Supplement
THE ADOPT PROJECT

Obesity

Accumulating Data to Optimally Predict Obesity Treatment (ADOPT) Core Measures: Environmental Domain

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Background: There is growing interest in how environment is related to adults' weight and activity and eating behaviors. However, little is known about whether environmental factors are related to the individual variability seen in adults' intentional weight loss or maintenance outcomes.
Objectives: The environmental domain subgroup of the Accumulating Data to Optimally Predict obesity Treatment (ADOPT) Core Measures Project sought to identify a parsimonious set of objective and perceived neighborhood and social environment constructs and corresponding measures to include in the assessment of response to adult weight-loss treatment.
Significance: Starting with the home address, the environmental domain subgroup recommended for inclusion in future weight-loss or maintenance studies constructs and measures related to walkability, perceived land use mix, food outlet accessibility (perceived and objective), perceived food availability, socioeconomics, and crime-related safety (perceived and objective) to characterize the home neighborhood environment. The subgroup also recommended constructs and measures related to social norms (perceived and objective) and perceived support to characterize an individual's social environment. The 12 neighborhood and social environment constructs and corresponding measures provide a succinct and comprehensive set to allow for more systematic examination of the impact of environment on adults' weight loss and maintenance.

Obesity (2018) **26**, S35–S44. doi:10.1002/oby.22159

Introduction

Physical and social environments likely influence adults' activity and eating behaviors. Environmental factors may also influence behavior change related to weight control, but environmental factors as predictors of adult weight loss success are rarely examined. Perhaps because of limited evidence about environmental factor predictors, published reviews examining factors to explain variability in adult obesity intervention response and treatment adherence focus almost exclusively on behavioral, biological, and psychosocial factors (1-4). Conceptual models that underpin interventions for adult weight loss also rarely include environmental exposure, despite a growing literature based on cross-sectional and longitudinal observational studies documenting associations between environmental factors and physical activity, diet, and weight (5-10).

Environmental exposures are potentially critical components in whether adults initiate and sustain healthy weight-related behaviors for weight loss and maintenance. The importance of the environment is highlighted in many conceptual models of health behaviors (11). Environmental factors could help explain differential variability in response to adult weight-management interventions across sites in multicenter trials, particularly if the physical and social environments vary considerably across study sites. Ongoing exposure to environmental factors in everyday life and the potential for these factors to explain disparate outcomes in meta-analyses of

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Funding agencies: The ADOPT Core Measures Working Group was supported by intramural funding from the following National Institutes of Health: The National Heart, Lung, and Blood Institute, the National Cancer Institute, and the Office of Disease Prevention. The Grid-Enabled Measures Database (GEM) is supported and administered by the National Cancer Institute.
Disclosure: All of the authors declared no conflicts of interest that are directly relevant to this work. The views expressed in this paper are those of the authors and do not necessarily represent the positions of the NIH, the DHHS, or the Federal Government.
Received: 22 December 2017; **Accepted:** 12 February 2018; **Published online 23 March 2018. doi:10.1002/oby.22159**

weight-loss trials across diverse populations are important reasons to consider them as potential weight loss predictors. Finally, the factors identified to date as predictors explain only a small amount of the variability in adults' response to weight-loss interventions. Perhaps exploring environmental factors or their interaction with biological, psychological, or behavioral factors could improve predictive ability (12,13).

The Accumulating Data to Optimally Predict obesity Treatment (ADOPT) Core Measures Project aims to better understand the factors influencing individual variability in response to adult obesity treatment by providing a framework for how obesity researchers can generate the evidence base needed to guide the development of tailored treatments of obesity (14). The identification of a core set of measures across four domains (all included in this issue of *Obesity*)—behavioral, biological, environmental, and psychosocial—to be used in a consistent manner across adult weight-loss trials represents a first step in an ongoing process that will be refined and updated dynamically as the science advances and new evidence accumulates.

