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Annual Review of Public Health The Next Generation of Diabetes Translation: A Path to Health Equity

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diabetes translation, health equity, social determinants of health, SDOH, root causes of health disparities, dissemination and implementation

Abstract

Disparities in diabetes burden exist in large part because of the social determinants of health (SDOH). Translation research and practice addressing health equity in diabetes have generally focused on changing individual behavior or providing supportive approaches to compensate for, rather than directly target, SDOH. The purpose of this article is to propose a pathway for addressing SDOH as root causes of diabetes disparities and as an essential target for the next generation of interventions needed to achieve health equity in diabetes prevention and treatment. This review describes (a) the current burden of diabetes disparities, (b) the influence of SDOH on diabetes disparities, (c) gaps in and implications of current translation research, and (d) approaches to achieving health equity in the next generation of diabetes translation.

INTRODUCTION

The past two decades have brought significant scientific advances in type 2 diabetes mellitus (T2DM) primary prevention, therapeutics and disease care, and comorbidity and complications management (30, 96) as well as policies to quell the global diabetes pandemic (63). Yet, the public health impact of these advances has not been realized. Over the past 30 years, the number of adults 18 years of age and older with diabetes has quadrupled globally, increasing from 108 million in 1980 to 422 million in 2014, while the age-standardized global prevalence has doubled from 4.7% to 8.5% (100). In the United States, 1 in every 11 people are now diagnosed with diabetes (29). Diabetes is ranked first in US public health spending and health care spending (inclusive of ambulatory care, inpatient care, pharmaceuticals, emergency department care, nursing facility care) (42). In 2017, the total economic cost of diagnosed diabetes was \$327 billion, with \$237 billion in direct medical costs and \$90 billion in reduced productivity (7). One in every four US health care dollars was spent on diabetes care (7). Thus, a chasm persists between the research advances in diabetes prevention and management and the current state of diabetes.

Diabetes translation is defined as research and practices to improve the reach, adoption, sustainability, and widespread dissemination and implementation of the scientific advances in real-world settings and populations (101). Populations of health disparity, which are systematic differences in health that are avoidable, unjust, and related to social or economic disadvantage (19), have been less likely to benefit from the translation of these advances and bear excess diabetes burden. Social determinants of health (SDOH), defined as (a) the circumstances in which people are born, live, work, and age and (b) the systems set up to address health or illness (137), account for 45-60%of this disparity in health status (45, 141). Health equity, the absence of unfair and avoidable differences in health among social groups (86), necessitates addressing the SDOH and striving to equalize opportunities for all populations to be healthy (22). The World Health Organization has called for actions to eliminate health disparities by tackling inequitable distributions of power, money, and resources, by accurately measuring these problems, and by evaluating interventions that address daily living conditions and their impact on health (86). Creating social and physical environments that promote health equity offers a strategy for eliminating diabetes disparities and improving the health of the entire population (133). Translation efforts, therefore, must incorporate the development, dissemination, and institutionalization of efficacious interventions that improve SDOH. The purpose of this article is to propose a pathway for addressing SDOH in the United States as root causes of diabetes disparities and as an essential target for interventions to achieve health equity in diabetes translation. To accomplish this goal, we review (a) the current burden of diabetes disparities, (b) the influence of SDOH on diabetes health equity, (c) gaps in and implications of current translation research, and (d) approaches to achieving health equity in the next generation of diabetes translation.

THE CURRENT BURDEN OF DIABETES HEALTH DISPARITIES

In the United States, an estimated 30.2 million people (12.2% of the population) have diabetes, with diagnosed diabetes in 23.1 million (9.3%) and undiagnosed diabetes in 7.2 million (2.9%) (29). Diabetes burden in racial and ethnic minorities and lower socioeconomic status (SES) groups contributes disproportionately to diabetes prevalence rates. Among non-Hispanic whites, diabetes prevalence is 7.4%, compared with 15.1% among Native Americans/Alaska Natives, 12.7% among non-Hispanic blacks, 12.1% among Hispanics, and 8.0% among Asian Americans (29, 106). Disparities in incidence rates are also observable in youth, in both type 1 diabetes and T2DM. Non-Hispanic whites experience the highest incidence rates of type 1 diabetes (27 per 100,000),

compared with racial and ethnic minorities (non-Hispanic black: 19 per 100,000; Hispanic: 14.8 per 100,000; Asian-Pacific Islander: 6.5 per 100,000; American Indian: 6.5 per 100,000). The trend is reversed in T2DM incidence rates; American Indian and non-Hispanic black populations have the highest incidence rates, 46.5 and 32.6 per 100,000 respectively, whereas non-Hispanic white vouth have the lowest incidence at 3.9 per 100,000 (29). Prevalence and incidence rates of diabetes differ by educational attainment, with higher prevalence associated with fewer years of education. In 2015, age-adjusted diabetes prevalence in adults with more than a high school education was 7.2%, as compared with 9.5% in adults with a terminal high school education and 12.6% in adults with less than a high school education (29). Similarly, age-adjusted diabetes incidence rates per 1,000 for adults with more than a high school education, high school education, and less than high school education were 5.3, 7.8, and 10.4, respectively (29). Income data reveal highest diabetes prevalence within the poorest stratum (<100% of the federal poverty level), with progressively lower diabetes prevalence within the nonpoor stratum (200-300% of the federal poverty level), and lowest diabetes prevalence in the least poor stratum (>400% of the federal poverty level) (53). In addition, over the past few decades, disparities in diabetes prevalence between the highest and lowest socioeconomic strata have widened in the United States rather than decreased.

Diabetes mortality and morbidity rates also reflect the excess diabetes burden borne by racial and ethnic minorities and the lower socioeconomic strata in the United States. African American, Native American, and Hispanic adults with diabetes die from diabetes at higher rates than do their non-Hispanic white counterparts (134). Socioeconomic inequities such as poverty and segregation have been found to contribute to racial disparities in diabetes mortality rates (115). Completion of high school or more education is associated with better diabetes survival rates compared with those with lower educational attainment (47), and low educational attainment and lack of financial wealth remain strong predictors of risk of diabetes mortality even after adjusting for factors including demographics, access to health care, and emotional distress (121). Disparities are evidenced among youth as well. Black children and adolescents with diabetes die at rates twice as high as those of white and Hispanic youth with diabetes, despite white youth having higher type 1 diabetes incidence rates and higher total diabetes prevalence rates than do black children and adolescents (120).

Finally, the high costs of diabetes exacerbate the socioeconomic burden of diabetes. Diabetes is the most expensive chronic condition in the United States (42). The average person with diabetes incurs annual medical expenses that are 2.3 times higher than those of their age- and sex-matched counterparts without diabetes (7). One in five adults with diabetes who is prescribed medication reports skipping medication doses, taking less medication, or delaying filling a prescription owing to costs (80).

THE INFLUENCE OF SDOH ON DIABETES HEALTH DISPARITIES: FRAMEWORK AND EVIDENCE

Health equity is an identified priority within key US public health initiatives; SDOH are key to this mission (133, 134). Because of the contribution of diabetes to observed racial/ethnic and socioeconomic health disparities nationally, achieving health equity at the US population level will require addressing health equity in populations with, and at risk of, diabetes. A comprehensive approach is needed to develop, manage, and evaluate translational interventions that promote health equity in diabetes prevention and treatment. We present a framework to guide these actions in addressing SDOH as critical targets of prevention and treatment (see **Figure 1**). Five SDOH areas are identified, including SES, living and working conditions, multisector domains, sociocultural context, and sociopolitical context. These areas of influence are linked by the perspective that



Figure 1

Health equity in diabetes translation framework.

they are not independent but rather are interdependent, an important distinction when considering intervention. The influence of SDOH occurs at an individual as well as at subpopulation and population levels. Life course exposure to influences of SDOH also impact health and diabetes outcomes. Addressing the influence of these factors on diabetes interventions as priorities for the next generation of diabetes translation may lead to equity in prevention and treatment. For the purposes of this article, we next describe a working definition for each predetermined SDOH area of influence, followed by evidence of effect on general health, and relevant research related to diabetes outcomes.

