J Behav Nutr Phy. 2009; 6: 42.

17. Klinker CD, Schipperijn J, Christian H et al. Using accelerometers and global positioning system devices to assess gender and age differences in children's school, transport, leisure and home based physical activity. Int J Behav Nutr Phy. 2014; 11: 8.

18. Carlson JA, Schipperijn J, Kerr J et al. Physical activity locations as assessed by GPS in young adolescents. Pediatrics. 2016; 137(1): 1-10.

19. Ding D, Sallis JF, Kerr J et al. Neighborhood environment and physical activity among youth: A review. Am J Prev Med. 2011; 41(4): 442-55.

20. Kerr J, Frank L, Sallis JF et al. Urban form correlates of pedestrian travel in youth: Differences by gender, race-ethnicity and household attributes. Transport Res D-TR E. 2007; 12: 177-82.

21. Frank L, Kerr J, Chapman J et al. Urban form relationships with walk trip frequency and distance among youth. Am J Health Promot. 2007; 21(4 Supp): 305-11.

22. McDonald NC. School siting: Contested visions of the community school. J Am Plann Assoc. 2010; 76(2): 184-98.

23. Carver A, Timperio A, Crawford D. Playing it safe: The influence of neighbourhood safety on children's physical activity – a review. Health Place. 2008; 14: 217-27.

24. Centers for Disease Control and Prevention (CDC). *Comprehensive School Physical Activity Programs: A Guide for Schools.* Atlanta (GA); 2013.

25. Cardon G, Van Cauwenberghe EV, Labarque V et al.The contribution of preschool playground factors in explaining children's physical activity during recess. Int J Behav Nutr Phys Act. 2008; 5: 11.

26. Van der Horst K, Paw MJ, Twisk JW et al. A brief review on correlates of physical activity and sedentariness in youth. Med Sci Sport Exer. 2007; 39(8): 1241-50.

27. Davison KK, Lawson CT. Do attributes in the physical environment influence children's physical activity? A review of the literature. Int J Behav Nutr Phys Act. 2006; 3: 9.

28. Beets MW, Cardinal BJ, Alderman BL. Parental social support and the physical activity-related behaviors of youth: A review. Health Educ Behav. 2010; 37(5): 621-44

29. Hinkley T, Crawford D, Salmon J et al. Preschool children and physical activity: A review of correlates. Am J Prev Med. 2008; 34(5): 435-41.

REFERENCES

30. Bauman AE, Reis RS, Sallis JF et al. Correlates of physical activity: Why are some people physically active and others not? The Lancet. 2012; 380(9838): 258-71.

31. Hirsch JA, Moore KA, Clarke PJ et al. Changes in the built environment and changes in the amount of walking over time: Longitudinal results from the multi-ethnic study of atherosclerosis. Am J Epidemiol. 2014; 180(8): 799-809.

32. Handy SL. Self-selection in the relationship between the built environment and walking. J Am Plann Assoc. 2006; 72(1): 55-74.

33. Handy S, Cao X, Mokhtarian P. *Active Travel: The Role of Self-Selection in Explaining the Effect of Built Environment on Active Travel.* A Research Brief. Princeton, NJ: Active Living Research, a National Program of the Robert Wood Johnson Foundation; 2009. Available at: http://activelivingresearch.org/active-travel-role-self-selection-explaining-effect-built-environment-active-travel. Accessed December 16, 2016.

34. Hooper P, Giles-Corti B, Knuiman M. Evaluating the implementation and active living impacts of a state government planning policy designed to create walkable neighborhoods in Perth, Western Australia. Am J Health Promot. 2014; 28(3 Suppl): S5-18.

35. Knuiman MW, Christian HE, Divitini ML et al. A longitudinal analysis of the influence of the neighborhood built environment on walking for transportation: The RESIDE Study. Am J Epidemiol. 2014; 180(5): 453-61.

36. Cohen A, Marsh T, Williamson S et al. Impact and cost-effectiveness of family Fitness Zones: A natural experiment in urban public parks. Health Place. 2012; 18(1): 39-45.

37. Goodman A, Sahlqvist S, Ogilvie D. New walking and cycling routes and increased physical activity: One- and 2-year findings from the UK iConnect Study. Am J Public Health. 2014; 104(9): e38-46.

38. Gustat J, Rice J, Parker KM et al. Effect of changes to the neighborhood built environment on physical activity in a low-income African American neighborhood. Prev Chronic Dis. 2012; 9: 110165.