The goal of the ADOPT environmental domain subgroup was to identify the environmental factors that may predict adults' response to weight loss and weight maintenance. The subgroup defined environmental influences as external factors such as built, natural, economic, or social environments to which individuals are exposed, in contrast to other ADOPT domains focused on cognition, attitudes, affect, or physiology. The subgroup recommendations focus on environmental variables that could impact weight-related behaviors on a regular basis through ongoing exposures. It is recognized that, relative to other ADOPT domains, there is little existing evidence concerning associations between environmental factors and adult weight loss or weight-loss maintenance, but implementing the proposed recommendations would be a first step toward building systematic evidence.

Identifying High-Priority Constructs and Measures for Environment

Much of the evidence about environmental factors and weight-related behaviors is observational and cross-sectional, examining differences in weight status and related behaviors at one point in time among individuals living in or otherwise exposed to different physical or social environments. Some more recent studies are longitudinal, examining the long-term effects of environmental factors on weight and related behaviors, or alternatively among individuals who move from one environment to another or among those otherwise exposed to environmental changes (e.g., pedestrian infrastructure improvements, opening new food stores) (8,15,16). The ADOPT environmental domain subgroup was only aware of a limited number of published reports that examine the association of environmental factors with weight-loss or maintenance among adult weight-management trial participants (e.g., Mendez et al. and Zenk et al. (17,18)).

Narrowing the environmental focus

Given existing evidence and the measures being proposed by other ADOPT subgroups, the environmental domain subgroup started with a focus on the physical and social aspects of the environments of the home neighborhood that might influence weight loss and maintenance. The physical environment includes the built and food environments, whereas the social environment includes both socioeconomic factors and social factors such as neighborhood crime and safety (19,20). The subgroup also decided to include other aspects of the social environment, such as an individual's level of social support for weight loss. The focus on the home neighborhood stems from it being the most studied setting in relation to adult weight status and activity and diet behaviors among the various environments an individual encounters routinely (21). This decision does not diminish the potential importance of other environments encountered on a regular basis (e.g., the work environment, the chemical/toxin environment) or at higher (e.g., regional environments) or lower levels (e.g., within-home activity and food environment) within the socioecological framework. Such other environments are less universal and/or adequate data resources or measurement tools specific to these other environments are lacking. Finally, the focus on the home neighborhood physical and social environments, as well as an individual's own social environment as the external context in which individuals are routinely embedded, recognizes that these factors are more proximal influences than the more upstream policy or systems influences or broader social contexts.

Criteria for environmental construct and measures selection

Consistent with overall ADOPT objectives, the ADOPT environmental domain subgroup identified high-priority potential explanatory environmental constructs or factors and the corresponding measures to assess these environmental constructs using the following criteria:

(a) environmental factors most directly related to adults' engagement in physical activity (particularly walking behavior, given its high prevalence), procurement or consumption of food, or to adherence to other weight loss behaviors;
(b) published evidence about the quality of measures (e.g., reliability, validity);
(c) feasibility of obtaining the measures within adult weight-management trials, including considerations of both participant burden and investigator expertise and burden;
(d) attempts to reduce overlap among constructs; for example, residential density and overall walkability are often highly correlated, so only one was recommended; and
(e) being in an intermediate level within socioecological models: beyond the individual level, but below governmental or organizational policy levels.

Unlike many individual-level constructs (e.g., self-efficacy), which are mostly self-reported, or biological measures obtained from biological samples, issues of feasibility for obtaining some objective environmental measures include the availability and cost of local, state, and national geographic information systems (GIS) data and the technical and analytic skills required for creating environmental measures and attributing them to individuals. For example, commonly used objective measures of the home neighborhood food environment require data on the type and location of food stores. Fortunately, many municipalities are improving availability of environmental information by developing publicly available GIS data systems that contain information about activity and food amenities

(e.g., parks, food stores) that can be used to characterize local activity and food environments (e.g., https://octo.dc.gov/service/dc-gis-services). This includes law enforcement posting publicly available crime data that are spatially categorized (e.g., linked to census geography or even more precisely to street intersections) and can be used to develop measures of crime-related safety. Other more detailed objective environmental measures (e.g., amenities and quality of parks and recreational facilities, food availability, food prices) that might better discern and characterize more aspects of individuals' environment currently require more intensive measurement efforts (e.g., on-the-ground observations). Given the geographic dispersion of participants in most intervention trials and the expense involved in collecting even brief versions of these more detailed measures, these were not deemed currently feasible to recommend.

