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Surveillance Systems to Track and Evaluate Obesity Prevention Efforts

Deanna M. Hoelscher, Nalini Ranjit, and Adriana Pérez

Michael & Susan Dell Center for Healthy Living, The University of Texas Health Science Center at Houston, Austin, Texas 78701; email: Deanna.M.Hoelscher@uth.tmc.edu, Nalini.Ranjit@uth.tmc.edu, Adriana.Perez@uth.tmc.edu

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Keywords

population health, obesity policy, body mass index, BMI, school surveillance, *Evaluating Progress of Obesity Prevention Efforts*, EPOP, obesity environmental measures

Abstract

To address the obesity epidemic, the public health community must develop surveillance systems that capture data at levels through which obesity prevention efforts are conducted. Current systems assess body mass index (BMI), diet, and physical activity behaviors at the individual level, but environmental and policy-related data are often lacking. The goal of this review is to describe US surveillance systems that evaluate obesity prevention efforts within the context of international trends in obesity monitoring, to identify potential data gaps, and to present recommendations to improve the evaluation of population-level initiatives. Our recommendations include adding environmental and policy measures to surveillance efforts with a focus on addressing underserved populations, harmonizing existing surveillance systems, including more sensitive measures of obesity outcomes, and developing a knowledgeable workforce. In addition, the widespread use of electronic health records and new technologies that allow self-quantification of behaviors offers opportunities for innovative surveillance methods.

INTRODUCTION

Growing consensus shows that obesity is a systems-level problem and that solutions can come only from approaches that involve the integrated actions of multiple stakeholders (55) within a comprehensive framework that is rooted in the social ecological model (60, 83). Governments, through their ability to set, implement, and monitor policies, have an important role in addressing the obesity epidemic, and many local, state, and nationwide policies and practices are designed to control further increases in the prevalence of obesity. In the United States, the Healthy People 2020 goals set a target of reducing the prevalence of obesity by 10% from 2005–2008 levels, among both adults and youth aged 2–19 years; these goals are among the Leading Health Indicators (LHI) for the nation (52). In addition, several Healthy People 2020 objectives target nutrition and physical activity behaviors or environments that are associated with obesity. Other policy and environmental measures to prevent obesity include initiatives such as the development of national guidelines for physical activity and foods in schools and early care and education (ECE) centers; recommendations for nutrition labeling; federal efforts to increase access to and financing for fresh fruits and vegetables; and changes in the built environment to accommodate increases in walking and bicycling (60).

Evaluating the effectiveness of population-wide initiatives requires data systems that are timely and actionable and include both behavioral and environmental determinants as well as reliable measures of obesity. The importance of these strategies as part of an overall surveillance system was emphasized in the Health and Medicine Division (HMD) of the National Academies of Sciences, Engineering, and Medicine (formerly the Institute of Medicine) reports *Progress in Preventing Childhood Obesity: How Do We Measure Up?* (65) and *Evaluating Obesity Prevention Efforts: A Plan for Measuring Progress (EPOP)* (58). The EPOP report, in particular, stresses the importance of a national plan that includes a coordinated system with designated leadership and resources to prioritize, implement, and oversee the surveillance process; identification of data sources; harmonization of existing data and surveillance systems; and effective presentation of data to end users (58). Routinely collected surveillance data are also emphasized as an important source of evidence and external validity in the HMD's Locate Evidence, Evaluate It, Assemble It, and Inform Decisions (L.E.A.D.) Framework, which has been proposed to bridge the evidence gap in the context of evaluating environmental and policy measures targeting obesity (57, 67). More recently, the HMD report *Assessing Prevalence and Trends in Obesity: Navigating the Evidence* (74) identifies challenges in collecting data and assessing trends, with a framework to address the goals of the end user.

Despite the importance of obesity surveillance in directing prevention efforts, few reviews have investigated the potential for strengthening existing surveillance systems. The objectives of this review are to (a) describe the current goals and structures of existing surveillance systems in the United States; (b) examine current international trends in obesity surveillance; (c) present examples of data that evaluate population-based obesity initiatives; and (d) review current opportunities for improving surveillance methods.

FRAMEWORK FOR OBESITY SURVEILLANCE SYSTEM EFFORTS

Models for the evaluation of obesity prevention efforts (58, 65) emphasize a systems-level approach, in which various sectors such as government, industry, health care, communities, work-sites, schools/ECE centers, and homes are targeted for obesity initiatives. Ultimate impacts include improvement of population-level health and health equity through the reduction of overweight and obesity prevalence and/or decreased incidence. Antecedents to overweight and obesity include behavioral outcomes related to energy balance such as diet, physical activity, and other individual

obesity-related behaviors as well as psychosocial factors. In addition to individual factors, these evaluation frameworks (58, 65) focus on the assessment of upstream determinants, such as the environments, institutions, systems, and policies that influence more proximal outcomes, which are the focus of recent obesity prevention efforts (60). The HMD's 2012 *Accelerating Progress in Obesity Prevention (APOP)* report, for example, targets five specific goals to advance progress in obesity prevention by addressing messaging, food and beverage, physical activity, school, and worksite/health care environments (60). Implementation of interventions at the systems or policy level can have broad population impact and is consistent with the focus on population health (58, 60, 63).

Shifting obesity prevention efforts toward broad environmental targets presents both opportunities and challenges. First, the relations between these environments and individual outcomes have historically been difficult to determine, and they rely on robust surveillance or study designs that can establish causality. Recent strides in the development and evaluation of environmental assessment tools have increased both the precision and the utility of these instruments for research and surveillance (44). Effective evaluation of environmental or policy interventions requires ongoing assessment of adoption and implementation as well as periodic surveillance of individual-level data over the life of the intervention using prospective study designs (91). Assessment of environmental factors that influence obesity-related outcomes can also highlight health equity issues that may be obscured when focusing on individual factors alone. Finally, although many current prevention efforts focus on policy, systems, and environmental interventions, most surveillance is conducted at the individual level (58).

CURRENT OBESITY SURVEILLANCE DATA SOURCES AND SYSTEMS

Surveillance, defined as “the ongoing systematic collection, analysis, and interpretation of data tracked over time to detect patterns, disparities and changes that may be associated with interventions or other causes” (58, pp. 2, 19), refers to data collected from populations over two or more points in time. The term surveillance has traditionally meant assessment, i.e., characterizing the scale and distribution of a problem, but the term is increasingly used to refer to an overall decision-making cycle that includes collection, review, and use of the data to make appropriate changes in policy or programmatic efforts (58, 96, 101).

