J Behav Med (2017) 40:127–144
DOI 10.1007/s10865-016-9802-2

New directions for diabetes prevention and management in behavioral medicine

Barbara Stetson[1] · **Karl E. Minges**[2] · **Caroline R. Richardson**[3]

Received: January 10, 2016 / Accepted: October 5, 2016 / Published online: October 14, 2016

Abstract Accelerating diabetes rates have resulted in a global public health epidemic. Lifestyle change is a cornerstone of care, yet regimen demands may result in adherence difficulties. Distress, depression, and other psychosocial concerns are higher in those with diabetes. While interventions, such as the Diabetes Prevention Program appear to be effective, further research is needed to support the translation of interventions to prevent diabetes. Studies assessing optimal approaches to promoting effective decision making, coping and adherence are needed. More information is needed to evaluate the influence and potential of emerging technologies on intervention delivery and quality of life in children and adults with diabetes. Theoretically informed, interdisciplinary studies that consider ecological models are needed to develop a roadmap for policies and diabetes management recommendations. Reduction of diabetes-related health disparities is a critical area for future studies. Behavioral medicine scientists and practitioners are poised to address these and other proposed future research directions to advance diabetes prevention and management.

Keywords Diabetes · Research · Behavior · Public health · Dissemination

✉ Barbara Stetson
barbara.stetson@louisville.edu

[1] Department of Psychological and Brain Sciences, University of Louisville, 317 Life Sciences Building, Louisville, KY 40292, USA

[2] School of Nursing, Yale University, Orange, CT 06447, USA

[3] Department of Family Medicine, University of Michigan, Ann Arbor, MI 48109, USA

Background and rationale

Global burden of diabetes

Diabetes now impacts over 300 million people worldwide (World Health Organization, 2014) and is projected to affect 439 million people by 2030 (Shaw et al., 2010). US diabetes prevalence increased 128 % between 1988 and 2008—22 million people in the US now have diabetes (National Center for Health Statistics, 2015). Globally, between 2010 and 2030, there will be a projected 69 % increase in adults with diabetes in developing countries and a 20 % increase in developed countries (Shaw et al., 2010). These rates are concerning as diabetes results in considerable health care burden and comorbid conditions. For instance, diabetes substantially increases risks of cardiovascular disease (CVD), among other common complications including neuropathy, retinopathy and nephropathy. Neuropathy, in turn, increases the risk of ulcers, infections and amputations (American Diabetes Association, 2015b); retinopathy is a leading cause of blindness; (Lee et al., 2015) and related impaired renal function is also a leading cause of kidney failure, contributing dialysis or kidney transplant and premature mortality (American Diabetes Association, 2015b; Morrish et al., 2001). Complications are also associated with higher rates of depression in diabetes (de Groot et al., 2001) and both are associated with relatively poor outcomes (Bartoli et al., 2016; Hofmann et al., 2013). Diabetes is also associated with an increase in risk of cognitive impairment (Everson-Rose & Ryan, 2015). These complications exert significant impact on health care utilization aspects of health related quality of life such as vitality, general health and functional impairment as well as mortality (Osthus et al., 2012) and health care expenditures (Ward et al., 2014).

Annual costs of diabetes in the US are estimated at $176 billion in direct costs and $69 billion in indirect expenses associated with disability, loss of work and premature mortality. The health care costs of individuals with diabetes are nearly two and half times of those without diabetes (American Diabetes Association, 2013). The significant global burden of diabetes, specifically in developing countries (World Health Organization, 2014), results in projections of staggering costs in both economic and health care burden and increasing health disparities.

The vast majority of diabetes cases (approximately 90 %) are type 2 diabetes, which is a consequence of the body's ineffective use of insulin (World Health Organization, 2014). Physical inactivity and excess body weight play a significant role in the development of type 2 diabetes and most people with type 2 diabetes are obese (Eckel et al., 2011). Type 1 diabetes (previously known as juvenile onset or insulin dependent diabetes) is a result of an absence of insulin production, and requires daily administration of insulin for survival. Gestational diabetes (elevated blood glucose levels during pregnancy) increases risks of pregnancy and delivery complications. Impaired glucose tolerance and elevated fasting glycemia, commonly referred to as "prediabetes," are conditions that appear to bridge normal glucose levels and diabetes. Prediabetes is increasing in prevalence in parallel with increases in obesity, and poses major risks for the eventual development of type 2 diabetes. Unfortunately, screening rates are low, and the majority of people living with prediabetes are undiagnosed—estimates are that while 86 million people have prediabetes, 90 % are unaware of this (Centers for Disease Control and Prevention, 2014). The emergence of increased type 2 diabetes prevalence in youth (Weinstock et al., 2015) highlights the extent of the crisis of prediabetes and type 2 diabetes and is a harbinger of future burden. Engagement in healthy eating and physical activity can significantly reduce the risk of individuals with prediabetes from developing type 2 diabetes.