Considerations Related to Data Collection in Environmental Domain

Subjective and objective measures

The ADOPT environmental domain subgroup considered it important to include constructs that are directly observed or derived from existing data (e.g., administrative data, road network data), often referred to as "objective," and constructs based on participant report or perception of environment, often referred to as "subjective" or "perceived." Objective environment measures are derived from existing or researcher-collected (e.g., from on-the-ground or remote audits) geospatial or administrative data. For instance, measures of street connectivity can be derived from data about the connectedness of streets around a location (e.g., an individual's home) using Census Tiger Line Files for roads and intersections. Alternately, perceived or subjective street connectivity can be obtained from querying individuals about the connectedness or pattern of streets in their home neighborhood. Objective and perceived environmental constructs are often intended to capture different constructs or different aspects of a single construct. Subjective measures may also explicitly assess attitudes about environments: for example,, "How concerned are you about the safety in your neighborhood?" versus "Is it safe to walk in your neighborhood?" The validity assessment of subjective and objective environment measures also differs. Obtaining subjective environment measures may capture constructs for which objective data are challenging to obtain, such as perceptions of aesthetics. Subjective and objective measures of seemingly similar environmental constructs can have independent associations with physical activity and diet (22-24). Therefore, resources permitting, and as others have recommended (19), the ADOPT environmental domain subgroup advocates collecting a combination of objective and subjective measures of the environment.

The importance and use of the home address

Obtaining objective home neighborhood environmental measures involves multiple steps starting with home address information. The home address, and other key locations such as the workplace, can be conceived as the environmental equivalent of a biological specimen; the home address can be stored for later analysis, but if it is not collected, then measures of objective environment factors will not be available. Indeed, study teams are strongly encouraged to routinely collect, preserve, and obtain permission to use study participants' home address information, even if the study lacks immediate plans to obtain and analyze objective home neighborhood environmental data. Ideally, the home address is first collected at study enrollment, with prior address information collected if participants have recently moved. Retrospective address collection to determine residential histories is possible but expensive and prone to error (25). Collection of street addresses, rather than post office boxes or ZIP codes alone, is critically important, as is frequent updating of home addresses. Failure to collect new address data to account for moving and to preserve old address data can lead to bias in estimates of participants' environments. Other address information, such as the work address, and even broader activity space locations (i.e., where individuals spend time), might also be beneficial to collect because the effects of environments in and around these locations on weight, weight loss, and weight maintenance are active areas of research (26,27).

The home address can be used in various ways to develop home neighborhood environment measures. An address can be entered directly into commercially available or free Web tools that generate environmental measures specific to that address (e.g., www.walkscore.com). The US Census provides a free high-quality tool for geocoding, with single addresses or batches of up to 1,000 addresses able to be entered at a time (https://www.census.gov/geo/maps-data/data/geocoder.html). Commercial services are also available that will geocode address files and link the geocode addresses to diverse data resources, including environmental measures from the census (e.g. http://geolytics.com/) and many others. It is also possible to geocode addresses using commercial or open-sourced computer software. These tools are becoming more accessible and easier to use; however, personnel with basic GIS training are often needed to use such software, as programming may be specific to the study question and data resource. Once data are geocoded and linked to census identifiers, measures of various environment features can be calculated, such as walkability or neighborhood deprivation.

Confidentiality and privacy protection are critical issues in objective environment measure development, as it requires matching participants' addresses to existing databases containing environmental information; this process represents the sharing of a personal identifier (an address) with the online service provider that does the matching (28). Bader et al. suggest some alternative approaches, such as geographic imputation, which involves entering an address from a similar area rather than from a participant address. Investigators should work with their institutional review board to determine how best to proceed when using online or hired commercial geocoding services.

Environmental Constructs and Corresponding Measures Recommended by ADOPT

Home neighborhood environment

The ADOPT environmental domain subgroup recommends measuring a combination of five perceived and objective physical environment constructs that focus on the physical activity and food environments in participants' home neighborhoods (Table 1).