39. McDonald NC, Steiner RL, Lee C et al. Impact of the safe routes to school program on walking and bicycling. J Am Plann Assoc. 2014; 80(2): 153-167.

40. Stewart O, Vernez Moudon A, Claybrooke C. Multistate evaluation of Safe Routes to School programs. Am J Health Promot. 2014; 28(sp3): S89-S96.

41. Dennison BA, Erb TA, Jenkins PL. Television viewing and television in bedroom associated with overweight risk among low-income preschool children. Pediatrics. 2002; 109(6): 1028-35.

42. Van Dyck D, Cerin E, Conway TL et al. Associations between perceived neighborhood environmental attributes and adults' sedentary behavior: Findings from the USA, Australia, and Belgium. Soc Sci Med. 2012; 74(9): 1375-84.

43. Frank LD, Sallis JF, Saelens BE et al. The development of a walkability index: Application to the Neighborhood Quality of Life Study. Br J Sports Med. 2010; 43: 124-31.

44. Federal Highway Administration. *A Resident's Guide for Creating Safe and Walkable Communities.* Washington (DC): 2008.

45. Thornton LE, Pearce JR, Kavanagh AM. Using Geographic Information Systems (GIS) to assess the role of the built environment in influencing obesity: A glossary. Int J Behav Nutr Phys Act. 2011; 8: 71.

46. Matthews SA, Moudon AV, Daniel M. Work Group II: Using Geographic Information Systems for enhancing research relevant to policy on diet, physical activity, and weight. Am J Prev Med. 2009; 36(4 Suppl): S171-76.

47. Kelly CM, Wilson JS, Baker EA et al. Using Google Street View to audit the built environment: Inter-rater reliability results. Ann Behav Med. 2013; 45 (Suppl 1): S108-12.

48. Clarke P, Ailshire J, Melendez R et al. Using Google Earth to conduct a neighborhood audit: Reliability of a virtual audit instrument. Health Place. 2010; 16(6): 1224-9.

49. Taylor BT, Fernando P, Bauman AE et al. Measuring the quality of public open space using Google Earth. Am J Prev Med. 2011; 40(2): 105-12.

50. Nasar JL. Assessing Perceptions of Environments for Active Living. Am J Prev Med. 2008; 34(4): 357-363.

51. Saelens BE, Sallis JF, Black JB et al. Neighborhood-based differences in physical activity: An environment scale evaluation. Am J Public Health. 2003; 93(9): 1552-8.

52. Spurrier NJ, Magarey AA, Golley R et al. Relationships between the home environment and physical activity and dietary patterns of preschool children: A cross-sectional study. Int J Behav Nutr Phys Act. 2008; 5: 31.

53. Gebel K, Bauman A, Owen N. Correlates of non-concordance between perceived and objective measures of walkability. Ann Behav Med. 2009; 37(2): 228-38.

54. Gebel K, Bauman AE, Sugiyama T et al. Mismatch between perceived and objectively assessed neighborhood walkability attributes: Prospective relationships with walking and weight gain. Health Place. 2011; 17(2): 519-24.

55. Prins RG, Oenema A, van der Horst K et al. Objective and perceived availability of physical activity opportunities:

Differences in associations with physical activity behavior among urban adolescents. Int J Behav Nutr Phys Act. 2009; 6: 70.

56. Kaczynski A, Potwarka LR, Smale BJA et al. Association of parkland proximity with neighborhood and park-based physical activity: Variations by gender and age. Leisure Sciences. 2009; 31(2): 174-91.

57. Saelens BE, Frank LD, Auffrey C et al. Measuring physical environments of parks and playgrounds: EAPRS instrument development and inter-rater reliability. J Phys Act Health. 2006; 3(Suppl 1): 190-207.

58. Jones NR, Jones A, van Sluijs EM et al. School environments and physical activity: The development and testing of an audit tool. Health Place. 2010; 16(5): 776-83.

59. Saelens BE, Handy SL. Built environment correlates of walking: a review. Med Sci Sports Exerc. 2008; 40(Suppl 7): S550-6.

60. Sallis JF, Bowles HR, Bauman A et al. Neighborhood environments and physical activity among adults in 11 countries. Am J Prev Med. 2009; 36(6): 484-90.

61. Norman GJ, Nutter SK, Ryan S et al. Community design and access to recreational facilities as correlates of adolescent physical activity and body-mass index. J Phys Act Health. 2006; 3: S118-28.