Socioeconomic Status

SES has been defined as the social standing or class of individuals or groups, operationalized as a combination of education, income, and occupation (8). Income and occupation, as markers of SES, are often measured by economic stability, resources, or social standing (21). Education can be operationalized by attainment and achievement or by quality, with lower education contributing to poorer health behaviors, knowledge, and problem-solving ability, yielding negative health outcomes (20, 69, 146). Educational attainment is often measured by years of education; low educational achievement can be measured by literacy as a more robust proxy for low SES among racial and ethnic minorities than is quantity of education (28, 84). Education influences health through multiple pathways, including increased access to economic and social resources; skill development that facilitates life navigation (including the health care system); reductions in exposures to determinants associated with low SES, such as neighborhood food deserts, environmental toxins, and crime; and biological pathways, including early-childhood brain development and allostatic load (148).

Research clearly demonstrates the relationship between SES and diabetes. Studies have found that low family income, parental education, and high youth stress are common among families of minority youth with T2DM, noting their influence on disparities in diabetes onset, quality of life, and family burden (26, 71). Walker and colleagues (138) focus on income and stress as key determinants of poor glycemic control. A review by Varanka-Ruuska and colleagues (135) noted that unemployment, while strongly linked to poor health generally, was also associated with 1.6-fold odds for prediabetes and 1.7-fold odds for T2DM. Low health literacy is also associated with poorer outcomes, including suboptimal diabetes self-management skills and behaviors, higher rates of hospitalizations and emergency department visits, and mortality (27, 69).

In general, translational research on SES and diabetes has focused on individual characteristics such as income, wealth, education, and occupation, as they influence diabetes outcomes (24); however, several studies have addressed change in SES as an intervention target. These studies targeted patient/family income and found that coverage of medication costs, which are a significant barrier to diabetes care, decreases disparities in diabetes-related death and complications between high- and low-income patients (18, 147). Conditional cash transfer programs, which provide direct income for achieving health-related or diabetes goals, have also shown evidence of reducing diabetes mortality among older Mexican adults (13, 76). Translational interventions that not only recognize SES influence on diabetes, but also target SES for change may further reduce inequities leading to diabetes disparities.

Living and Working Conditions

Living and working conditions are defined by the quality of the neighborhood environment in which people reside, often operationalized as the built and food environment, which in turn has a direct impact on physical activity, healthy eating, and other behaviors associated with diabetes (21). Variations in the built environment are related to adequacy of housing, safe worksites, air and water quality, public transportation, and street connectivity, quality, or density (15), which may explain some of the racial and other disparities found in diabetes outcomes. A recent review by Dendup and colleagues (41) found moderate evidence of the association between T2DM and the environment defined by walkability, air pollution, food and physical activity environment, and roadways proximity; living in neighborhoods with higher levels of walkability and green space was associated with lower T2DM risk, whereas higher levels of air pollution and noise were associated with increased T2DM risk (41). Jones and colleagues (68) analyzed North Carolina, New York, and Maryland census data and found an increased likelihood of availability of recreational facilities and parks in predominantly non-Hispanic white neighborhoods compared with ethnic minority neighborhoods (i.e., predominantly black and Hispanic neighborhoods). Den Braver and colleagues (40) reported that living in an urban residence was associated with higher T2DM risk or prevalence compared with living in a rural residence; higher neighborhood walkability and more green space tended to be associated with lower T2DM risk or prevalence. Several other reviews noted the role of adequate housing in overall health and well-being (23, 130, 131); one reported that housing instability and unmet material needs were associated with increased risk of diabetes and poorer outcomes among diabetes patients (14). Others found that working conditions are associated with environmental and occupational exposures that impact health and well-being (99, 116).

The quality of the food environment can be measured by access to healthy foods, and food insecurity is defined by the insufficient quantity of nutritious foods with periods of hunger (51, 123). As poverty in the United States has increased, so has the proportion of households experiencing severe food insecurity (38). While the national average of household food insecurity is 11.8%, it is 18% for Hispanic households and 21.8% for African American households as compared with 8.8% for non-Hispanic white households (38). Low-income, ethnic minority, and female-headed households experience the greatest risk of food insecurity (103). Lack of access to sufficient and nutritious food affects the ability of individuals to manage health conditions in general, and diabetes in particular (58). Food insecurity is present in 11.8% of US households (38); food insecurity is more common in households with a person living with diabetes, reported in approximately 20% of patients with diabetes; and it has been linked to poor glycemic control (16, 83, 122). Food insecurity and neighborhood context may impact self-care behaviors, whereas neighborhood characteristics such as social cohesion are associated with glycemic control (126). Heerman and colleagues (62) report that food insecurity is associated with lower adherence to general dietary recommendations, measured by eating poorly and skipping meals and yielding worse glycemic control when compared with food-secure individuals. Other studies report that food insecurity is associated with depression, diabetes distress, low medication adherence, and worse glycemic control (124). In general, however, the heterogeneity in definition and outcome measures as defined across studies has led to mixed but not negligible findings of the effect of the food environment on obesity as a precursor to T2DM (17, 56).

Several initiatives have sought to improve living and working conditions through school (36), worksite (25, 129), or community policy and systems change (111). The Moving to Opportunity for Fair Housing Demonstration (MTO) randomly assigned housing vouchers to public housing residents to test the effect of moving to low-poverty neighborhoods to promote access to jobs and middle-class social networks (104). Positive outcomes included improved overall adult health and, for child participants, increased future college attendance and earnings (35); adult employment outcomes did not significantly differ from those of the control group (79, 118). Overall, this body of research suggests the influence of living and working conditions on health in general and diabetes in particular, and interventions targeting improvements in these conditions may advance diabetes prevention and care (18, 94).

The Multisector Domain

The multisector domain, and engagement across these sectors, is an important and necessary component of diabetes prevention and treatment. Social disadvantage can affect the well-being of a population through a number of sectors (e.g., health care, criminal justice, financial, education, housing) (97). Recent reports have explored multisector partnerships with business, legal, and educational entities that engage residents to improve the community environment with a goal to reduce health disparities and improve health and well-being (97). These unique but interdependent systems are relevant to multisector interventions, allowing for the targeting of social factors and related determinants to promote lifestyle behavior change associated with diabetes prevention or improved treatment outcomes (37, 137). The focus to date of many diabetes translation efforts has been on change in health care, which plays a prominent role in not only access to care but also the quality of the care received by subpopulations (70, 134). Low-income inner cities and rural areas often lack access to health care providers and quality diabetes care, while lower SES is associated with an inconsistent patient-provider relationship (95). Studies of patients who cite difficulties in obtaining care, who use acute care facilities for routine care, and who have no usual source of care report significantly higher hemoglobin A1c when compared with patients seen in primary care or physician offices (112, 137). Chin and colleagues (36) proposed a road map for promising clinical interventions that are culturally tailored, are skills based, employ multidisciplinary teams involving community and family members, and target multiple leverage points to assure equitable patient care. Yet, the contributions of clinical health care and behavioral choices to the

prevention and management of T2DM do not adequately explain poor diabetes-related health outcomes, particularly among disadvantaged populations (54, 66). The number and complexity of social factors faced by patients can also have a negative impact not only on access, but also on quality of care received and diabetes management (70). Dietz and colleagues (43) describe the need to link many community sectors and clinical systems, offering a means to integrate social and other elements into diabetes care. However, in general, more interventions are needed that target social factors and related determinants as drivers of behavior change (34). Additional research is needed to create multisector partnerships beyond the health care system to better address the influence of SDOH on diabetes prevention, treatment, and outcomes.

Sociocultural Context

Sociocultural context denotes the within-group beliefs and norms (e.g., shared cultural values, practices, experiences) that influence behavior, cognition, learning, and identity (87). Cultural beliefs and patterns of group or family behavior may also be associated through religion, ethnicity, or social interaction (136). Additionally, attitudes and beliefs of different cultures, which are transferred across generations, are also shaped by historical and social forces (61). Sociocultural context has been associated with health and health-related behaviors among African American, Hispanic, American Indian/Alaska Native, and other minority groups, acting as a strong independent predictor of risk behaviors (3, 67, 90, 145).