Walkability, objective. Two approaches for measuring objective walkability are recommended: an individual residence-specific

TABLE 1 Recommended constructs and measures from ADOPT environmental domain subgroup of ADOPT working group

Construct	Measure	Measure type	Logistics			Source of evidence
			Number of items	Administration time (min)	Resource needs	
Home neighborhood						
Home address	Home address	Self-administered	1	< 5		
Walkability, objective	*Walk Score* or *EPA Walkability*	Derived	N/A	N/A	None	C
Land use mix, perceived	Neighborhood Environment Walkability Scale, Land Use Mix Access Subscale	Self-administered	3	< 5	None	C
Food outlet accessibility, objective	*Density of* (1) *supermarkets*, (2) *fast-food restaurants, and* (3) *convenience stores*	Derived	N/A	N/A	Basic GIS skills	L, C
Food outlet accessibility, perceived	Perceived presence of (1) supermarkets, (2) fast-food restaurants, and (3) convenience stores, plus others (Liese)	Self-administered	6	< 5	None	L, C
Food availability, perceived	MESA neighborhood healthy food availability	Self-administered	8	< 5	None	L, C
Socioeconomic deprivation, objective	*Neighborhood Deprivation Index (Diez Roux et al)*	Derived	N/A	N/A	None	L, C
Personal safety, objective	*Neighborhood police-reported crime*	Derived	N/A	N/A	Basic GIS skills	C
Personal safety, perceived	MESA perceived neighborhood safety	Self-administered	2	< 5	None	C
Individual social environment						
BMI of individuals in their social network, objective	*BMI of spouse/partner*	Interviewer	N/A	N/A	None	L, C
Weight status of individuals in their social network, perceived	Weight-Related Social Norms Scale	Self-administered	29	15-20	None	L, C
Support from social network	Modified Sallis Social Support Scales	Self-administered	23	10-15	None	L, C
Perceived autonomy support	Important Others Questionnaire	Self-administered	6 or 12	5-10	None	L, C

Italics indicate objective measure. Evidence included both weight-related outcomes (e.g., weight loss) and behaviors related to weight loss (e.g., physical activity).
C, cross-sectional; EPA, Environmental Protection Agency; GIS, geographic information systems; L, longitudinal; MESA, Multi-Ethnic Study of Atherosclerosis; N/A, not applicable.

measure of walkability and a neighborhood-wide measure of walkability based on census data. Walk Score, a commercially generated index that considers proximities to diverse destinations (e.g., retail, services), provides an estimate of walkability specific to individual addresses and can be obtained for free by entering addresses into a Web site or at cost through arrangements with the company (www.walkscore.com). Several studies have demonstrated associations between Walk Score and physical activity obtained by walking, particularly walking for transportation (29-33). If submission of addresses to a Web-based data source is a concern, linkage to precalculated area-based measures of walkability is an alternative measure. A number of walkability indices are available for specific areas, such as census tracts or blocks (34,35). The Environmental Protection Agency Office of Smart Growth recently released a nationwide Environmental Protection Agency Walkability Index at the census block group level (https://www.epa.gov/smartgrowth/smart-location-mapping). A recent study reported associations between accelerometer measures of physical activity and this walkability index, although it is not known if it is associated with weight trajectories (36). Nevertheless, it would be straightforward to link census geography for home addresses to this index.

Land use mix, perceived. Walkability is a multifaceted construct, with a significant component within it being land use mix, defined for home neighborhood environment purposes as the extent of nonresidential destinations near one's home. The ADOPT environmental domain subgroup recommends obtaining a measure of perceived land use mix. Perceived land use mix has been related to higher rates and amounts of adults' utilitarian walking behavior (37-39). Higher land use mix also frequently co-occurs with other aspects of higher neighborhood walkability, including greater residential density and higher street network connectivity. Thus, measuring perceived land use mix allows for a parsimonious proxy assessment of perceived neighborhood walkability. The Land Use Mix Access Subscale of the abbreviated Neighborhood Environment Walkability Survey (40,41), is a three-item scale to measure perceived land use mix.