In general, most existing obesity surveillance systems in the United States use data to monitor trends in populations and collect a limited number of anthropometric measures, such as height and weight data used for calculating body mass index (BMI). Data on behavioral antecedents of obesity, such as diet and physical activity, may come from the same surveys or other national data sets. Behavioral measures often tend to be self-reported, although some surveys use objective measures such as accelerometry to assess physical activity. High-risk populations, e.g., demographic or health status subgroups, are often not adequately represented in national or state-level surveys (58). Most surveillance does not include the measurement of policy or environmental factors, although recent efforts have been made to include some of the contextual factors that may influence obesity (58). Because the behavioral and environmental determinants of obesity can be varied, relevant assessments involve surveys from other sectors or disciplines that can be difficult for health researchers to access.

Surveillance of Obesity Prevalence and Individual-Level Risk Factors

Several surveillance systems with differing purposes and types of data support monitoring of obesity and related risk factors at the individual level (**Table 1**). Data from many of these surveys serve as benchmarks for Healthy People 2020 goals (49). A more complete listing of surveillance systems in the United States can be found in the *EPOP* report (58) or through the searchable

Table 1 Examples of national surveillance and evaluation systems in the United States (adapted from Reference 58)

Data source and website	Sponsor	Frequency of data updates	Sample design and sample size	Target population (or components)	Level of estimates or data available	Comments
Surveillance systems that assess predominantly individual factors						
National Health and Nutrition Examination Survey (NHANES) (15) http://www.cdc.gov/nchs/nhanes/	CDC	Every year	National sample of adults and children	Children and adults in the United States	National	Diet and activity behaviors
Behavioral Risk Factor Surveillance System (BRFSS) (19) http://www.cdc.gov/brfss/	CDC	Every year	National sample of adults	Adults in the United States, DC, and US territories	National State	Physical activity Consumption of fruits and vegetables Obesity and overweight
Youth Risk Behavior Surveillance System (YRBSS) (26) http://www.cdc.gov/HealthyYouth/data/yrbbs/index.htm	CDC	Every 2 years	National survey of high school students	Youth and young adults	National State Community	Nutrition and physical activity behaviors
National Health Interview Survey (NHIS) (28) http://www.cdc.gov/nchs/nhis/	CDC	Every year	National sample of adults	Children and adults in the United States	National	Physical activity behaviors
Health and Diet Survey (32) http://www.fda.gov/Food/FoodScienceResearch/ConsumerBehaviorResearch/ucm193895.htm	HHS/FDA	Periodic 1982–2008	Cross-sectional random-digit-dial telephone survey	Noninstitutionalized adults in 50 states and DC	National	Consumer knowledge, attitudes, and dietary practices
National Consumer Panel (formerly known as AC Nielsen Homescan) http://www.ncppanel.com/content/ncp/ncphome.html	IRI and Nielsen	Ongoing	National sample of US adults	Adults in the United States	National	Purchase of foods and beverages recommended in Dietary Guidelines for Americans
National Household Travel Survey (NHTS) http://nhts.ornl.gov/	US DoT	Periodic 1969–2009	National sample of adults	Adults in the United States	National	Active commuting to school Bicycling by adults

National Vital Statistics System (23) http://www.cdc.gov/nchs/nvss/	CDC	Every year	50 states, DC, NYC, Puerto Rico, the Virgin Islands, Guam, American Samoa, Commonwealth of the Northern Mariana Islands	Children and adults in the United States	National State	Birth weight Gestational weight gain Maternal prepregnancy weight
Early Childhood Longitudinal Study–Birth (ECLS-B) and –Kindergarten (ECLS-K) https://nces.ed.gov/ecls/	DoED	2 previous cohorts: 2001 birth cohort; 1998–1999 K-cohort followed through eighth grade 2010–2011 K-cohort followed through fifth grade	National sample of children in three cohorts Longitudinal follow-up	Children from birth or kindergarten through middle school	National	Measured height and weight Food consumption at home and school
National Survey of Children’s Health (NSCH) http://childhealthdata.org/learn/NSCH	CDC	Periodic 2003–2012	National sample of US children	Children in the United States and DC	National State	Physical activity behaviors, attitudes, and perceptions Breastfeeding
National Household Education Surveys (NHES) program http://nces.ed.gov/nhes	DoED	Every other year	Provides descriptive data on the educational activities of the US population and offers researchers, educators, and policy makers a variety of statistics on the condition of education in the United States	Preschool-age children through adults	National Regional	Early child care Before- and after-school care of school-age children

(Continued)

Table 1 (Continued)

Data source and website	Sponsor	Frequency of data updates	Sample design and sample size	Target population (or components)	Level of estimates or data available	Comments
Surveillance systems that assess predominantly individual factors						
Early Head Start Family and Child Experiences Survey (Baby FACES) https://www.acf.hhs.gov/opre/research/project/early-head-start-family-and-child-experiences-study-baby-faces	HHS/ACF	Periodic 2007–2014	Cohort study (through age 3 years) Representative sample of 89 Early Head Start programs in 2009 and 2 cohorts of families: (a) a perinatal group and (b) a group of infants about 1 year old	Children in Early Head Start	National	Breastfeeding Infant feeding practices Diet and activity behaviors Child care
Head Start Family and Child Experiences Survey (FACES) http://www.acf.hhs.gov/programs/opre/research/project/head-start-family-and-child-experiences-survey-faces	HHS/ACF	Periodic 1997–2013	Cohort study Samples of Head Start families, children, and programs 65 programs, 130 centers, 486 classrooms, and 3,718 children in 2009 FACES	Children in Head Start	National	Diet and activity behaviors Child care
National Immunization Survey (NIS) (22) http://www.cdc.gov/vaccines/imz-managers/nis/index.html	CDC	Every year	National sample of child vaccination providers	Children in the United States	National State	Breastfeeding disparities
Infant Feeding Practices Study II (IFPS-II) (16) http://www.cdc.gov/breastfeeding/data/ifps/index.htm	CDC	2005–2007; 2012	Longitudinal survey of women and their infants	Infants during their first year of life and their mothers; six-year follow-up study	National	Employer lactation support programs Gestational weight gain Maternal pre- and postpregnancy weight
Surveillance systems that assess predominantly environments						
School Health Policies and Practices Study (SHPPS) (17) http://www.cdc.gov/healthyyouth/data/shpps/index.htm	CDC	Periodic	State and district levels (2012) School and classroom levels (2014) All levels (1994, 2000, 2006)	School health policies and practices in US schools	National State	