62. Carver A, Timperio AF, Crawford DA. Neighborhood road environments and physical activity among youth: The CLAN study. J Urban Health. 2008; 85: 532-44.

63. Ferreira I, van der Horst K, Wendel-Vos W et al. Environmental correlates of physical activity in youth – a review and update. Obes Rev. 2007; 8(2): 129-54.

64. Cain KL, Millstein RA, Sallis JF et al. Contribution of streetscape audits to explanation of physical activity in four age groups based on the Microscale Audit of Pedestrian Streetscapes (MAPS). Soc Sci Med. 2014; 116: 82-92.

65. Sallis JF, Conway TL, Prochaska JJ et al. The association of school environments with youth physical activity. Am J Public Health. 2001; 91: 618-620.

66. Rosenberg D, Ding D, Sallis JF et al. Neighborhood Environment Walkability Scale for Youth (NEWS-Y): Reliability and relationship with physical activity. Prev Med. 2009; 49(2-3): 213-8.

67. Forsyth A, Schmitz KH, Oakes M et al. Standards for environmental measurement using GIS: Toward a protocol for protocols. J Phy Act Health. 2006; 3(Suppl 1): S241-57.

68. Brownson RC, Hoehner CM, Day K et al. Measuring the built environment for physical activity: State of the science. Am J Prev Med. 2009; 36(4 Suppl): S99-123.

69. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics. 1977; 33(1): 159-74.

70. Shrout PE, Fleiss JL. Intraclass correlations: Uses in assessing rater reliability. Psychol Bull. 1979; 86(2): 420-8.

71. Carmines EG, Zeller RA. *Reliability and Validity Assessment*. Thousand Oaks (CA): Sage Publications, Inc.; 1979.

72. Vandenberg RJ, Lance C. A review and synthesis of the measurement invariance literature: Suggestions, practices, and recommendations for organizational research. Organ Res Methods. 1999; 3(1): 4-69.

73. Sallis JF, Kerr J, Carlson JA et al. Evaluating a brief self-report measure of neighborhood environments for physical activity research and surveillance: Physical Activity Neighborhood Environment Scale (PANES). J Phys Act Health. 2010; 7(4): 533-40.

74. Cervero R, Kockelman K. Travel demand and the 3 Ds: Density, diversity, and design. Transport Res D-Tr E. 1997; 2(3): 199-219.

75. Ewing R, Schmid T, Killingsworth R et al. Relationship between urban sprawland physical activity, obesity, and morbidity. Am J Health Promot. 2003; 18(1): 47-57.

76. Frank LD, Schmid TL, Sallis JF et al. Linking objectively measured physical activity with objectively measured urban form: Findings from SMARTRAQ. Am J Prev Med. 2005; 28(2 Suppl 2): 117-25.

77. Walk Score. Walk Score Methodology. 2016. Available at: https://www.walkscore.com/methodology.shtml Accessed December 16, 2016.

78. Carr LJ, Dunsinger SI, Marcus BH. Walk Score as a global estimate of neighborhood walkability. Am J Prev Med. 2010; 39(5): 460-3.

79. Carr LJ, Dunsinger SI, Marcus BH. Validation of Walk Score for estimating access to walkable amenities. Br J Sports Med. 2011; 45(14): 1144-8.

80. Duncan DT, Aldstadt J, Whalen J et al. Validation of Walk Score for estimating neighborhood walkability: An analysis of four US metropolitan areas. Int J Environ Res Public Health. 2011; 8(11): 4160-79.

81. Millstein RA, Cain KL, Sallis JF et al. Development, scoring, and reliability of the Microscale Audit of Pedestrian Streetscapes (MAPS). BMC Public Health. 2013; 13: 403.

82. Pikora TJ, Bull FC, Jamrozik K et al. Developing a reliable audit instrument to measure the physical environment for physical activity. Am J Prev Med. 2002; 23(3): 187-94.

83. Boarnet MG, Day K, Alfonzo M et al. The Irvine-Minnesota inventory to measure built environments: Reliability tests. Am J Prev Med. 2006; 30(2): 153-9.

84. Clifton KJ, Smith ADL, Rodriguez D. The development and testing of an audit for the pedestrian environment. Landscape Urban Plan. 2007; 80(1-2): 95-110.

REFERENCES

85. Sallis JF, Cain KL, Conway TL et al. Is your neighborhood designed to support physical activity? A brief streetscape audit tool. Prev Chronic Dis. 2015; 12: 150098.