Food outlet accessibility and food availability. For the food environment, the ADOPT environmental domain subgroup recommends objective and subjective measures of neighborhood food outlet accessibility and a subjective measure of healthy food availability. Food accessibility refers to consumer food supply locations (e.g., food stores, restaurants) and ease of getting to these locations. Food availability refers to the presence or adequacy of healthful and less healthful food products in those locations. The subgroup's selection of these two dimensions of food access is guided by Caspi's adaptation of Penchansky and Thomas's model (42,43), but it is also guided by other conceptualizations (44,45). The subgroup recognizes that access to both healthful and less healthful food sources and products is relevant, given the evidence that the relative accessibility of healthful to less healthful food outlets and products is associated with diet quality and body weight (46,47).

The proposed objective and subjective measures of accessibility examine three types of food outlets in the home neighborhood: supermarkets, fast-food restaurants, and convenience stores. Supermarkets tend to have the largest selection of healthful foods, whereas both fast-food restaurants and convenience stores tend to predominately sell energy-dense, nutrient-poor foods and beverages with few healthful alternatives (48,49). Multiple studies have shown that greater accessibility to supermarkets is associated with healthier dietary intake and lower body weight, whereas greater accessibility to fast-food restaurants and convenience stores is associated with less healthy dietary intake and higher body weight (6,50). For objective measures, for each of the three food outlets, the subgroup suggests measuring the density of outlets within a given area around the home (e.g., 1 mile and 3 miles) and distance to the closest outlet. For a subjective measure of food outlet accessibility, the subgroup recommends a six-item scale on the perceived presence of food outlets in the neighborhood developed and tested by Liese and colleagues (51,52). For food availability, the subgroup recommends a three-item scale on the neighborhood availability of fruits and vegetables and low-fat foods developed for the Multi-Ethnic Study of Atherosclerosis (53,54), which is the most widely used subjective measure of healthy food availability to date. However, there are limitations with this screener, and others have updated such screeners to include additional items and other dietary constructs (e.g., whole grains) (55).

Social environment

In addition to the physical environment around one's home, the social environment in which one lives may impact an adult's weight loss and maintenance. The ADOPT environmental domain subgroup recommends collecting measures for three neighborhood social environment constructs, focusing on socioeconomics and objective and perceived safety, and four individual social environment constructs, focusing on objective and perceived social norms and two aspects of social support.

Neighborhood socioeconomic environment. As with other environmental factors, current data are limited on the impact of neighborhood-level socioeconomic characteristics on adult weight loss or weight-loss maintenance (17). However, extensive observational data support inclusion of neighborhood deprivation as an ADOPT environmental domain subgroup construct. Evidence demonstrates that health outcomes differ across neighborhoods of varying socioeconomic status (SES), independent of individuals' socioeconomic level (56,57). Studies also show that neighborhood- and individual-level SES discordance, in which those with lower individual-level SES live in areas of higher SES and vice versa, exists and has a differential association with mortality when compared to socioeconomic level concordance (58). Neighborhood deprivation has been associated with weight change over time and weight-related health behaviors (59-61). Additionally, exposure to increasing deprivation when moving to a lower socioeconomic-level neighborhood has been associated with subsequent weight gain. The Moving to Opportunity study, in which participants were randomly assigned to live in areas of varying neighborhood SES, demonstrated that moving from a high- to low-poverty area was associated with a decreased likelihood of obesity among women (8).

Neighborhood deprivation can be measured based on census variables at the census tract– or block group–level. Principal components factor analyses have been used to identify key variables for inclusion in an index, often comprising a combination of education, employment and occupation, housing conditions, income and poverty, racial composition, and/or residential stability. Specifically, the variables that make up a neighborhood deprivation index are those that have the highest loading scores in factor analyses; this is also applicable across geographic regions if characterizing neighborhood

deprivation for populations in different cities or states. These census variables are then standardized, weighted based on factor loading coefficients, and summed to determine an overall neighborhood deprivation index. Many potential measures exist to characterize neighborhood deprivation, with the subgroup recommending the neighborhood deprivation index developed by Diez Roux and colleagues (59). Research teams can consider use of other indices, such as the neighborhood socioeconomic position index developed by Krieger (62) or the neighborhood deprivation index developed by Lian and colleagues (63). Using an additional index may depend on whether the research team has access to a previously calculated index for the geographic location of interest or whether the team considers specific census-level variables important to include in creating the index (i.e., neighborhood racial composition).