School Nutrition Dietary Assessment (SNDA) study (102) http://www.fns.usda.gov/school-nutrition-dietary-assessment-study-iv	USDA	Periodic	National survey of US school districts	School nutrition programs	National	
Classification of Laws Associated with School Students (CLASS) http://class.cancer.gov/	National Cancer Institute	Periodic	Provides scoring of state-level codified laws for physical education and nutrition in schools	Children in United States	National State	Water and sugar-sweetened-beverage school policies
National Survey of Maternity Practices in Infant Nutrition and Care (mPINC) (20) http://www.cdc.gov/breastfeeding/data/mpinc/index.htm	CDC	Every two years	Survey of US facilities that routinely provide maternity care services	Maternity and breastfeeding practices in the United States	National State	
Studies of Child and Adult Care Food Program (CACFP) (105) http://www.fns.usda.gov/cacfp/child-and-adult-care-food-program	USDA/FNS	Child Care Food program began in 1968; name changed in 1990	Day care programs with CACFP	Children and adults receiving day care services in CACFP	Children to age 18 years and adults	Child care meals and snacks Adult day care meals and snacks
Studies of Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) participants (104) http://www.fns.usda.gov/Ora/menu/Published/WIC/WIC.htm	USDA/FNS	Biennial since 1992 (multiple studies)	Cross-sectional Varies by survey	Participants in WIC	National	Breastfeeding Infant-feeding practices WIC policies and practices

(Continued)

Table 1 (Continued)

Data source and website	Sponsor	Frequency of data updates	Sample design and sample size	Target population (or components)	Level of estimates or data available	Comments
Surveillance systems that assess predominantly environments						
SNAP Policy Database (103) http://www.ers.usda.gov/data-products/snap-policy-database.aspx	USDA	Periodic	50 states and DC (data provided from January 1996 through December 2011)	State SNAP-Ed programs	State	
National Household Food Acquisition and Purchase Survey (FoodAPS) (107) http://www.ers.usda.gov/data-products/foodaps-national-household-food-acquisition-and-purchase-survey.aspx	USDA/ERS	2012	Cross-sectional study of households, seven-day diaries of foods purchased/acquired at home and away from home	Supplemental Nutrition Assistance Program (SNAP) participants and non-SNAP participants	National	Food environment Food purchases and shopping behavior Food security
Food Environment Atlas (106) http://www.ers.usda.gov/data-products/food-environment-atlas.aspx	USDA/ERS	Ongoing	Assembles statistics on food environment indicators	Varies	Varies	Food environment
State and Local Area Integrated Telephone Survey (SLAITS) (18) http://www.cdc.gov/nchs/slatis.htm	USDA/CDC	Periodic	Random-digit-dial supplement drawn from the National Immunization Survey sample frame	Adults and children (depending on survey year)	State Local area	Health care
National Survey on Energy Balance-Related Care among Primary Care Physicians (75) http://healthcaredelivery.cancer.gov/energy_balance/	NIH	2008	National survey of primary care physicians	Children and adults in the United States	National	Health care
Healthcare Effectiveness Data and Information Set (HEDIS) http://www.ncqa.org/hedis-quality-measurement	NCQA	Every year	Assembles statistics on US health plans	Obesity screening and prevention metrics	National Regional State	

National Ambulatory Medical Care Survey (NAMCS) (21) http://www.cdc.gov/nchs/ahcd/	CDC	Every year	National sample of visits to emergency and outpatient departments	Healthy lifestyles patient programs	National
National Profile of Local Health Departments (50) https://www.healthypeople.gov/2020/data-source/national-profile-of-local-health-departments	HHS	Periodic	Survey of local health departments in the United States	US health department nutrition- and physical activity-related services	National
National College Health Assessment (NCHA) http://www.acha-ncha.org/	American College Health Association	Every semester	National sample of students at participating two- and four-year US colleges	College students in the United States	National
National Survey of Employer-Sponsored Health Plans (51) https://www.healthypeople.gov/2020/data-source/national-survey-of-employer-sponsored-health-plans	HHS	Every year	Survey of employers in the United States	Employer-sponsored health plans in the United States	National
					College nutrition and physical education
					Employee health promotion

Abbreviations: ACF, Administration for Children and Families; CDC, Centers for Disease Control and Prevention; DC, District of Columbia; DoED, Department of Education; DoT, Department of Transportation; ERS, Economic Research Service; FDA, Federal Drug Administration; FNS, Food and Nutrition Service; HHS, Health and Human Services; NCQA, National Committee on Quality Assurance; NIH, National Institutes of Health; NYC, New York City; SNAP-Ed, Supplemental Nutrition Assistance Program-Education; USDA, US Department of Agriculture.

NHANES: National Health and Nutrition Examination Survey

CDC: Centers for Disease Control and Prevention

BRFSS: Behavioral Risk Factor Surveillance System

YRBSS: Youth Risk Behavioral Surveillance System

catalog maintained by the National Collaborative on Childhood Obesity Research (NCCOR) (73). Several of the most common surveys are described below.

National-level surveillance. The National Health and Nutrition Examination Survey (NHANES), which is overseen by the National Center for Health Statistics (NCHS) at the Centers for Disease Control and Prevention (CDC), provides the most comprehensive individual-level data on obesity and related behaviors (58). The NHANES is a series of national-level cross-sectional surveys that have been administered at irregular intervals since the 1960s and on a rolling basis since 1999, with data released in two-year increments. The current NHANES survey includes all ages, from infants 2 months of age to adults. Obesity data from the NHANES are based on measured height and weights and provide benchmarks for current trends for adults (ages 20 years and above), children (ages 2–19 years), and infants/toddlers (<2 years). However, the sample weighting scheme allows only an estimation of BMI across broad age, gender, and racial/ethnic categories. For example, the NHANES divides children into age categories of 0–2, 2–5, 6–11, and 12–19, which do not correspond to child developmental levels and thus limit the use of these data in evaluating intervention strategies. In addition to collecting height and weight data, the NHANES collects detailed dietary and physical activity behaviors as well as other biologic information (27).

The Early Childhood Longitudinal Study (ECLS) is one of the few nationally representative cohort data sets with information on child BMI obtained from measured height and weight. The program includes three separate longitudinal studies, one from birth to kindergarten, one from kindergarten to eighth grade, and one from kindergarten through fifth grade. ECLS data have been used to examine BMI trajectories (37), as well as individual obesity-related risk factors such as self-reported dietary intake, physical activity, and screen time (30). The National Longitudinal Study of Adolescent Health (Add Health) also collected data from a nationally representative sample of adolescents in grades 7–12 in the United States over 4 measurement waves from 1994–1995 through 2008–2009, i.e., from adolescence (ages 12–20) through the transition to adulthood (ages 24–32) (<http://www.cpc.unc.edu/projects/addhealth>). In addition to repeat measures of height, weight, diet, physical activity, and use of health care services, the Add Health data set is longitudinally geocoded, allowing investigators to assess responses to local obesity environment and policy effects (77).