Translational trials have supported state laws integrating community health workers within health care systems, a strategy designed to promote broad dissemination of a workforce that is effective in meeting the needs of disadvantaged populations on the basis of proximity, relatedness, and knowledge of the sociocultural context (31). The Centers for Medicare and Medicaid Services (CMS) Equity Plan for Medicare identifies community health workers as a workforce that delivers culturally and linguistically appropriate interventions to meet the health and social needs of disadvantaged populations (32, 33). Studies on what and how to translate efficacy trials to real-world settings found that group interventions delivered by trained community health workers showed high reductions in the incidence of T2DM (11, 46). Other interventions have focused on sociocultural influences on obesity, weight management, and diabetes risk behaviors (9, 34, 105). Sanders-Thompson and colleagues (119) reviewed 29 studies using sociocultural strategies across diabetes materials for addressing elements unique to racial/ethnic populations; only 52% involved information gathering or a formative research phase to support the cultural modifications needed to avoid stereotypical views of racial/ethnic communities. There remains limited research designed to increase understanding of how specific cultural health beliefs and practices vary across populations and subpopulations, and more research is also needed on strategies to influence the reach, uptake, and impact of diabetes translation efforts (92, 93, 142).

Sociopolitical Context

The sociopolitical context encompasses societal and political norms that are root-cause ideologies and policies underlying health disparities (e.g., institutional racism, classism, genderism; the resulting lack of between-group shared experiences; and inequities in health and other life experiences) (114). Racism is defined by intentionally discriminatory actions and attitudes as well as those embedded in societal structures that systematically constrain opportunities and resources on the basis of race or ethnic group (107, 108). Racial discrimination, like other forms of systematic oppression, can influence diabetes prevention and care through three main pathways, reflecting interactions with other SDOH, causing (*a*) lower levels of subpopulation-level SES (owing to lower-quality

education and lower-paying jobs), (b) residential segregation (owing to lower income and wealth accumulation, higher rates of unemployment), and (c) psychological distress (due, in part, to fewer quality health care and community services) (139, 143). Disparities across communities are often due to structural determinants of racism and discrimination as evidenced by residential segregation, lack of financial services in neighborhoods, or criminal justice policies (10, 110, 139, 143). The For the Sake of All project described the impact of various policies (including financial and housing) and their link to discriminatory practices and negative health and diabetes outcomes of the black population in St. Louis (110). The Black Women's Health Study, a follow-up of 59,000 African American women, found that women who perceived a high level of everyday racism had a 31% increased risk of diabetes; those reporting exposures to the highest levels of lifetime racism had a 16% increased risk of T2DM (12). Other studies found that perceived discrimination impacted health behaviors (64) and that American Indian women with diabetes who reported perceived discrimination completed fewer diabetes services, which placed them at increased risk for comorbidities of diabetes (55); these findings support the notion that discrimination is associated with an increased risk of incident diabetes (147). Thus, chronic stress due to racism and discrimination can affect diabetes outcomes (12, 71, 144). However, there is a dearth of interventions that include strategies to address racism or discrimination as factors related to diabetes outcomes.

Life-Course Exposure

Life-course exposure, a critical element of our model, is the length of time one spends growing up in resource-deprived environments, such as those defined by poverty, lack of quality education, or lack of health care, which has a significant impact on diabetes risk, diagnosis, and outcomes (44). Among populations affected by health disparities, historical trends can explain social, economic, and health differences, including long-standing poverty, low educational attainment, and unemployment, which impact health in general and diabetes more specifically (110). Childhood disadvantage is associated with an increased risk of obesity, a precursor to diabetes; those who are disadvantaged across the life course are at the highest risk (39). Weathering, or the cumulative burden of adverse psychosocial and economic circumstances on the physical health of minority populations, is associated with adverse health risks among African Americans (39, 82). The length of exposure to these influences can lead to intergenerational transfer of health patterns and behaviors that can lead to diabetes (59), which means that the foundation for diabetes may be laid in early life, with exposure to disadvantaged conditions having long-lasting biologic and behavioral consequences (59). Translational interventions that consider and measure life-course exposure to SDOH are lacking and needed to better understand and guide interventions to achieve health equity (50).

RESEARCH GAPS AND IMPLICATIONS OF CURRENT TRANSLATION RESEARCH

The prevention and treatment of diabetes are dependent on the equitable translation of scientific evidence to populations at large. The primary focus of health disparities research to date has been on what we define as compensatory interventions, designed to improve outcomes at the individual level, for the individual who is receiving the intervention, for as long as that individual is receiving that intervention. These compensatory approaches have achieved a level of success in preventing and treating diabetes. The Diabetes Prevention Program (DPP) is one of the best examples to date of the impact of individually focused strategies to prevent and treat diabetes in the United States: from a National Institutes of Health (NIH) multicenter efficacy trial with a multiethnic study

population, to effectiveness studies in translational settings, to national US policy, to standardized program and training/certifications under the oversight of the Centers for Disease Control and Prevention (CDC), to Medicare reimbursement via public health/non-health care channels (27). This landmark study demonstrated that both lifestyle and pharmacological interventions prevent or delay the onset of T2DM in high-risk, prediabetes populations by 25-60% at follow-up; the largest reductions were accomplished through lifestyle interventions (72, 73, 132). The DPP was time and resource intensive, requiring individual case managers or lifestyle coaches; frequent contact; a structured, 16-session core curriculum; supervised physical activity; a maintenance intervention; and other support (72, 128). Reviews of real-world DPP translation programs reported clinically significant (4-5%) weight loss and high reductions in the incidence of T2DM, achieved by lay educators delivering more realistic, less intensive interventions, with outcomes dependent in part on the number and intensity of sessions offered as well as on attendance (5, 46, 140). The YMCA also provided the DPP to Medicare beneficiaries with prediabetes in participating YMCAs nationwide (1, 6), reducing medical spending and utilization, inpatient admissions, and emergency department visits. In 2010, the National DPP (NDPP) was authorized by Congress to build an infrastructure of community-based programs across the country (74), with new regulations expanding CMS coverage for Medicare beneficiaries in 2015 (91, 125). As mandated and funded by Congress, the Indian Health Service implemented the Special Diabetes Program for Indians demonstration project, translating the DPP lifestyle intervention across rural, reservation, and urban American Indian/Alaska Native communities (62).

Despite a level of broad success, the DPP has been translated less effectively in populations at risk for disparities (125). Recent findings from the NDPP found that non-Hispanic whites lose more weight than do Hispanics and non-Hispanic blacks; low-income participants lose less weight than do those from high-income communities. Differences in success have been attributed to challenges to participation associated with the program's duration and intensity requirements, factors that have less to do with the individual than with their life circumstances (49, 113, 114). Adapted DPP interventions generally translate protocols, methods, and materials to address individual knowledge, attitudes, or behavior change, offering supportive services to mitigate disadvantaged conditions (75). This focus on translational interventions that are compensatory in nature, while important, has been unable to reduce diabetes disparities at a population level. Further progress toward eliminating disparities, and achieving the full impact of efficacious interventions such as the DPP, requires an evolution and expansion of translational efforts that act to improve, rather than solely compensate for, root causes of diabetes disparities. The next generation of diabetes translation research must focus not only on disseminating interventions to individuals, but also on determining the root causes of disparities and key drivers of health behavior options (see **Table 1**). Doing so requires a transformation in approach to test macrolevel interventions targeting SDOH through policy, systems, and community change, implemented through multisector partnerships (43). Finally, both the compensatory approaches, aiding individuals in addressing immediate diabetes-related needs, and the next-generation interventions, promoting foundational change, have a role to play in eliminating diabetes disparities. Expanding our singular, individual, medical treatment focus, and rebalancing our translational priorities to address social determinant influences, may further ameliorate conditions that result in diabetes disparities.