Neighborhood crime-related safety. Another critical aspect of the neighborhood social environment is safety. Thus, the ADOPT environmental domain subgroup recommends including objective and subjective measures of home neighborhood crime–related safety for examining as predictors of adult weight loss and weight-loss maintenance. Police-reported crime is the recommended objective measure of safety. Higher police-reported crime has been associated with lower rates of walking for physical activity (64). Police-reported crime can be attributed to individuals' home neighborhood environment by linking geocoded address data with publicly available data on the location, date, and type of crime from local or federal government databases. Police-reported crime is then matched to geocoded home address data by calculating the number of crimes within a specified buffer or area surrounding a home address, commonly a 1-mile buffer. Creation of the buffer and calculation of a crime rate can be completed with commercially available or open-source geospatial software. Prior analyses have found that increasing perceived safety is associated with increased rates of walking (from cross-sectional data) (65), and increasing perceived safety over time has been associated with decreasing adiposity in a longitudinal study (66). For subjective safety, important constructs include perceived safety in walking in one's home neighborhood, perceived neighborhood violence, and perceived safety from crime in the neighborhood. Measurement of perceived safety is often obtained through questions querying respondents about the existence of or their fear of crime in their neighborhood (22,65). The subgroup recommends using the two items that Evenson and colleagues used for perceived neighborhood safety within the Multi-Ethnic Study of Atherosclerosis (65).

Individual social norms and social support. Another aspect of the social environment to consider is the influence of friends and family members on health behaviors and weight management. Observational research suggests that weight gain, weight loss, and related behaviors can spread in social networks (9,10,67), and clinical trials have demonstrated associations between weight loss outcomes and various types of social support and weight-related social norms (68-70). In the adult weight management literature, much of this research has focused on the interdependence of weight among marital dyads; spouses tend to be of a similar weight status at the start of marriage and follow a similar weight gain trajectory over time (71,72) Growing evidence suggests that weight loss tends to have a ripple effect within dyads, with meaningful weight loss observed in the untreated spouses and partners of weight-loss participants (73,74). Thus, the ADOPT environmental domain subgroup recommends that the weights and heights of weight-loss treatment participants' spouses or significant others be directly (i.e., not by self-report) measured. There is also evidence that subjective perceptions of the weight status and eating behaviors of individuals in one's broader social network can influence treatment response and/or intentions to lose weight (69,75). To capture these perceptions, the subgroup recommends the use of Leahey and colleagues' measure of weight-related social norms. This measure taps social norms for overweight (e.g., "How many of your friends and acquaintances are overweight?"), social norms for weight management (e.g., "How acceptable is it in your social circle to lose weight or control your weight?"), and social norms for weight-related behaviors (e.g., "How acceptable is it in your social circle to eat unhealthy foods/large portions?"). The measure has strong psychometrics and predicts weight loss outcomes in behavioral programs (69,75).

In addition to social norms, direct support or lack thereof from others around healthy eating and physical activity change has long been recognized as an important determinant of health behaviors, and the type of support provided by family and friends is known to influence weight loss response. The Social Support and Eating Habits Survey and the Social Support and Exercise Survey (76) are recommended by the ADOPT environmental domain subgroup because they are popular measures used to assess several types of support from family and friends (e.g., encouragement and discouragement of healthy eating; participation in exercise; use of rewards and punishment for exercise) and have demonstrated associations with eating and exercise behaviors (77,78). A recent update by Kiernan et al. suggests that greater support from family and friends at entry in treatment contributes to the likelihood of weight loss success, although a paradoxical effect was found between the absence of friend support and later weight loss success in group-based lifestyle programs (68). A more nuanced exploration of the types of support from household partners linked to weight loss outcomes has found autonomy support (e.g., providing choice and options, listening to the other's perspective) as measured by the Important Others Questionnaire (79) to be a more positive and consistent predictor of 6- and 18-month weight loss outcomes than more directive forms of support measured by the Sallis survey (70). Because these measures assess different aspects of support, the subgroup recommends including both the 23-item Sallis measure and either the 6- or the 12-item version of the Important Others Questionnaire.