State-level surveillance. The Behavioral Risk Factor Surveillance System (BRFSS) and the Youth Risk Behavioral Surveillance System (YRBSS) provide national- and state-level survey data and are conducted by the CDC (19). The BRFSS survey is administered annually to ~500,000 adults (ages ≥18) over the telephone and includes self-reported height and weight data as well as behavioral measures. All states and US territories are included in the survey, and statistical weights are provided to allow estimates of obesity prevalence at the state level. BRFSS data also provide data by selected metropolitan and micropolitan statistical areas (MMSAs) (25). BRFSS data have been used to plot state trends in obesity prevalence; in fact, the Obesity Trend Maps using BRFSS data were among the most powerful tools used to identify the rapid increase in obesity among the states (**Figure 1**). Because the BRFSS allows estimates to be generated at the state level and is conducted continuously, these data are useful in identifying population trends and effects of any statewide initiatives (58). However, self-reported BRFSS data are subject to bias. For example, the national adult obesity prevalence estimates from the NHANES are often higher than those reported for the BRFSS (34.9% in NHANES 2011–2012 versus 28.1% in BRFSS 2012) (19, 80).

The YRBSS, conducted by the CDC, obtains data for six health risk behaviors, including self-reported height and weight, dietary behaviors, and physical activity behaviors, from US high school students at national and state levels. Data are collected every two years among

Obesity trends* among US adults BRFSS, 1990, 2000, 2010

*BMI ≥ 30 , or about 30 lbs overweight for a 5'4" person

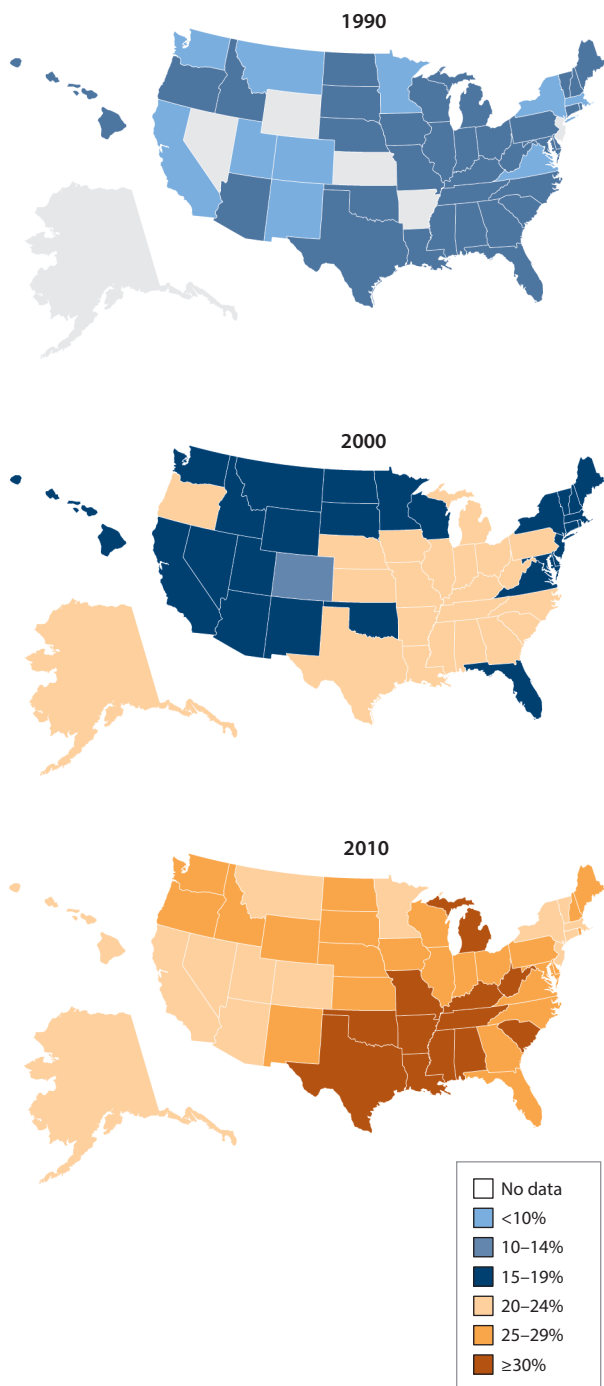


Figure 1

Use of Behavioral Risk Factor Surveillance System (BRFSS) data to highlight the rapid increase in obesity from 1990 to 2010. Source: Reference 24.

ninth- through twelfth-grade students and allow for stratification by race/ethnicity and gender (26). As with the BRFSS, the YRBSS data allow investigators to estimate state-level prevalence rates for most states and some large urban districts.

The National Survey of Children's Health (NSCH) (6) includes parent-reported height and weight data on children aged 0–17 years at national, regional, and state levels. Data were collected at three different time points from 2003 to 2012, but annual data collections are planned from 2016 onward (see <http://childhealthdata.org/learn/NSCH>). The validity of parent-reported data varies depending on the age of the child and race/ethnicity (46, 47) but may be improved if parents are asked to measure their children at home before providing height and weight data (56).

Local- or regional-level surveillance. Because most national data sets are of limited utility in evaluating initiatives at local levels, several local surveillance systems have emerged. School-based surveillance systems, which typically span entire states, offer several advantages. Because a majority of US children attend schools, most children can be reached through this setting; obesity measurements can be incorporated into other school-based screenings; and school-level obesity data can be used to evaluate specific school-based policy changes and programs, as well as to identify subgroups at greatest risk of obesity (69, 78, 79). BMI data are often collected as part of an overall physical fitness assessment, such as FITNESSGRAM® (109); however, data from physical fitness assessments can be more variable and subject to error compared with standard surveillance measures (62). Often, school-based assessments provide population data, as well as individual screening, i.e., notifying parents if their children are overweight or obese. Screening at school can be problematic, though, because of parent confusion about BMI categories and the lack of community resources for referrals (78). To date, legislation mandating some form of BMI surveillance and/or screening programs has passed in 25 US states (86), although not all of these states have an active school-based surveillance program: A recent study found that only 14 states collect BMI data that can be used for public health surveillance, and 13 of those programs are school-based (5). Concerns about privacy, stigmatization, and the possibility of dysfunctional behavioral responses such as eating disorders have been raised about school-level BMI surveillance, and schools are increasingly sensitive to these concerns (70).

Health systems data. The use of electronic health record (EHR) data for monitoring of population health, clinical research, and improved patient care has accelerated owing to the meaningful use initiative in the United States (7). Data sharing across multiple institutions for child obesity surveillance is feasible and produces data similar to that obtained in national surveys (3). In adults, weight data obtained through EHRs has been highly correlated with data obtained from trained research staff (1).

One example of the utility of EHRs is the Nationwide Inpatient Sample (NIS), the largest publicly available all-payer inpatient health care database in the United States (48), which includes individuals covered by Medicare, Medicaid, or private insurance, as well as those who are uninsured. Although findings from such special-purpose data sets are not generalizable to the general population, the populations they represent are often at-risk; therefore, these data sets can be a way to study health disparities.