86. Lee C, Kim HJ, Dowdy DM et al. TCOPPE school environmental audit tool: Assessing safety and walkability of school environments. J Phys Act Health. 2013; 10(7): 949-96

87. Dannenberg AL, Cramer TW, Gibson CJ. Assessing the walkability of the workplace: A new audit tool. Am J Health Promot. 2005; 20(1): 39-44.

88. Seymour M, Reynolds KD, Wolch J. Reliability of an audit tool for systematic assessment of urban alleyways. J Phys Act Health. 2010; 7(2): 214-23.

89. Troped PJ, Cromley EK, Fragala MS et al. Development and reliability and validity testing of an audit tool for trail/path characteristics: The Path Environment Audit Tool (PEAT). J Phys Act Health. 2006; 3(Suppl 1): S158-75.

90. Kaczynski AT, Stanis SA, Besenyi GM. Development and testing of a community stakeholder park audit tool. Am J Prev Med. 2012; 42(3): 242-9.

91. Lee RE, Booth KM, Reese-Smith JY et al. The Physical Activity Resource Assessment (PARA) instrument: Evaluating features, amenities and incivilities of physical activity resources in urban neighborhoods. Int J Behav Nutr Phys Act. 2005; 2: 13.

92. McKenzie TL, Moody JS, Carlson JA et al. Neighborhood income matters: Disparities in community recreation facilities, amenities, and programs. J Park Recreat Admi. 2013; 31(4): 12-22.

93. Ward D, Hales D, Haverly K et al. An instrument to assess the obesogenic environment of child care centers. Am J Health Behav. 2008; 32(4): 380-6.

94. Boles RE, Burdell A, Johnson SL et al. Home food and activity assessment. Development and validation of an instrument for diverse families of young children. Appetite 2014 Sep; 80: 23-7.

95. Bryant MJ, Ward DS, Hales D et al. Reliability and validity of the Healthy Home Survey: A tool to measure factors within homes hypothesized to relate to overweight in children. Int J Behav Nutr Phys Act. 2008; 5: 23.

96. Hipp JA, Reeds DN, van Bakergem MA et al. Review of measures of worksite environmental and policy supports for physical activity and healthy eating. Prev Chronic Dis. 2015; 12: 140410.

97. Oldenburg B, Sallis JF, Harris D et al. Checklist of Health Promotion Environments at Worksites (CHEW): Development and measurement characteristics. Am J Health Promot. 2002; 16(5): 288-99.

98. DeJoy DM, Wilson MG, Goetzel RZ, et al. Development of the Environmental Assessment Tool (EAT) to measure organizational physical and social support for worksite obesity prevention programs. J Occup Environ Med. 2008; 50(2): 126-37.

99. Kerr J, Carlson JA, Sallis JF, et al. Assessing health-related resources in senior living residences. J Aging Stud. 2011; 25: 206-14.

100. Yousefian A, Hennessy E, Umstattd MR, et al. Development of the rural active living assessment tools: Measuring rural environments. Prev Med. 2010; 50(Suppl 1): S86-92.

101. Cerin E, Conway TL, Saelens BE et al. Cross-validation of the factorial structure of the Neighborhood Environment Walkability Scale (NEWS) and its abbreviated form (NEWS-A). Int J Behav Nutr Phys Act. 2009; 6: 32.

102. Brownson RC, Chang JJ, Eyler AA et al. Measuring the environment for friendliness toward physical activity: A comparison of the reliability of 3 questionnaires. Am J Public Health. 2004; 94(3): 473-83.

103. Giles-Corti B, Timperio A, Cutt H et al. Development of a reliable measure of walking within and outside the local neighborhood: RESIDE's Neighborhood Physical Activity Questionnaire. Prev Med. 2006; 42(6): 455-9.

104. Slater S, Full K, Fitzgibbon M, Floyd MF. How well do adolescents know their local parks? Test-retest reliability and validity of an adolescent self-report park survey for diverse low-income urban neighborhoods. J Child Adolesc Behav. 2013; 1: 108.

105. Durant N, Kerr J, Harris SK, et al. Environmental and safety barriers to youth physical activity in parks and streets: Reliability and validity. Pediatr Exerc Sci. 2009; 21: 86-99.

106. Spruijt-Metz D, Wolch J, Jerrett M et al. Development, reliability, and validity of an urban trail use survey. Am J Health Promot. 2010; 25(1): 2-11.