Other Environmental Constructs and Measures Considered

Many other aspects of the environment that the ADOPT environmental domain subgroup considered could be explored as potential predictors of adult weight loss and maintenance. Reasons for not recommending other environment constructs and corresponding measures included the following: insufficient evidence for consistent associations with weight-related behaviors (even within cross-sectional studies), low measurement feasibility, and unknown psychometrics for existing measures. For example, the subgroup considered recommending objective measures of food availability and food prices (80) to more precisely measure healthy versus unhealthy food availability and prices near participants' homes. However, food store and/or restaurant audits were determined to be prohibitively expensive to recommend. When resources are available, there are valid and reliable measures available for such constructs that yield more

comprehensive assessments of environments (e.g., Glanz et al., Ohri-Vachaspati and colleagues, Rimkus et al., and Saelens et al. (81-84)). Moreover, we considered food price measures derived from secondary data through companies such as the Council for Community and Economic Research (C2ER, formerly ACCRA) and Nielsen, but these are only available for select areas of the country (e.g., metropolitan areas, market areas) and have no variation within an area. These data could be a resource for those clinical trials conducted across a large number of metropolitan areas covered by these data sources. Similarly, more recent attempts to characterize environments for physical activity have included in-person or remote audits (e.g., through Google Street View) (85-88), but such approaches remain expensive and their added utility relative to the already proposed measures is equivocal.

Other noteworthy, but not yet recommended, environmental constructs considered include the within-home food and activity environments, the neighborhood recreation environment, and the worksite environment. Both objective and subjective measures of home food availability are available, but they are typically long (e.g., $>$ 0.5 hours to complete) and/or have not have undergone more rigorous psychometric testing (89). Evidence also suggests that adults' home neighborhood recreation environment (e.g., the presence of parks, public recreation facilities, or gyms near home) is less related to adults' physical activity than other aspects of the home neighborhood (e.g., walkability) and that the neighborhood recreation environment may influence children's more than adults' physical activity (90,91). Considerable evidence exists regarding worksite interventions for adult weight management (92,93), although many of the interventions have taken an individual-focused rather than environmentally focused approach (94) (for exceptions, see Fernandez et al. (95)). Less is known about whether and which aspects of the worksite environment may impact an individual's ability to initiate or sustain healthy behaviors while engaged in active weight loss or maintenance attempts. In addition, the subgroup recognizes that weather, the light environment, the chemical environment, and other environmental factors may be impactful, but these require further measurement development and evidence of their potential impact on weight and weight-related behaviors. Food marketing conceptualized as environmental factors could be highly influential on food choices and consumption (80), but corresponding measures are complex. More research is needed on the development of subjective and objective measures of media exposure and exposure to other food marketing, including advertisements within food outlets. Finally, there is growing interest in better characterizing the environments in which individuals actually spend their time and are exposed (i.e., their activity space) rather than relying only on measurements of static environments (e.g., the home neighborhood environment) that assume high levels of time spent in the home environments and, hence, high exposure. Given the realities of contemporary living, particularly for working adults, this assumption may not be valid, but more research is needed to reliably measure activity space.