Surveillance of Obesity Environments and Policy

Within the past 10 years, research on environmental determinants of obesity has accelerated, largely owing to the growing evidence connecting these factors, including policy, to obesity outcomes (60), as well as to the recognition that a healthy weight and related behaviors are difficult

to sustain in current food and physical activity environments that promote energy imbalances (34, 39, 60, 90, 98).

Environmental and Policy Measures

Assessing environments can be difficult and presents numerous methodological challenges, owing to the broad reach and the diffuse and confounding nature of multiple influences and levels in real-world settings (90). Evaluation of policies related to obesity prevention should include measures of adoption and implementation, as well as prospective study designs (72, 91). Several recently developed measures provide valid and quantifiable data for the environment (**Table 2**). These measures include, among others, policy analyses collected by Bridging the Gap (34); the Nutrition Environment Measures Survey (NEMS), which provide observations and quantifications of food availability at restaurants, stores, and vending machines (45; <http://www.med.upenn.edu/nems/measures.shtml>); school and ECE policy measures (WellSAT and WellCCAT) (41; <http://www.wellsat.org/>); and the environment and policy assessment and observation (EPAO) designed for ECE centers (108), as well as observations of the built environment or neighborhoods using geographic information systems (GIS). Active Living Research (<http://activelivingresearch.org/>) and Healthy Eating Research (<http://healthyeatingresearch.org/>) both provide links to environmental measures for physical activity and nutrition, respectively, as well as relevant research in these areas (89). The NCCOR measures registry also provides listings of measures for the food and physical activity environment, with a focus on child obesity (73).

Environmental and Policy Surveillance

In 2013, the *EPOP* report provided a list of 83 indicators derived from current surveillance systems and databases, which can be used to evaluate obesity prevention efforts (58). Notably, this list of indicators emphasizes contextual measures, which comprise environmental, policy, and setting-specific indicators. Because of the relatively recent focus on environmental determinants of health as obesity intervention targets, few surveillance systems have been developed specifically for this purpose. Some of the most comprehensive measures of environment and policy are at the school level, likely owing to the established public school infrastructure and federal regulations regarding food and physical activity. The School Health Policies and Practices Study (SHPPS), conducted by the CDC, evaluates school health and environment in a nationally representative sample of schools at all levels (elementary, middle, high school) (17). Also conducted at a national level, the School Nutrition Dietary Assessment (SNDA) study assesses the implementation of the federal school meal standards, as well as other related food policies and programs (102). The Classification of Laws Associated with School Students (CLASS) survey collects data about laws regarding school nutrition and physical activity environments at the state level (see <http://class.cancer.gov/>). These data are then compared with national standards, and a state profile tool allows end users to view the strength of school laws relative to these standards.

Other national surveillance systems collect data that examine active transport and/or the built environment and track obesity-related policies, policies and practices for infants and preschool children, and practices and environments in health care settings (**Table 1**). Thus, multiple sources of data to assess obesity-related environments exist but differ in periodicity, populations, and sampling units. Evaluation using these data involves manipulating large data sets and complicated analytic techniques, which can be challenging. Several compilations of obesity and obesity-related environmental data have recently been developed, including the

Table 2 Examples of measurement tools and research methods to assess food and physical activity environments

Tool/method	Type of environment	Description
Physical Activity and Media Inventory (PAMI) (97)	Home	Parent reports of the availability and accessibility of physical activity and media equipment in the home.
System for Observing Play and Leisure Activity in Youth (SOPLAY) (71)	Free-play settings such as playgrounds and fields	Physical environmental variables included type of location; size of play space; presence of structural improvements; presence of equipment such as balls; presence of supervision; and weather.
Checklist for Health Environments at Work (CHEW) (81)	Worksite	Worksite physical attributes such as the presence of exercise equipment and showers, stairs, and bicycle parking and surrounding attributes including distance to parking, walking, or cycling trails, and access to health clubs. Information environment also assessed.
Neighborhood Environment Walkability Scale (NEWS) (88)	Neighborhood	Assesses residential density, land use mix diversity and access, street connectivity, infrastructure, traffic and crime safety, and aesthetics.
Walkability Index (http://health-design.spph.ubc.ca/tools/walkability-index/)	Neighborhood	Includes four components of the physical environment: residential density, commercial density, land use mix and street connectivity.
Home Food Inventory (43)	Home	Assesses availability of 13 major healthy and unhealthy food categories and accessibility of two food categories in the kitchen and the refrigerator.
NEMS (Nutrition Environment Measures Survey) tools for different community and consumer nutrition environments (http://www.med.upenn.edu/nems/measures.shtml)	Stores, restaurants, corner stores, vending machines, perceived nutrition environment	Series of observational measures to assess availability of healthful and unhealthful choices, prices, and quality at each of various consumer nutrition environments.
Nutrition and PA Self-Assessment for Child Care (NAPSACC) (4)	Practice and policy environment at early care and education (ECE) centers	Questions assess the extent to which child care center practices and policies related to nutrition and physical activity are in accord with evidence-based practices or state/federal policies.
Wellness School Assessment Tool (WellSAT) (94)	Practice and policy environment at schools	Self-assessment of the quality of their school district's written wellness policies relating to supports for nutrition, physical activity and reduced sedentary behavior.
Wellness Child Care Assessment Tool (WellCCAT) (42)	Practice and policy environment at ECE centers	Provides a standard method for the quantitative assessment of nutrition, physical activity, and wellness policies written in parent handbooks, staff handbooks, and other child care center policy documents.
School Health Policies and Practices Study (SHPPS) (17)	Policy and practices relating to health in the school environment	Series of surveys designed to assess school and classroom policies and practices related to multiple domains, including but not limited to healthy and safe school environments, nutrition services, and physical education and activity.
EPAO (Environment and Policy Assessment and Observation) (9)	Practice and policy environment at ECE centers	One-day observation of several domains, including types of foods served to children, staff mealtime interactions, physical activity and sedentary opportunities, staff support, and the physical environment.

Community Commons (<http://www.communitycommons.org/>), the Health Indicators Warehouse (<http://www.healthindicators.gov/>), and the US Department of Agriculture Food Environment Atlas (<http://www.ers.usda.gov/data-products/food-environment-atlas.aspx>). Users can access these resources to obtain data at various levels (e.g., state, county) as well as maps or graphs.

Despite recent advances, there are still gaps in the availability of both indicators and surveillance systems for areas such as community-level estimates of obesity-related environments, policies, programs, partnerships, and social norms; community-based physical activity programs; surveillance of local policies on nutrition standards for foods and beverages in the ECE setting; community-level data on exposure to food marketing; national- and community-level data on worksite programs; and obesity-related policies on college campuses (58).