ACHIEVING HEALTH EQUITY IN THE NEXT GENERATION OF DIABETES TRANSLATION

Several critical elements are needed to advance priorities for achieving health equity in diabetes prevention. These elements form the basis for the next generation of translational interventions,

Domains of social determinants of health	Compensatory interventions	Next-generation interventions
Socioeconomic status	 Adapting of diabetes health education materials and public health information for low literacy (less than a fifth-grade readability criterion) Referrals to nonprofit social services in communities (e.g., food pantries and food banks, shelters) Tailoring of recommendations or care for low-income patients due to cost (e.g., avoiding high-cost foods, such as fresh fruits and vegetables and lean proteins, in favor of canned or packaged options that are less expensive; making health care procedure or medication-prescribing decisions on the basis of nationary (ability to nay) 	 Provision of high-quality, evidence-based diabetes educational curricula across income levels, neighborhoods, or geographic region Access to high-quality early education and child care Adequate teacher compensation and incentives to attract and maintain quality educators Conditional cash transfer programs that support diabetes care Living wages policies (especially for the service professions) Pay equality policies to address gender and racial inequities in pay for equal work Job/skills-training programs in low-income
	of patients admity to pay)	Antidiscrimination in hiring policy enforcement
Living and working conditions	Home-based exercise adaptations to avoid unsafe environments (e.g., encourage walking up and down stairs, doing chair exercises, using food cans or milk jugs as weights) Partnerships with grocery stores to deliver groceries for individuals or families in low-income neighborhoods and food deserts Transportation service interventions to take residents of low-income neighborhoods on periodic grocery trips to higher-income neighborhoods Family and social network interventions on	Residential/built environment planning and aesthetics for walking, biking, and community living, across income levels and geographic regions Mixed-income housing and access policies Housing stability vouchers Safety/crime policy initiatives Equitable practices for home ownership, loans, and neighborhood access Equitable access to nutrition at school for children (e.g., school nutrition policies) Distribution of healthy food sources across neighborhoods and geographic regions Restriction of unhealthy businesses (e.g., fast foods, liquor stores) in low-income neighborhoods Behavioral economics practices that make healthy foods default and incentivize healthy food choices via pricing practices
	lifestyle/behavior change	through education, employment, and financial management interventions
Sociopolitical context	Community worker social support programs	Antibias and antidiscrimination policies and enforcement across sectors (education, employment, banking, housing, criminal justice, health)
Multisector domain	Addition of ancillary personnel workforces, including patient navigators, case managers, and lay health workers to bridge, translate, or supplement health care for effectiveness Clinic-community partnerships that guide underserved patients back to their communities to identify resources to meet social service needs	Equal access to high-quality health care across health care settings and payers Redesign for access to and incentives for disease prevention Health equity policies and enforcement Extension of care and lifestyle behavior support outside of health care settings and providers

Table 1 Moving from compensatory to next-generation interventions

which are designed to address the root causes of diabetes and are critical to achieving diabetes health equity.

Make Health Equity a Goal of Diabetes Translation

Health equity is achievable; diabetes disparities are preventable. Interventions that move from compensating for SDOH influences to targeting those influences for change are needed to eliminate diabetes disparities. Prioritizing actions and tracking the progress of interventions that seek to improve diabetes outcomes by improving SDOH are also needed (2, 4). Systematic evaluation of progress is necessary to achieve health equity as an outcome goal of diabetes translation interventions. Taking advantage of big data while assuring routine and transparent reporting of progress should be regularly addressed by national and local diabetes organizations, which should also promote health equity as a goal of diabetes research, practice, and translation efforts.

Establish Common Definitions of SDOH

Language is important. Current translational research uses a variety of definitions for SDOH, leading to numerous measures and outcomes associated with the SDOH. This variance limits the interpretation of findings across studies and populations. Consistency and clarity regarding the implementation of translational interventions will advance our understanding of what works and why. Consensus around language associated with SDOH and diabetes intervention needs to be achieved across research and practice communities.

Define a Suite of Core Measures of Diabetes Health Equity

What gets measured gets done. For example, metabolic control is the gold standard of diabetes care and provides a universally agreed on metric for quality practice. Yet, despite extensive evidence of influence on diabetes outcomes, there is a lack of consistency on what, when, and how to consistently measure with regard to the SDOH or health equity in diabetes research. Conceptual models exist for prioritizing, identifying, selecting, and incentivizing the use of measures targeting health equity (98). Consensus is also needed on translational measures that move beyond health care and capture the impact of social advantage and disadvantage in population settings.

Engage Multiple Sectors in Diabetes Translation

SDOH are complex, interactive, and synergistic influences on life, health, and diabetes. Yet, there is an overemphasis on health care as the primary or singular intervention setting for patient diabetes care, even as it accounts for a small proportion of health-related and diabetes outcomes compared with other settings (85). This singular approach ignores the interactive, real-world environment of the individual influenced by SDOH. Multisector partnerships are critical to translation efforts (89) by offering purposeful collaborations of various stakeholder groups (e.g., government, community, private sector) and individual sectors (e.g., health, housing, transportation, environment, and economy) who work to achieve a common outcome (52, 57, 77, 117). These partnerships promote coordinated action across local and national sectors, which is required to design and implement interventions to eliminate the root causes of diabetes disparities (89, 127).

Implement Macrolevel Interventions

A necessary paradigm shift in moving beyond compensatory and toward next-generation interventions requires approaches that will be larger in scope (e.g., policy, systems change) and tested over time, both within and between multiple sectors. Studies of complex interventions, examining the interactive effects of multifaceted systems that influence SDOH, will also transform and move translational efforts toward large-scale solutions that promote equity for all populations (60) and mitigate the influence of SDOH on diabetes outcomes (63, 88).

Use Dissemination and Implementation Science

Evidence-based interventions and policies take an average of 17 years to be incorporated into routine systems, with only about half ever reaching widespread use (94). This gap is heightened among disadvantaged populations (65). Dissemination and implementation (D&I) science studies the translation of research findings into practice in order to improve health outcomes in the broader community (81, 102). D&I offers a systematic structure to inform methods that enhance the adoption, implementation, and sustainability of interventions and to inform reporting strategies that allow for systematic comparisons across groups (109). Descriptions of interventions, how they were adapted, and the reach or uptake are currently described variably, which limits the ability to interpret impact. D&I research will enable us to unpack the black box, which comprises an intervention, and consistently describe its translation and implementation to address the root causes of diabetes disparities.

Train Clinicians and Scientists in Next-Generation Translational Research and Practice

Health care providers and researchers practice what they learn; the current system focuses on training the workforce for acute or episodic care, with less emphasis on a holistic view that includes a person's social and environmental influences (48). Increasing diversity among health care providers, ensuring cultural competence, and fostering transdisciplinary educational experiences encompassing multisector partners are needed to develop a workforce that is congruent with advancing diabetes translation (78).

Expand Funding Streams for Next-Generation Translation

Funders support grant making in ways that are consistent with their mission and where they believe they will achieve the greatest impact. Traditionally, academic research and translational funding have relied primarily on government funds (e.g., NIH, CDC), which, given their comprehensive mission and competing areas of research, can provide only limited support for new priority translational areas. However, expanding beyond the medical or health care setting to include multiple partners and collaborators from business, transportation, and education and from across the social spectrum opens the door for innovative funding strategies. Pursuit of this type of funding requires promoting the benefits of diabetes prevention and treatment that can be achieved to advance the research priorities of nontraditional funding sources.

CONCLUSION

Substantial disparities in diabetes exist, owing in part to the influence of SDOH. Diabetes translation interventions have generally focused on changing individual behavior to compensate for, rather than change, these SDOH. The next generation of interventions should prioritize health equity in diabetes translation research as a goal and work through multisector partnerships to test macrolevel interventions addressing the root causes of diabetes disparities. Rigorous

evaluation through D&I science and common core measures of health equity are needed to eliminate diabetes disparities across populations. The training of researchers and health care providers to promote health equity approaches and the broadening of funding mechanisms to advance these priorities are needed. Expanding the scope of prior intervention research, and rebalancing efforts to address health equity in diabetes translation, can further reduce or eliminate disparities in prevention and treatment.

DISCLOSURE STATEMENT

Contents of this article are solely the responsibility of the authors and do not necessarily represent the official view of the Johns Hopkins Institute for Clinical and Translational Research (ICTR), the National Center for Advancing Translational Sciences (NCATS), the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), or the NIH.