107. Durant N, Harris SK, Doyle S et al. Relation of school environment and policy to adolescent physical activity. J Sch Health. 2009; 79(4): 153-9.

108. Lounsbery MAF, McKenzie TL, Morrow JR et al. School physical activity policy assessment. J Phys Act Health. 2013; 10(4): 496-503.

109. Benjamin SE, Neelon B, Ball SC et al. Reliability and validity of a nutrition and physical activity environmental self-assessment for child care. Int J Behav Nutr Phys Act. 2007; 4: 29.

110. Hume C, Salmon J, Ball K. Children's perceptions of their home and neighborhood environments, and their association with objectively measured physical activity: A qualitative and quantitative study. Health Educ Res. 2005; 20(1): 1-13.

111. Hume C, Ball K, Salmon J. Development and reliability of a self-report questionnaire to examine children's perceptions of the physical activity environment at home and in the neighbourhood. Int J Behav Nutr Phys Act. 2006; 3: 16.

112. Rosenberg D, Sallis JF, Kerr J, et al. Brief scales to assess physical activity and sedentary equipment in the home. Int J Behav Nutr Phys Act. 2010; 7: 10.

113. Hoehner CM, Budd EL, Marx CM, et al. Development and reliability testing of the Worksite and Energy Balance Survey. J Public Health Manag Pract. 2013; 19(3, Suppl 1): S105-13.

114. Blunt GH, Hallam JS. The worksite supportive environments for active living survey: Development and psychometric properties. Am J Health Promot. 2010; 25(1): 48-57.

115. Duncan MJ, Rashid M, Vandelanotte C et al. Development and reliability testing of a self-report instrument to measure the office layout as a correlate of occupational sitting. Int J Behav Nutr Phys Act. 2013; 10(1): 16.

116. Umstattd MR, Baller SL, Hennessy E et al. Development of the Rural Active Living Perceived Environmental Support Scale (RALPESS). J Phys Act Health. 2012; 9(5): 724-30.

117. Ryan S, Lindsey G. *Counting Bicyclists and Pedestrians to Inform Transportation Planning. A Research Brief.* Princeton, NJ: Active Living Research, a National Program of the Robert Wood Johnson Foundation; 2013. Available at: activelivingresearch.org/counting-bicyclists-and-pedestrians-inform-transportation-planning Accessed December 16, 2016.

118. McKenzie TL, Cohen DA, Sehgal A et al. System for Observing Play and Recreation in Communities (SOPARC): reliability and feasibility measures. J Phys Act. 2006; 3(Suppl 1): S208-22.

119. McKenzie TL, Marshall SJ, Sallis JF et al. Leisure-time physical activity in school environments: An observational study using SOPLAY. Prev Med. 2000; 30: 70-7.

120. Krenn PJ, Titze S, Oja P et al. Use of global positioning systems to study physical activity and the environment: A systematic review. Am J Prev Med. 2011; 41(5): 508-15.

121. University of California, San Diego. Personal Activity and Location Measurement System (PALMS) wiki. Available at: https://ucsd-palms-project.wikispaces.com/. Accessed June 5, 2016.

122. Welk G, ed. *Physical Activity Assessments for Health-Related Research*. Champaign, IL: Human Kinetics; 2002.

123. Centers for Disease Control and Prevention (CDC). Develop SMART Objectives. 2011. Available at: http://www.cdc.gov/phcommunities/resourcekit/evaluate/smart_objectives.html Accessed December 16, 2016.

124. National Center for Safe Routes to Schools. Available at: http://www.saferoutesinfo.org/. Accessed June 5, 2016.

125. Adams MA, Frank LD, Schipperijn J, et al. International variation in neighborhood walkability, transit, and recreation environments using geographic information systems: The IPEN adult study. Int J Health Geogr. 2014; 13: 43.

126. ESRI. ArcGIS Content. Available at: http://www.esri.com/data/find-data. Accessed June 5, 2016.

127. United States Census Bureau. TIGER Products. 2016. Available at: https://www.census.gov/geo/maps-data/data/tiger.html. Accessed June 5, 2016.

128. Adams, MA, Chapman JC, Sallis JF, et al. The International Physical Activity and Environment Network (IPEN) Study Coordinating Center. Built Environment and Physical Activity: GIS Templates and Variable Naming Conventions. 2012. Available for download at: http://www.ipenproject.org/methods_gis.html. Accessed December 16, 2016.