EVALUATING OBESITY PREVENTION EFFORTS

In a recent paper in the *Lancet*, Brownell & Roberto (11) call for a greater role for strategic science in obesity research, defined as research to address gaps in knowledge important to policy makers. Surveillance systems can provide data to address these gaps, but it is difficult to evaluate changes in obesity prevalence resulting from specific policy measures. For example, the SHPPS collects data from a representative sample of schools approximately every six years, the latest data collection taking place in 2014 (10, 17). Although the SHPPS has been useful in mapping school policies, the data have limited utility for several reasons: (a) Data are not collected at a local level, (b) the time period between data collections is lengthy, and (c) child BMI data are not collected concurrently. If surveillance systems can be expanded to provide data for specific policy or environmental interventions for local municipalities, there is a greater likelihood that such evidence will be utilized in the development of statewide or national policies and therefore will have a more sustained effect on obesity initiatives.

Examples of Obesity Policy Evaluation Using Surveillance Data

For various reasons, national-level obesity prevention policies, however well intentioned, often fail to yield a significant effect on the targeted outcomes (114). Moreover, national-level policies tend to be modest in scope and hedged by many competing interest groups. We need to assess policy implementation, as well as complementary or supportive policies, both of which can promote the effectiveness of other approaches and strengthen ultimate impact (90, 91, 114).

In this context, policies enacted at the local level are usually far more innovative and precisely targeted and can be implemented in supportive communities (85). School policies are a good example of local-level mandates. A wide variety of policy options are available to schools, and these options can be legislated at several levels: state, municipal, or school district (33, 34). For example, one study examined the relation between state laws regulating the nutrition content of “competitive foods” (e.g., foods sold at schools outside of the reimbursable meals) and adolescent weight gain (100). Using data from the ECLS to examine BMI changes from fifth to eighth grade (2003–2006) among 6,300 children in 40 states, investigators found more favorable weight trajectories among children in states that had strong and consistent nutrition standards, relative to states with no laws or weak and inconsistent laws. In a review of competitive school food-and-beverage policies, 6 of 24 studies used outcome data from a variety of nationally representative surveys of students and/or school officials, such as the ECLS-K, the NSCH, and the National Youth Physical Activity and Nutrition Survey (NYPANS) conducted by the CDC (33). Nationwide data on high school students from the YRBSS for 1999, 2001, and 2003 were merged with state

policy data from several sources and used to demonstrate that participation in physical education (PE) classes for boys and girls was positively correlated with both a PE unit requirement and a state PE curriculum. State spending on parks and recreation was positively correlated with girls' overall physical activity (14).

In a California-based study, 10 years of routinely collected school FITNESSGRAM® data from more than 2 million fifth-grade students in approximately 5,000 public schools were used to demonstrate a reduction in obesity after the introduction of laws governing the nutritional content of competitive foods and beverages (92). The sample was large enough to allow the researchers to demonstrate that the amount of reduction in overweight/obesity prevalence was greater in schools of higher socioeconomic status.

Data from the Texas School Physical Activity and Nutrition (SPAN) surveillance study were used to evaluate outcomes of a natural experiment that included local implementation of community and school programs combined with media messages targeting obesity in a large regional population, i.e., El Paso, Texas. SPAN data from 2004–2005 found significant decreases from 2000–2002 in the prevalence of obesity among fourth-grade students in El Paso (54). Furthermore, compared with a similar border region in Texas (Rio Grande Valley) without changes in obesity prevalence, there were significant increases in sports team participation, reductions in television viewing time, better meal patterns, and greater consumption of milk/yogurt and cereal; however, there was no relation with sugary beverages or fruit/vegetable consumption (40). By the time the 2009–2011 SPAN survey was administered, however, obesity prevalence in fourth-grade students in El Paso had reverted to preintervention levels, perhaps reflecting a reduction in funding for community initiatives in El Paso after 2008 (**Figure 2**). Case studies such as this one are useful in determining policy outcomes but would provide stronger evidence if coupled with more robust surveillance of programs and policies.

INTERNATIONAL EFFORTS FOR OBESITY SURVEILLANCE

An awareness of obesity surveillance systems outside of the United States is important to understanding how obesity trends relate to those in other countries. Data from other countries can also provide insights into opportunities and trends in assessment methodologies that may have relevance for US approaches.

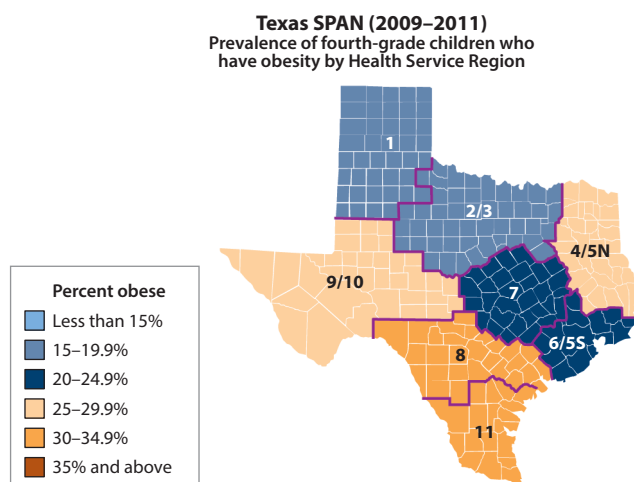
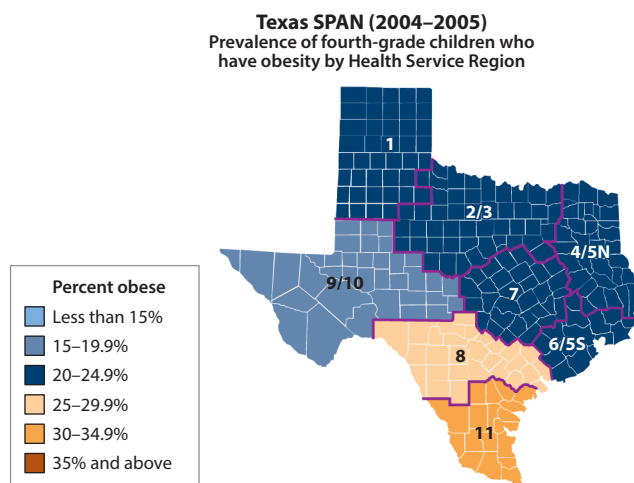
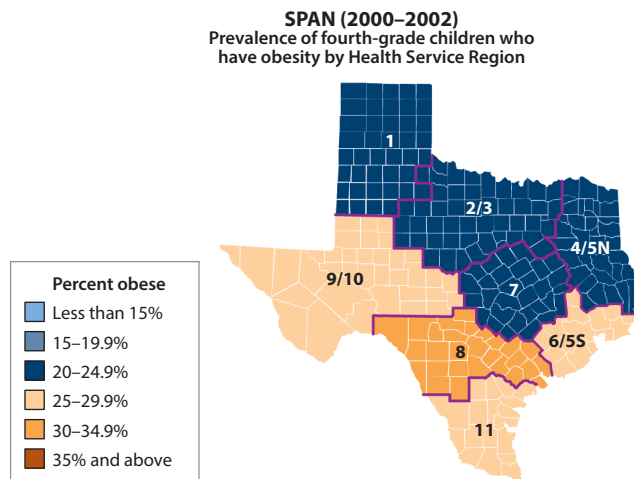
Individual-Level Data