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LITERATURE CITED

- 1. Ackermann RT, Holmes AM, Saha C. 2013. Designing a natural experiment to evaluate a national health care-community partnership to prevent type 2 diabetes. *Prev. Chronic Dis.* 10:E12
- 2. AHRQ (Agency Healthc. Res. Quality). 2011. 2010 National healthcare disparities report. Rep., AHRQ, Rockville, MD. https://archive.ahrq.gov/research/findings/nhqrdr/nhdr10/nhdr10.pdf
- Airhihenbuwa CO, Kumanyika SK, TenHave TR, Morssink CB. 2000. Cultural identity and health lifestyles among African Americans: a new direction for health intervention research? *Ethn. Dis.* 10:148– 64
- 4. Albright HW, Moreno M, Feeley TW, Walters R, Samuels M, et al. 2011. The implications of the 2010 Patient Protection and Affordable Care Act and the Health Care and Education Reconciliation Act on cancer care delivery. *Cancer* 117:1564–74
- Ali MK, Echouffo-Tcheugui JB, Williamson DF. 2012. How effective were lifestyle interventions in real-world settings that were modeled on the Diabetes Prevention Program? *Health Aff.* 31:67–75
- Alva ML, Hoerger TJ, Jeyaraman R, Amico P, Rojas-Smith L. 2017. Impact of the YMCA of the USA Diabetes Prevention Program on Medicare spending and utilization. *Health Aff*. 36:417–24
- 7. Am. Diabetes Assoc. 2018. Economic costs of diabetes in the U.S. in 2017. Diabetes Care 41:917-28
- APA (Am. Psychol. Assoc.) Task Force on Socioecon. Status. 2007. Report of the APA Task Force on Socioeconomic Status. Rep., APA, Washington, DC. https://www.apa.org/pi/ses/resources/publications/task-force-2006.pdf
- Ash T, Agaronov A, Young T, Aftosmes-Tobio A, Davison KK. 2017. Family-based childhood obesity prevention interventions: a systematic review and quantitative content analysis. *Int. J. Behav. Nutr. Phys. Act* 14:113
- Assari S, Lee DB, Nicklett EJ, Moghani Lankarani M, Piette JD, Aikens JE. 2017. Racial discrimination in health care is associated with worse glycemic control among black men but not black women with type 2 diabetes. *Front. Public Health* 5:235
- 11. Aziz Z, Absetz P, Oldroyd J, Pronk NP, Oldenburg B. 2015. A systematic review of real-world diabetes prevention programs: learnings from the last 15 years. *Implement. Sci.* 10:172

- Bacon KL, Stuver SO, Cozier YC, Palmer JR, Rosenberg L, Ruiz-Narváez EA. 2017. Perceived racism and incident diabetes in the Black Women's Health Study. *Diabetologia* 60:2221–25
- Barham T, Rowberry J. 2013. Living longer: the effect of the Mexican conditional cash transfer program on elderly mortality. J. Dev. Econ. 105:226–36
- Barnard LS, Wexler DJ, DeWalt D, Berkowitz SA. 2015. Material need support interventions for diabetes prevention and control: a systematic review. *Curr: Diabetes Rep.* 15:574
- Bauman AE, Reis RS, Sallis JF, Wells JC, Loos RJ, Martin BW. 2012. Correlates of physical activity: Why are some people physically active and others not? *Lancet* 380:258–71
- Berkowitz SA, Baggett TP, Wexler DJ, Huskey KW, Wee CC. 2013. Food insecurity and metabolic control among U.S. adults with diabetes. *Diabetes Care* 36:3093–99
- 17. Black JL, Macinko J. 2008. Neighborhoods and obesity. Nutr. Rev. 66:2-20
- Booth GL, Bishara P, Lipscombe LL, Shah BR, Feig DS, et al. 2012. Universal drug coverage and socioeconomic disparities in major diabetes outcomes. *Diabetes Care* 35:2257–64
- Braveman P. 2006. Health disparities and health equity: concepts and measurement. Annu. Rev. Public Health 27:167–94
- Braveman P, Gottlieb L. 2014. The social determinants of health: It's time to consider the causes of the causes. *Public Health Rep.* 129:19–31
- Braveman PA, Cubbin C, Egerter S, Williams DR, Pamuk E. 2010. Socioeconomic disparities in health in the United States: what the patterns tell us. *Am. J. Public Health* 100(Suppl. 1):S186– 96
- Braveman PA, Kumanyika S, Fielding J, LaVeist T, Borrell LN, et al. 2011. Health disparities and health equity: The issue is justice. Am. J. Public Health 101:S149–55
- Breysse J, Jacobs DE, Weber W, Dixon S, Kawecki C, et al. 2011. Health outcomes and green renovation of affordable housing. *Public Health Rep.* 126(Suppl. 1):64–75
- Brown AF, Ettner SL, Piette J, Weinberger M, Gregg E, et al. 2004. Socioeconomic position and health among persons with diabetes mellitus: a conceptual framework and review of the literature. *Epidemiol. Rev.* 26:63–77
- Brown SA, Garcia AA, Zuñiga JA, Lewis KA. 2018. Effectiveness of workplace diabetes prevention programs: a systematic review of the evidence. *Patient Educ. Couns.* 101:1036–50
- Butler AM. 2017. Social determinants of health and racial/ethnic disparities in type 2 diabetes in youth. Curr. Diabetes Rep. 17:60
- Caruso R, Magon A, Baroni I, Dellafiore F, Arrigoni C, et al. 2018. Health literacy in type 2 diabetes patients: a systematic review of systematic reviews. *Acta Diabetol.* 55:1–12
- Carvalho JO, Tommet D, Crane PK, Thomas ML, Claxton A, et al. 2015. Deconstructing racial differences: the effects of quality of education and cerebrovascular risk factors. J. Gerontol. B Psychol. Sci. Soc. Sci. 70:545–56
- CDC (Cent. Dis. Control Prev.). 2017. National diabetes statistics report, 2017. Rep., CDC, Atlanta. https://www.cdc.gov/diabetes/pdfs/data/statistics/national-diabetes-statistics-report.pdf
- CDC (Cent. Dis. Control Prev.). 2018. National Diabetes Prevention Program. Centers for Disease Control and Prevention. https://www.cdc.gov/diabetes/prevention/index.html
- CDC (Cent. Dis. Control Prev.), Natl. Cent. Chronic Dis. Prev. Health Promot. 2013. State law fact sheet: a summary of state community health worker laws. Fact Sheet, CDC, Atlanta. https://www.cdc.gov/dhdsp/ pubs/docs/chw_state_laws.pdf
- CDC (Cent. Dis. Control Prev.), Natl. Cent. Chronic Dis. Prev. Health Promot. 2015. Addressing chronic disease through community health workers: a policy and systems-level approach. Policy Brief, CDC, Atlanta, GA. https://www.cdc.gov/dhdsp/docs/chw_brief.pdf
- CMS (Cent. Medicare Medicaid Serv.), Off. Minor. Health. 2015. The CMS equity plan for improving quality in Medicare. Rep., CMS, Washington, DC. https://www.cms.gov/About-CMS/Agency-Information/OMH/OMH_Dwnld-CMS_EquityPlanforMedicare_090615.pdf
- CMS (Cent. Medicare Medicaid Serv.), Off. Minor. Health. 2017. Racial and ethnic disparities in diabetes prevalence, self-management, and health outcomes among Medicare beneficiaries. Data Highlight 6, CMS,

Washington, DC. https://www.cms.gov/About-CMS/Agency-Information/OMH/Downloads/ March-2017-Data-Highlight.pdf