Limitations and Challenges

The ADOPT environmental domain subgroup recognizes the challenges and potential limitations of the recommended constructs and measures. First, the subgroup sought to balance the comprehensiveness and depth of characterizing the environment with the feasibility of including environmental measures within adult weight-loss trials not designed primarily to examine environmental factors or environmental changes. There exist considerably more detailed and high-quality measures of activity environments (e.g., measures of pedestrian infrastructure) and food environments (e.g., measures of the healthfulness of different food stores and restaurants); see the National Collaborative on Childhood Obesity Research's Measures Registry (https://www.nccor.org/nccor-tools/measures/). Even among the measures proposed herein, the feasibility of collecting these measures may differ significantly by investigative team or geographic location. Examination of objective environmental factors has become easier with improvements to the availability of spatial data as well as the tools that help to derive objective environmental measures based on spatial data. Even more user-friendly tools and processes could increase the feasibility of collecting environmental measures and help researchers and practitioners who lack sophisticated spatial methodology expertise. Second, it is also important to note regional and international differences in the availability and detail of administrative and other spatial data. This limits the ability to create the same objective environmental measures across the United States or within other countries -a particular challenge for multicenter trials. Therefore, the ADOPT environmental domain subgroup currently recommends objective measures that rely on existing data with at least broader national availability, but this limits the type and perhaps the quality of the environmental measures that can be recommended. Third, there are likely cultural, socioeconomic, and other biases to the subjective measures of environment, thus requiring more testing to examine their reliability and validity in diverse populations. Such testing may identify additional constructs that are critical to examine among different sociodemographic populations. In addition, only some of the proposed subjective measures have been translated into languages other than English. It is noteworthy that most of the proposed environmental measures were developed for use in urban and suburban settings, so their applicability to rural settings is unknown. Finally, some environmental measures attempt to isolate individual constructs, whereas others are indices that more fully capture various aspects of environments as single overall metrics. For example, indices characterizing aspects of the environment, such as overall walkability or socioeconomic deprivation, may be additive or may be obtained from multivariate analysis of the selected variables (35,61). It is not yet clear how to apply such measures to the smaller sample sizes of many intervention studies, and there is a lack of agreed-upon and standardized metrics applicable across the country.

These limitations may have discouraged researchers investigating adult weight-loss treatment from including environmental measures as potential predictors of success. It could also be that there is little perceived heterogeneity among home neighborhood food or activity environments among individuals in any given weight-loss trial, perhaps particularly for small trials. Yet the ADOPT group now encourages collection of a core set of measures across various domains (biological, behavioral, psychological, and environmental) within all trials to facilitate data pooling and meta-analysis, thus potentially yielding more heterogeneity in participants' environmental data (14). As most weight-loss trials are of relatively short duration, it is unlikely that the set of environmental measures will change during the course of a trial for any individual participant. This may be a larger concern for weight-loss trials that last longer or that enroll more low-income participants, as this population tends

to change residences more frequently. It also may be of greater concern in long-term follow-up for assessment of the maintenance of weight loss, although frequent home address verification could mitigate such concerns.

Looking Forward

Individual response to weight-loss and weight-maintenance treatment is highly variable. To further refine our understanding of environmental influences on adult weight loss and maintenance (e.g., "With whom do they have influence?" and "Which factors are most influential?"), the ADOPT environmental domain subgroup encourages the use of the proposed set of environmental core measures within adult weight-loss trials as the first step in building the empirical evidence base for environmental factors as treatment predictors. More complete details about the proposed ADOPT environmental measures are available in the Grid-Enabled Measures database (https://www.gem-measures.org/workspaces/ADOPT). Environmental factors may explain some of the observed adult weight-loss variation, either alone or in combination with behavioral, biological, or psychosocial factors. For example, perhaps individuals who have the combination of higher self-efficacy for physical activity and living in a more walkable neighborhood are best able to initiate and sustain higher levels of physical activity. There is growing evidence of environmental factors moderating physical activity interventions (96). Consistent measures of environmental factors across a variety of intervention types and intervention settings are vital to determine how much of the variation can be explained by the environment. Such evidence could inform the development of tailored or multilevel interventions that address environmental influences on weight-related interventions. The subgroup specifically decided not to establish a prioritization within the proposed constructs and measures. This first set of recommended constructs and measures should be reevaluated after evidence has been collected on the potential influence of environmental forces. In addition, evidence from research focused on environmental influences on weight-related behaviors should be monitored to consider adding new constructs and measures, including more detailed or comprehensive measures that become more feasible to collect. Whether through direct or indirect effects, identifying environments that are supportive or challenging to initiating or sustaining weight loss and maintenance behaviors has the potential to better inform candidates for treatment success, to inform the need to modify individual-based interventions to better fit the contexts in which participants are embedded, and to inform targets for environmental change. O

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