Most data on obesity prevalence and trends in the developing world have been obtained by multicountry surveillance programs. The Demographic and Health Surveys (DHS), with funding from the US Agency for International Development (USAID; <http://www.dhsprogram.com/>), are part of the DHS program that seeks to improve and institutionalize the collection and use of data by host countries for program monitoring and for policy decisions. DHS surveys include objectively measured height and weight data for children under age 5 as well as for adults, along with some measures of dietary intake. Similar to the DHS, the World Health Surveys (WHS) have been implemented by the World Health Organization (WHO) with the intent of obtaining valid and reliable health data according to a standard protocol from multiple countries representing major regions of the world (111).

Recently, there has been a move by the European member states of the WHO to standardize data collection across European countries. In 2006, the WHO Regional Office for Europe initiated the WHO European Childhood Obesity Surveillance Initiative (COSI) with 13 member states (112). The COSI protocol was started in response to a perceived need for nationally

Figure 2

Use of School Physical Activity and Nutrition (SPAN) obesity surveillance data in Texas to highlight child obesity trends in fourth-grade students from 2000–2002 to 2009–2011.



representative and standardized data on obesity prevalence among primary-school children in European countries (68). It includes direct measurement of children's heights and weights, along with survey information on numerous individual-level risk factors related to obesity.

Environmental-Level Data

In 2008, the WHO released the report, *A Framework to Monitor and Evaluate Implementation: WHO Global Strategy on Diet, Physical Activity and Health* (110). This report identified indicators that assess not only outcomes such as obesity, diet, and physical activity, but also a variety of environmental and policy measures, including political will, cultural climate, dietary and activity norms, and legislative efforts. Environmental measures are being incorporated into existing surveillance systems, such as the COSI protocol, which includes detailed school environmental measures as an option (112, 113).

The International Network for Food and Obesity/Noncommunicable Diseases Research Monitoring and Action Support (INFORMAS) was formed to accelerate the creation of healthy food environments through monitoring, benchmarking, and supporting related governmental and private efforts (99). Food environments in this context are defined as physical, economic, policy, and sociocultural and focus on governmental policies and actions as well as private-sector policies and actions (66, 99). The project is currently working on developing protocols, databases, and data systems and pilot testing (99). The completed modules will eventually be available for countries to use to collect comparable data. The INFORMAS program is a good model for international collaboration and coordination for food environment surveillance systems.

HOW CAN WE IMPROVE CURRENT SURVEILLANCE SYSTEMS AND DATA?

Current surveillance methods and infrastructure need to (a) become more nimble in responding to research findings, (b) provide data that are sufficiently timely and precise to evaluate obesity policies and programs at different geographic levels, and (c) link these data to policy measures. Below, we propose enhancements to existing surveillance systems that can maximize their utility.

Increase the Number and Scope of Environmental Measures and Surveillance Systems

Although much work has been focused on developing and evaluating environmental measures for food and physical activity environments, research and implementation gaps still exist. Recommendations from an expert meeting on environmental and policy research on obesity, physical activity, and diet call for surveillance systems with good measures of the environment, policy surveillance measures, and systems; surveillance to track changes in food industry activities over time; attention to minority and low-income populations; and measures of valuation (91). Another review identified gaps in research related to macroenvironments (city or larger) and within economic and political microenvironments in home, workplace, and neighborhood settings (64). To address these issues, greater surveillance infrastructure is needed at the local and state levels, where these policies are often implemented first.

Considerations for socially disadvantaged and culturally diverse populations are often not adequately incorporated into surveillance systems and measures. Low numbers or regional locations of underserved populations, insufficient provisions for differences in language or culture, and lack of infrastructure must be anticipated, and surveillance systems should be monitored to be sure these elements are addressed (58).

Harmonize Data Across State and National Surveillance Systems

Harmonization of data can be accomplished by coordinating efforts and standardizing protocols across different surveillance and evaluation structures to minimize duplication of effort, leverage resources, and maximize data use (58). Coordinating data sources can allow for pooling of data from different sources, leading to increased sample sizes that can facilitate the analyses of obesity determinants and consequences for underrepresented groups. Consistency of obesity-related measures is emphasized in the report *Assessing Prevalence and Trends in Obesity: Navigating the Evidence* (74), which proposes (a) use of the new Assessing Prevalence and Trends framework, which integrates end user perspectives with assessment considerations; (b) designation of a national convener to organize stakeholders to standardize data collection methodologies; and (c) research focused on improving obesity assessment methodology.

Improve the Sensitivity and Relevance of Obesity Measures

One of the hallmarks of a robust surveillance system is the ability to measure the same variables over time in a consistent manner. However, recent studies suggest that the addition of new measures or methods can augment current data collection and amplify research and monitoring possibilities.

Additions to BMI measures. Measurement of BMI has long been a consistent outcome of obesity surveillance systems, owing to the ease and low cost of directly measured height and weight or even obtaining these data via self-report. BMI misclassifies as nonobese one-quarter of adult males and nearly half of adults whose dual energy x-ray absorptiometry (DXA) measurements classify them as obese (95). BMI has similarly poor sensitivity as a measure of adiposity in children (61). In addition, BMI does not detect an accumulation of abdominal fat, which is known to correlate with insulin resistance even in lean individuals (35). Surveillance science has been slow to take advantage of research that identifies alternative anthropometric measures of obesity (8). Combining two or more different anthropometric measures, such as waist-to-hip ratio and waist-circumference-to-height ratio, works well and may be more sensitive to the accumulation of abdominal fat (8, 13, 115), although these measurements are more invasive and require additional privacy.

Addition of longitudinal data. Methods for longitudinal population-based analyses are essential to assess the impact of policy-led interventions on the incidence of obesity during crucial developmental time periods, such as childhood or transitions from high school to college (36). Developing cohorts with regularly assessed obesity measures over the lifespan would provide data on incidence of obesity that would coincide with obesity prevention initiatives. Longitudinal BMI measure analyses are uncommon, particularly among low-resource populations, which are at greater risk of obesity.