- Chetty R, Hendren N, Katz LF. 2016. The effects of exposure to better neighborhoods on children: new evidence from the Moving to Opportunity experiment. Am. Econ. Rev. 106:855–902
- Chin MH, Clarke AR, Nocon RS, Casey AA, Goddu AP, et al. 2012. A roadmap and best practices for organizations to reduce racial and ethnic disparities in health care. *J. Gen. Intern. Med.* 27:992– 1000
- Clarke AR, Goddu AP, Nocon RS, Stock NW, Chyr LC, et al. 2013. Thirty years of disparities intervention research: What are we doing to close racial and ethnic gaps in health care? *Med. Care* 51:1020– 26
- Coleman-Jensen A, Rabbitt MP, Gregory CA, Singh A. 2018. Household food security in the United States in 2017. Rep. Summ. ERR-256, US Dep. Agric., Econ. Res. Serv. https://www.ers.usda.gov/webdocs/ publications/90023/err256_summary.pdf?v=0
- 39. Das A. 2013. How does race get "under the skin"?: inflammation, weathering, and metabolic problems in late life. *Soc. Sci. Med.* 77:75–83
- 40. Den Braver NR, Lakerveld J, Rutters F, Schoonmade LJ, Brug J, Beulens JWJ. 2018. Built environmental characteristics and diabetes: a systematic review and meta-analysis. *BMC Med.* 16:12
- Dendup T, Feng X, Clingan S, Astell-Burt T. 2018. Environmental risk factors for developing type 2 diabetes mellitus: a systematic review. Int. J. Environ. Res. Public Health 15:78
- 42. Dieleman JL, Baral R, Birger M, Bui AL, Bulchis A, et al. 2016. US spending on personal health care and public health, 1996–2013. *JAMA* 316:2627–46
- 43. Dietz WH, Solomon LS, Pronk N, Ziegenhorn SK, Standish M, et al. 2015. An integrated framework for the prevention and treatment of obesity and its related chronic diseases. *Health Aff*. 34:1456–63
- 44. Dixon B, Peña MM, Taveras EM. 2012. Lifecourse approach to racial/ethnic disparities in childhood obesity. *Adv. Nutr.* 3:73–82
- 45. Donkin A, Goldblatt P, Allen J, Nathanson V, Marmot M. 2018. Global action on the social determinants of health. *BMJ Glob. Health* 3:e000603
- 46. Dunkley AJ, Bodicoat DH, Greaves CJ, Russell C, Yates T, et al. 2014. Diabetes prevention in the real world: effectiveness of pragmatic lifestyle interventions for the prevention of type 2 diabetes and of the impact of adherence to guideline recommendations: a systematic review and meta-analysis. *Diabetes Care* 37:922–33
- Dupre ME, Silberberg M, Willis JM, Feinglos MN. 2015. Education, glucose control, and mortality risks among U.S. older adults with diabetes. *Diabetes Res. Clin. Pract.* 107:392–99
- Dzau VJ, McClellan MB, McGinnis JM, Burke SP, Coye MJ, et al. 2017. Vital directions for health and health care: priorities from a National Academy of Medicine initiative. *JAMA* 317:1461–70
- Ely EK, Gruss SM, Luman ET, Gregg EW, Ali MK, et al. 2017. A national effort to prevent type 2 diabetes: participant-level evaluation of CDC's National Diabetes Prevention Program. *Diabetes Care* 40:1331–41
- Evans-Campbell T. 2008. Historical trauma in American Indian/Native Alaska communities: a multilevel framework for exploring impacts on individuals, families, and communities. *J. Interpers. Violence* 23:316–38
- Feed. Am. 2016. Spotlight on senior health: adverse health outcomes of food insecure older Americans. Rep., Feed. Am., Natl. Found. End Senior Hunger, Alexandria, VA. https://www.feedingamerica.org/ sites/default/files/research/senior-hunger-research/or-spotlight-on-senior-health-executivesummary.pdf
- 52. Fenelon A, Mayne P, Simon AE, Rossen LM, Helms V, et al. 2017. Housing assistance programs and adult health in the United States. *Am. 7. Public Health* 107:571–78
- 53. Gaskin DJ, Thorpe RJ Jr., McGinty EE, Bower K, Rohde C, et al. 2014. Disparities in diabetes: the nexus of race, poverty, and place. *Am. J. Public Health* 104:2147–55
- Gillies CL, Abrams KR, Lambert PC, Cooper NJ, Sutton AJ, et al. 2007. Pharmacological and lifestyle interventions to prevent or delay type 2 diabetes in people with impaired glucose tolerance: systematic review and meta-analysis. *BMJ* 334:299

- Gonzales KL, Lambert WE, Fu R, Jacob M, Harding AK. 2014. Perceived racial discrimination in health care, completion of standard diabetes services, and diabetes control among a sample of American Indian women. *Diabetes Educ*. 40:747–55
- 56. Gordon-Larsen P. 2014. Food availability/convenience and obesity. Adv. Nutr. 5:809-17
- Green LW, Brancati FL, Albright A. 2012. Primary prevention of type 2 diabetes: integrative public health and primary care opportunities, challenges and strategies. *Fam. Pract.* 29(Suppl. 1):i13–23
- Gucciardi E, Vahabi M, Norris N, Del Monte JP, Farnum C. 2014. The intersection between food insecurity and diabetes: a review. *Curr. Nutr. Rep.* 3:324–32
- Haire-Joshu D, Tabak R. 2016. Preventing obesity across generations: evidence for early life intervention. Annu. Rev. Public Health 37:253–71
- Harris FM, Maxwell M, O'Connor R, Coyne JC, Arensman E, et al. 2016. Exploring synergistic interactions and catalysts in complex interventions: longitudinal, mixed methods case studies of an optimised multi-level suicide prevention intervention in four European countries (Ospi-Europe). BMC Public Health 16:268
- Hasson RE, Adam TC, Pearson J, Davis JN, Spruijt-Metz D, Goran MI. 2013. Sociocultural and socioeconomic influences on type 2 diabetes risk in overweight/obese African-American and Latino-American children and adolescents. *J. Obes.* 2013:512914
- Heerman W, Wallston K, Osborn C, Bian A, Schlundt D, et al. 2016. Food insecurity is associated with diabetes self-care behaviours and glycaemic control. *Diabet. Med.* 33:844–50
- Hu FB, Satija A, Manson JE. 2015. Curbing the diabetes pandemic: the need for global policy solutions. JAMA 313:2319–20
- Ikram UZ, Snijder MB, Agyemang C, Schene AH, Peters RJ, et al. 2017. Perceived ethnic discrimination and the metabolic syndrome in ethnic minority groups: the healthy life in an urban setting study. *Psychosom. Med.* 79:101–11
- Isaacs SL, Schroeder SA. 2004. Class—the ignored determinant of the nation's health. N. Engl. J. Med. 351:1137–42
- Jack L Jr., Liburd L, Spencer T, Airhihenbuwa CO. 2004. Understanding the environmental issues in diabetes self-management education research: a reexamination of 8 studies in community-based settings. *Ann. Intern. Med.* 140:964–71
- 67. Jiang L, Manson SM, Beals J, Henderson WG, Huang H, et al. 2013. Translating the Diabetes Prevention Program into American Indian and Alaska Native communities: results from the Special Diabetes Program for Indians Diabetes Prevention demonstration project. *Diabetes Care* 36:2027–34
- Jones SA, Moore LV, Moore K, Zagorski M, Brines SJ, et al. 2015. Disparities in physical activity resource availability in six US regions. *Prev. Med.* 78:17–22
- Kao G, Thompson JS. 2003. Racial and ethnic stratification in educational achievement and attainment. Annu. Rev. Sociol. 29:417–42
- Katz A, Chateau D, Enns JE, Valdivia J, Taylor C, et al. 2018. Association of the social determinants of health with quality of primary care. *Ann. Fam. Med.* 16:217–24
- Kawachi I, Daniels N, Robinson DE. 2005. Health disparities by race and class: why both matter. *Health* Aff. 24:343–52
- Knowler WC, Barrett-Connor E, Fowler SE, Hamman RF, Lachin JM, et al. 2002. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. N. Engl. J. Med. 346:393–403
- Knowler WC, Fowler SE, Hamman RF, Christophi CA, Hoffman HJ, et al. 2009. 10-year follow-up of diabetes incidence and weight loss in the Diabetes Prevention Program Outcomes Study. *Lancet* 374:1677–86
- Konchak JN, Moran MR, O'Brien MJ, Kandula NR, Ackermann RT. 2016. The state of diabetes prevention policy in the USA following the Affordable Care Act. *Curr. Diabetes Rep.* 16:55
- Kramer MK, Kriska AM, Venditti EM, Miller RG, Brooks MM, et al. 2009. Translating the Diabetes Prevention Program: a comprehensive model for prevention training and program delivery. *Am. J. Prev. Med.* 37:505–11
- Lagarde M, Haines A, Palmer N. 2007. Conditional cash transfers for improving uptake of health interventions in low- and middle-income countries: a systematic review. JAMA 298:1900–10