129. Design for Health. Environment and Physical Activity GIS Protocols Manual. Available at: http://designforhealth.net/resources/other/gis-protocols/. Accessed May 23, 2016.

130. Leal C, Chaix B. The influence of geographic life environments on cardiometabolic risk factors: A systematic review, a methodological assessment and a research agenda. Obes Rev. 2011; 12(3): 217-30.

131. James P, Berrigan D, Hart JE et al. Effects of buffer size and shape on associations between the built environment and energy balance. Health Place. 2014; 27: 162-70.

132. Carlson JA, Sallis JF, Kerr J et al. Built environment characteristics and parent active transportation are associated with active travel to school in youth age 12-15. Br J Sports Med. 2014; 48(22): 1634-9.

133. Frank L, Bradley M, Kavage S et al. Urban form, travel time, and cost relationships with tour complexity and mode choice. Transportation. 2007; 35: 37-54.

134. Coombes E, van Sluijs E, Jones A. Is environmental setting associated with the intensity and duration of children's physical activity? Findings from the SPEEDY GPS study. Health Place. 2013; 20: 62-65.

135. Rodriguez DA, Cho GH, Evenson KR et al. Out and about: Association of the built environment with physical activity behaviors of adolescent females. Health Place. 2012; 18(1): 55-62.

136. Cerin E, Chan K, Macfarlane DJ et al. Objective assessment of walking environments in ultra-dense cities: Development and reliability of the Environment in Asia Scan Tool – Hong Kong version (EAST-HK). Health Place. 2011; 17(4): 937-45.

137. McMillan TE, Cubbin C, Parmenter B et al. Neighborhood sampling: How many streets must an auditor walk? Int J Behav Nutr Phy. 2010; 7: 20.

138. Rundle AG, Bader MDM, Richards CA et al. Using Google Street View to audit neighborhood environments. Am J Prev Med. 2011; 40(1): 94-100.

REFERENCES

139. Griew P. Hillsdon M, Foster C et al. Developing and testing a street audit tool using Google Street View to measure environmental supportiveness for physical activity. Int J Behav Nutr Phys Act. 2013; 10: 103.

140. Wilson J, Kelly C. Navigating Google Street View: A Guide to Conducting Audits of the Built Environment Using Google Street View. 2011. Available at: http://activelivingresearch.org/built-environment-audits-google-street-view. Accessed December, 16, 2016.

141. Rand Corporation. SOPARC online app: System for Observing Play and Recreation in Communities. Available at: http://www.rand.org/health/surveys_tools/soparc.html. Accessed June 5, 2016.

142. Buman MP, Winter SJ, Sheats JL et al. The Stanford Healthy Neighborhood Discovery Tool: A computerized tool to assess active living environments. Am J Prev Med. 2013; 44(4): e41-7.

143. Diez-Roux AV. Multilevel analysis in public health research. Annu Rev Public Health. 2000; 21: 171-92.

144. Singer JD. Using SAS PROC MIXED to fit multilevel models, hierarchical models, and individual growth models. J Educ Behav Stat. 1998; 24(4): 323-55.

145. Hoehner CM, Ivy A, Ramirez LK et al. Active neighborhood checklist: A user-friendly and reliable tool for assessing activity friendliness. Am J Health Promot. 2007; 21(6): 534-7.

146. Wier M, Sciammas C, Seto E et al. Health, traffic, and environmental justice: Collaborative research and community action in San Francisco, California. Am J Public Health. 2009; 99(Suppl 3): S499-504.

147. Bedimo-Rung AL, Gustat J, Tompkins BJ et al. Development of a direct observation instrument to measure environmental characteristics of parks for physical activity. J Phys Act Health 2006; 3: 176-89.

148. Glanz K, Sallis JF, Saelens BE. Advances in physical activity and nutrition environment assessment tools and applications: Recommendations. Am J Prev Med. 2015; 48(5): 615-9.

149. World Health Organization. Global Action Plan for the Prevention and Control of Noncommunicable Diseases, 2013–2020. 2013. Available at: http://www.who.int/nmh/events/ncd_action_plan/en/. Accessed December 16, 2016.

150. Active Living Research (ALR). Tools and Resources. 2016. Available at: http://activelivingresearch.org/toolsandresources/all. Accessed December 16, 2016.

MAY 2017

NCCOR

National Collaborative on Childhood Obesity Research