Workforce Development

Although few data have assessed the size of the workforce that is engaged in surveillance work, similar studies have documented shortages in related disciplines, such as epidemiologists, public health nurses, and informaticians (38). Investigators have estimated that three-quarters or more of the public health workforce do not receive adequate training in public health, and most clinical health professionals are not exposed to population health or public health concepts (38, 59). Initial actions that would help to achieve a competent surveillance workforce include developing

learning competencies for surveillance; offering training opportunities for the existing workforce using webinars or online formats; setting up a continuous training process; and planning for future training needs (38, 44).

THE FUTURE OF OBESITY SURVEILLANCE

As the technology around data collection, storage, and data linkage advances and becomes more integrated into routine clinical care practices and work and school settings, we can envision a future where obesity surveillance systems of individual data are augmented or replaced by aggregations of registries that contain individual screening data. As with most innovations, these offer both promise and challenges for researchers and practitioners.

Use of Electronic Health Records

EHRs are likely to play a key role in the future of obesity surveillance systems. As of 2014, 80% of physicians reported using EHRs (53), and EHRs have been effective in identifying and flagging obesity (2). As EHRs become more sophisticated, and eventually incorporated into big data analysis systems along with personal data from wearable devices and social media (84), these data will be used for obesity surveillance as well as to inform both individual- and population-level interventions. Statistical analyses with such data are possible and include plotting individual and group-based weight trajectories over the life course, examining demographic subgroups, and examining associations of weight trajectories with behavioral risk factors as well as clinical outcomes (76, 93).

Incorporation of Self-Measurements or Individualized Electronic Data Collection into Surveillance Efforts

Recent years have seen the development of a variety of consumer-friendly wearable devices and sensors for self-tracking of health, including activity trackers, smart watches, smart clothing, and smart implants (31, 44), which can provide usable health data. Consumer acceptability of these devices is high, and an intensely competitive market ensures that the cost of these devices stays low. Hence, there is considerable potential for their use in obtaining measures relevant to obesity in a general population. The use of these types of self-measurements has been feasible, even among low-income communities (116). Data from social media postings of individuals offer another source of self-measured data. Social media and text analytics methods make it possible to search through social media postings and extract data relevant to health (29) and, potentially, to include such data as part of routine data collection systems (44).

Privacy Considerations of Individual Data

The increased use of data registries and surveillance for assessing the effects of obesity initiatives is promising but can be troublesome to participants, especially with current news stories about data leaks and hacks. A recent survey across 27 European Union countries found that participants appreciated the usefulness of EHR data but are concerned about widespread availability of the data to others, especially insurance companies, pharmaceutical companies, and academic researchers (82). To gain the public's trust, decision makers must emphasize the importance of the information to be gained, as well as put the provisions in place to safeguard the individual's privacy (82).

Timely Feedback Loops to Data Consumers

Feedback loops to the end user or practitioner are a crucial part of the surveillance system. As previously mentioned, the BRFSS maps (**Figure 1**) have provided an easily digestible visual to represent the rapid onset and widespread reach of the obesity epidemic in the United States (24). Through the use of GIS, as well as other advanced data visualization techniques, researchers and practitioners can display obesity data and environmental factors such as the density of fast-food restaurants and green space by region; the availability of such data has impacts for policy makers and municipal planners (12, 87). Data dashboards and report cards are also effective means of highlighting surveillance data in easily understandable summaries, especially when compared with standard recommendations.

CONCLUSIONS

Although the United States has robust surveillance of obesity and individual obesity-related behaviors, to fully understand the etiology of obesity and the effects of prevention efforts, we must expand current surveillance systems in terms of settings, measures, periodicity, and populations. Increases in funding and infrastructure for local surveillance would assist in obtaining data on underserved populations to better understand health disparities in obesity and prevention efforts. Also critical is the addition of environmental and policy measures to surveillance systems to allow for a better understanding of the effects of obesity prevention initiatives.

With the emerging technological advances in measurements and data management, the ability to obtain more and better surveillance presents unlimited opportunities for obesity prevention efforts, especially when coupled with the presentation of this information using data visualization techniques and easy-to-understand dashboards. To capitalize on this convergence of technology and data collection, researchers will need to nurture the science of surveillance by providing increased funding for new methodologies and outlets for presenting and publishing the resulting findings. Facilitating the development and use of surveillance data for evaluating obesity prevention efforts has the potential to significantly advance action against obesity.

FUTURE ISSUES

1. To fully determine the tracking and effects of current and future initiatives for obesity control and prevention, current surveillance systems for overweight and obesity should be expanded to incorporate both behavioral and environmental measures, as well as biologic outcomes. In addition, measures such as waist circumference, which more accurately track obesity risk, should be added to surveillance systems. Finally, representative serial cohort studies, beginning in childhood, should be initiated to provide data on incidence of obesity.
2. Because several innovative obesity prevention and control initiatives are being implemented at the local or state level, surveillance efforts should also be expanded to provide local data that are comparable to national and international data.
3. Current sources of existing data, such as EHRs and wearable devices, provide promise for more accurate and timely data collection that may be leveraged for obesity surveillance. Incorporation of decision supports into EHRs and links to current manufacturers of wearable devices would ensure more consistent collection of data.

4. With increased surveillance of body size and contextual factors, it is necessary to implement procedures to ensure adequate privacy and anonymization of sensitive data.
5. Actionable data for decision-making purposes need to include a rapid feedback mechanism for practitioners in easily understandable formats, such as dashboards or infographics. Progress toward national health goals, such as *Healthy People 2020*, should be included in user feedback.
6. To allow for the expansion of data surveillance systems, it will be necessary to further develop or expand infrastructure in terms of catalogs of measures, development of new measures, increased training in surveillance and epidemiologic methods, and workforce development.
7. To encourage the development of better surveillance methods and systems, it is necessary to provide funding streams for research as well as opportunities for peer review through publications and presentations at national conferences and meetings.
8. Current surveillance systems should be examined to ensure the inclusion of children or adults who are at an above-average risk of obesity and related health conditions.

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RELATED RESOURCES

Centers for Disease Control and Prevention Chronic Disease State Policy Tracking System:
<http://nccd.cdc.gov/CDPHPPolicySearch/default.aspx>
 Community Commons: <http://www.communitycommons.org>

Health Indicators Warehouse: <http://www.healthindicators.gov>
National surveillance systems for overweight and obesity: <http://www.cdc.gov/obesity/data/surveillance.html>
NCCOR Catalogue of Surveillance Systems: <http://nccor.org/nccor-tools/catalogue>
NCCOR interactive tool to search across all systems and compare key characteristics of each system: <http://tools.nccor.org/css>
NCCOR measures registry: <http://nccor.org/nccor-tools/measures/index>