- 77. Lancet. 2017. A multisectoral approach to childhood development. Lancet 390:1564
- LaVeist TA, Pierre G. 2014. Integrating the 3Ds—social determinants, health disparities, and healthcare workforce diversity. *Public Health Rep.* 129:9–14
- Lens MC, Gabbe CJ. 2017. Employment proximity and outcomes for Moving to Opportunity families. J. Urban Aff. 39:547–62
- 80. Lessem SE, Pendley RP. 2017. Percentage of adults aged ≥45 years who reduced or delayed medication to save money in the past 12 months among those who were prescribed medication, by diagnosed diabetes status and age—National Health Interview Survey, 2015. MMWR 66:679
- Lomas J. 1993. Diffusion, dissemination, and implementation: Who should do what? Ann. N. Y. Acad. Sci. 703:226–35; discussion 35–37
- Love C, David RJ, Rankin KM, Collins JW Jr. 2010. Exploring weathering: effects of lifelong economic environment and maternal age on low birth weight, small for gestational age, and preterm birth in African-American and white women. *Am. J. Epidemiol.* 172:127–34
- Lyles CR, Wolf MS, Schillinger D, Davis TC, Dewalt D, et al. 2013. Food insecurity in relation to changes in hemoglobin A1c, self-efficacy, and fruit/vegetable intake during a diabetes educational intervention. *Diabetes Care* 36:1448–53
- Manly JJ. 2006. Deconstructing race and ethnicity: implications for measurement of health outcomes. Med. Care 44:S10–16
- 85. Marmot M, Allen JJ. 2014. Social determinants of health equity. Am. J. Public Health 104:S517-19
- Marmot M, Friel S, Bell R, Houweling TA, Taylor S. 2008. Closing the gap in a generation: health equity through action on the social determinants of health. *Lancet* 372:1661–69
- Martin L, Nelson K, Tobach E. 2008. Sociocultural Psychology: Theory and Practice of Doing and Knowing. Cambridge, UK: Cambridge Univ. Press
- Matson-Koffman DM, Brownstein JN, Neiner JA, Greaney ML. 2005. A site-specific literature review of policy and environmental interventions that promote physical activity and nutrition for cardiovascular health: What works? *Am. J. Health Promot.* 19:167–93
- Mayan M, Lo S, Oleschuk M, Paucholo A, Laing D. 2016. Leadership in community-based participatory research: individual to collective. *Engag. Sch. J.* 2:11–24
- McCurley JL, Gutierrez AP, Gallo LC. 2017. Diabetes prevention in U.S. Hispanic adults: a systematic review of culturally tailored interventions. *Am. J. Prev. Med.* 52:519–29
- 91. Medicare Diabetes Prevention Act of 2015. 2015. S. 1131/H.R. 2102, 114th Cong.
- Millan-Ferro A, Caballero AE. 2007. Cultural approaches to diabetes self-management programs for the Latino community. *Curr. Diabetes Rep.* 7:391–97
- Mora N, Golden SH. 2017. Understanding cultural influences on dietary habits in Asian, Middle Eastern, and Latino patients with type 2 diabetes: a review of current literature and future directions. *Curr: Diabetes Rep.* 17:126
- 94. Morris ZS, Wooding S, Grant J. 2011. The answer is 17 years, what is the question: understanding time lags in translational research. *J. R. Soc. Med.* 104:510–20
- 95. Nam S, Chesla C, Stotts NA, Kroon L, Janson SL. 2011. Barriers to diabetes management: patient and provider factors. *Diabetes Res. Clin. Pract.* 93:1–9
- 96. Nathan DM. 2015. Diabetes: advances in diagnosis and treatment. JAMA 314:1052-62
- Natl. Acad. Sci. Eng. Med. 2018. Exploring Equity in Multisector Community Health Partnerships: Proceedings of a Workshop. Washington, DC: Natl. Acad. Press
- Natl. Quality Forum. 2017. A roadmap for promoting health equity and eliminating disparities: the four I's for health equity. Rep., Natl. Quality Forum, Washington, DC. https://www.qualityforum. org/Publications/2017/09/A_Roadmap_for_Promoting_Health_Equity_and_Eliminating_ Disparities_The_Four_I_s_for_Health_Equity.aspx
- Navas-Acien A, Silbergeld EK, Streeter RA, Clark JM, Burke TA, Guallar E. 2006. Arsenic exposure and type 2 diabetes: a systematic review of the experimental and epidemiological evidence. *Environ. Health Perspect.* 114:641–48
- NCD Risk Factor Collab. 2016. Worldwide trends in diabetes since 1980: a pooled analysis of 751 population-based studies with 4.4 million participants. *Lancet* 387:1513–30

- NIDDK (Natl. Inst. Diabetes Dig. Kidney Dis.). 2015. Centers for Diabetes Translation Research overview. Centers for Diabetes Translation Research. https://www.diabetes-translation.org/
- NIMH (Natl. Inst. Ment. Health). 2002. Dissemination and implementation research in mental health. Rep., NIH, Bethesda, MD. https://archives.nih.gov/asites/grants/03-16-2017/Grants/guide/noticefiles/NOT-MH-02-009.html
- 103. Nord M, Andrews M, Carlson S. 2009. Household food security in the United States, 2008. Econ. Res. Rep. 83, US Dep. Agric., Washington, DC. https://www.ers.usda.gov/webdocs/publications/46273/ 10987_err83_1_.pdf?v=0
- 104. Orr L, Feins JD, Jacob R, Beecroft E, Sanbonmatsu L, et al. 2003. Moving to Opportunity: interim impacts evaluation. Rep., US Dep. Hous. Urban Dev., Off. Policy Dev. Res., Washington, DC. https:// www.huduser.gov/portal//Publications/pdf/MTOFullReport.pdf
- Orzech KM, Vivian J, Huebner Torres C, Armin J, Shaw SJ. 2013. Diet and exercise adherence and practices among medically underserved patients with chronic disease: variation across four ethnic groups. *Health Educ. Behav.* 40:56–66
- Peek ME, Cargill A, Huang ES. 2007. Diabetes health disparities: a systematic review of health care interventions. *Med. Care Res. Rev.* 64:101s–56s
- Pérez-Escamilla R. 2011. Acculturation, nutrition, and health disparities in Latinos. Am. J. Clin. Nutr. 93: 1163s-7s
- Pérez-Escamilla R, Putnik P. 2007. The role of acculturation in nutrition, lifestyle, and incidence of type 2 diabetes among Latinos. *J. Nutr.* 137:860–70
- Proctor EK, Landsverk J, Aarons G, Chambers D, Glisson C, Mittman B. 2009. Implementation research in mental health services: an emerging science with conceptual, methodological, and training challenges. *Adm. Policy Ment. Health* 36:24–34
- 110. Purnell J, Camberos G, Fields R. 2015. For the Sake of All: A report on the health and well-being of African Americans in St. Louis and why it matters for everyone. Rep., Wash. Univ. in St. Louis, Saint Louis Univ. https://forthesakeofall.org/wp-content/uploads/2016/06/FSOA_report_2.pdf
- Purnell JQ, Herrick C, Moreland-Russell S, Eyler AA. 2015. Outside the exam room: policies for connecting clinic to community in diabetes prevention and treatment. *Prev. Chronic Dis.* 12:140403
- 112. Rhee MK, Cook CB, Dunbar VG, Panayioto RM, Berkowitz KJ, et al. 2005. Limited health care access impairs glycemic control in low income urban African Americans with type 2 diabetes. *J. Health Care Poor Underserved* 16:734–46
- 113. Ritchie ND, Christoe-Frazier L, McFann KK, Havranek EP, Pereira RI. 2018. Effect of the National Diabetes Prevention Program on weight loss for English- and Spanish-speaking Latinos. Am. J. Health Promot. 32:812–15
- Ritchie ND, Sauder KA, Phimphasone-Brady P, Amura CR. 2018. Rethinking the National Diabetes Prevention Program for low-income whites. *Diabetes Care* 41:e56–57
- Rosenstock S, Whitman S, West JF, Balkin M. 2014. Racial disparities in diabetes mortality in the 50 most populous US cities. *J. Urban Health* 91:873–85
- Ruiz D, Becerra M, Jagai JS, Ard K, Sargis RM. 2018. Disparities in environmental exposures to endocrine-disrupting chemicals and diabetes risk in vulnerable populations. *Diabetes Care* 41:193–205
- 117. Salunke S, Lal DK. 2017. Multisectoral approach for promoting public health. *Indian J. Public Health* 61:163–68
- 118. Sanbonmatsu L, Ludwig J, Katz LF, Gennetian LA, Duncan GJ, et al. 2011. Moving to Opportunity for Fair Housing demonstration program: final impacts evaluation. Rep., US Dep. Hous. Urban Dev., Off. Policy Dev. Res., Washington, DC. https://www.huduser.gov/publications/pdf/mtofhd_fullreport_v2.pdf
- Sanders Thompson VL, Johnson-Jennings M, Bauman AA, Proctor E. 2015. Use of culturally focused theoretical frameworks for adapting diabetes prevention programs: a qualitative review. *Prev. Chronic Dis.* 12:140421
- Saydah S, Imperatore G, Cheng Y, Geiss LS, Albright A. 2017. Disparities in diabetes deaths among children and adolescents—United States, 2000–2014. MMWR 66:502–5
- 121. Saydah SH, Imperatore G, Beckles GL. 2013. Socioeconomic status and mortality: contribution of health care access and psychological distress among U.S. adults with diagnosed diabetes. *Diabetes Care* 36:49–55

- 122. Seligman HK, Jacobs EA, López A, Tschann J, Fernandez A. 2012. Food insecurity and glycemic control among low-income patients with type 2 diabetes. *Diabetes Care* 35:233–38
- 123. Shalowitz MU, Eng JS, McKinney CO, Krohn J, Lapin B, et al. 2017. Food security is related to adult type 2 diabetes control over time in a United States safety net primary care clinic population. *Nutr: Diabetes* 7:e277
- 124. Silverman J, Krieger J, Kiefer M, Hebert P, Robinson J, Nelson K. 2015. The relationship between food insecurity and depression, diabetes distress and medication adherence among low-income patients with poorly-controlled diabetes. *J. Gen. Intern. Med.* 30:1476–80
- 125. Siminerio LM, Albright A, Fradkin J, Gallivan J, McDivitt J, et al. 2018. The National Diabetes Education Program at 20 years: lessons learned and plans for the future. *Diabetes Care* 41:209–18
- 126. Smalls BL, Gregory CM, Zoller JS, Egede LE. 2015. Assessing the relationship between neighborhood factors and diabetes related health outcomes and self-care behaviors. *BMC Health Serv. Res.* 15:445
- 127. Sweet SN, Ginis KA, Estabrooks PA, Latimer-Cheung AE. 2014. Operationalizing the RE-AIM framework to evaluate the impact of multi-sector partnerships. *Implement. Sci.* 9:74
- 128. Tabak RG, Sinclair KA, Baumann AA, Racette SB, Sebert Kuhlmann A, et al. 2015. A review of diabetes prevention program translations: use of cultural adaptation and implementation research. *Transl. Behav. Med.* 5:401–14
- 129. Tam G, Yeung MPS. 2018. A systematic review of the long-term effectiveness of work-based lifestyle interventions to tackle overweight and obesity. *Prev. Med.* 107:54–60
- 130. Thomson H, Thomas S, Sellstrom E, Petticrew M. 2009. The health impacts of housing improvement: a systematic review of intervention studies from 1887 to 2007. *Am. J. Public Health* 99(Suppl. 3):S681–92
- 131. Thomson H, Thomas S, Sellstrom E, Petticrew M. 2013. Housing improvements for health and associated socio-economic outcomes. *Cochrane Database Syst. Rev.* 2013:CD008657
- Tuomilehto J, Lindström J, Eriksson JG, Valle TT, Hämäläinen H, et al. 2001. Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. N. Engl. J. Med. 344:1343–50
- 133. US Dep. Health Hum. Serv. 2009. Healthy People 2020 public meetings. Rep., US Dep. Health Hum. Serv., Washington, DC. https://www.healthypeople.gov/2010/hp2020/Objectives/files/ Draft2009Objectives.pdf
- 134. US Dep. Health Hum. Serv. 2011. *HHS action plan to reduce racial and ethnic health disparities: a nation free of disparities in health and health care.* Rep., US Dep. Health Hum. Serv., Washington, DC. https://minorityhealth.hhs.gov/npa/files/Plans/HHS/HHS_Plan_complete.pdf
- 135. Varanka-Ruuska T, Rautio N, Lehtiniemi H, Miettunen J, Keinänen-Kiukaanniemi S, et al. 2018. The association of unemployment with glucose metabolism: a systematic review and meta-analysis. *Int. J. Public Health* 63:435–46
- 136. Vongmany J, Luckett T, Lam L, Phillips JL. 2018. Family behaviours that have an impact on the selfmanagement activities of adults living with type 2 diabetes: a systematic review and meta-synthesis. *Diabet. Med.* 35:184–94
- 137. Walker RJ, Smalls BL, Campbell JA, Strom Williams JL, Egede LE. 2014. Impact of social determinants of health on outcomes for type 2 diabetes: a systematic review. *Endocrine* 47:29–48
- 138. Walker RJ, Strom Williams J, Egede LE. 2016. Influence of race, ethnicity and social determinants of health on diabetes outcomes. *Am. J. Med. Sci.* 351:366–73
- Whitaker KM, Everson-Rose SA, Pankow JS, Rodriguez CJ, Lewis TT, et al. 2017. Experiences of discrimination and incident type 2 diabetes mellitus: the Multi-Ethnic Study of Atherosclerosis (MESA). *Am. J. Epidemiol.* 186:445–55
- Whittemore R. 2011. A systematic review of the translational research on the Diabetes Prevention Program. *Transl. Behav. Med.* 1:480–91
- 141. WHO (World Health Organ.). 2010. A conceptual framework for action on the social determinants of health. Soc. Determ. Health Discuss. Pap. 2, WHO, Geneva, Switz. http://www.who.int/sdhconference/ resources/ConceptualframeworkforactiononSDH_eng.pdf
- 142. Willging CE, Helitzer D, Thompson J. 2006. 'Sharing wisdom': lessons learned during the development of a diabetes prevention intervention for urban American Indian women. *Eval. Program Plann.* 29:130–40

- 143. Williams IC, Clay OJ, Ovalle F, Atkinson D, Crowe M. 2018. The role of perceived discrimination and other psychosocial factors in explaining diabetes distress among older African American and white adults. *J. Appl. Gerontol.* https://doi.org/10.1177/0733464817750273
- 144. Wolff LS, Acevedo-Garcia D, Subramanian SV, Weber D, Kawachi I. 2010. Subjective social status, a new measure in health disparities research: Do race/ethnicity and choice of referent group matter? *J. Health Psychol.* 15:560–74
- 145. Wong KA, Kataoka-Yahiro MR. 2017. Nutrition and diet as it relates to health and well-being of Native Hawaiian kūpuna (elders): a systematic literature review. *J. Transcult. Nurs.* 28:408–22
- 146. Zajacova A, Lawrence EM. 2018. The relationship between education and health: reducing disparities through a contextual approach. *Annu. Rev. Public Health* 39:273–89
- 147. Zhang Y, Lave JR, Donohue JM, Fischer MA, Chernew ME, Newhouse JP. 2010. The impact of Medicare Part D on medication adherence among older adults enrolled in Medicare-Advantage products. *Med. Care* 48:409–17
- 148. Zimmerman EB, Woolf SH, Haley A. 2015. Understanding the relationship between education and health: a review of the evidence and an examination of community perspectives. Rep., Agency Healthc. Res. Quality, Rockville, MD. https://www.ahrq.gov/professionals/education/curriculum-tools/populationhealth/zimmerman.html