The increasing prevalence of diabetes suggests an urgent need to develop additional, innovative ways to improve both diabetes management and prevention for global and diverse populations. Behavioral medicine can be this platform by drawing on behavior change concepts and theories to better understand efforts to improve self-care behaviors, determine active ingredients of change and develop psychometrically supported measurement instruments to enhance screening and evaluation of processes and outcomes in a range of patient-centered health care and community settings across the diabetes risk continuum. Behavioral medicine's perspective on patient-centered approaches and ecological frameworks can further the promotion of interdisciplinary approaches to care and the consideration of social and environmental issues impacting self-care behavior, psychological well-being and implementation of evidence-based health care approaches. These approaches may help to promote the transition of diabetes care from specialty clinics to primary care and community settings, aiding efforts towards reducing health disparities and promoting diabetes prevention efforts. Indeed, the past several decades of diabetes research has spawned numerous studies and reviews that highlight the roles of the individual patient, provider(s), health care setting and environmental context when developing effective diabetes management interventions. However, future direction is needed to drive the field, which is critical to the development of an informed evidence-based practice and public health policies to prevent and manage diabetes in the modern era.

Diabetes differentially impacts certain subgroups. For instance, diabetes burden is greater in ethnic minorities and low-income groups with health disparities in prevalence, complications and mortality worldwide (Spanakis & Golden, 2013). While the prevalence of diabetes is equivalent in men and women, sex differences have also emerged in a number of domains. Women with diabetes have twice the excess coronary heart disease (CHD) risk compared with men. Higher rates of obesity, post-menopausal hypertension, higher metabolic syndrome and other cardiovascular risk profiles and poorer response to exercise training in diabetic women have all been implicated in gender differences in diabetes health-related outcomes and responses to interventions (Regensteiner et al., 2015). Social determinants of health such as living in neighborhoods with limited healthful grocery stores, walkability and access to health care facilities may also play significant roles regarding the disparities in the development and progression of diabetes (Fisher, 2008; Marrero et al., 2013).

Need for improved outreach and delivery

Diabetes care delivery has increasingly seen a shift in treatment approaches with increased focus on primary care settings, collaboration of multidisciplinary teams (National Diabetes Education Program, 2011) and emphasis on prevention and patient-centered approaches and support (Peterson et al., 2015; Rittenhouse & Shortell, 2009; Shojania et al., 2004). Community-based programs and resources aimed at providing diabetes interventions and support have enhanced treatment reach and delivery and offer promise for bridging gaps in care. National programs aimed at improving care have increasingly focused on use of process and outcomes data, including patient-reported outcomes (AHRQ, 2015). Recent data indicates overall improvements in the quality of care and outcomes in the last decade, however the least improvements were noted for younger adults, particularly those under age 40, and for

ethnic minorities, and it has been speculated that the influence of diabetes management skills and resources, access to quality care and social determinants on treatment response warrant further study (Stark Casagrande et al., 2013).

In light of the rapid increases in diabetes and the urgent need for additional, effective approaches to improve reach and delivery of prevention and management, this paper identifies and highlights new directions for diabetes research and care in behavioral medicine.

Summary and critical review of the current state of behavioral medicine in diabetes

Diabetes prevention

The causes of diabetes are complex; however, research indicates that the dramatic increases in worldwide rates of diabetes are, in large part, due to rapid increases in overweight/obesity, which is largely facilitated by lack of physical activity, poor diet and proliferation of a sedentary lifestyle. There are now approximately 1.5 billion overweight and obese adults worldwide (World Obesity Federation, 2015). In the US, recent estimates suggest that 35 % of adults are obese (defined as BMI $\geq$ 30) and 17 % of youth are obese (defined as BMI $\geq$ 85th percentile of the sex-specific BMI-for-age growth charts). Body weight and prediabetes and type 2 diabetes are highly related, with studies suggesting that body mass index (BMI) may account for about 60 % of the risk (World Obesity Federation, 2015). Together, with behavioral factors such as dietary intake patterns and physical inactivity, BMI plays an important role both in the prevention, development and management of type 2 diabetes.

The landmark Diabetes Prevention Program (DPP) trial found that preventive intervention approaches are successful in reducing risk factors and delaying or preventing the onset of diabetes in adults with prediabetes (Knowler et al., 2002). Intensive lifestyle intervention focusing on weight reduction through caloric restriction and consistent physical activity resulted in a 58 % risk reduction, while metformin reduced risk by only 31 %. Intensive lifestyle participants had favorable CVD risk factors; benefits were more pronounced in older adults (Knowler et al., 2002). Follow up studies have shown long-term benefits of intensive lifestyle intervention in slowing progression to diabetes (Perreault et al., 2014) and translational studies have indicated that DPP replications are feasible in community settings (Ackerman, 2013; DeJoy et al., 2013; Whittemore et al., 2009).

Efficacy trials of Diabetes Prevention Programs have shown impressive results and initial efforts to translate such interventions to broader populations in the community are promising (Ali et al., 2012). However, the scale of the need for diabetes prevention is massive and we are only just starting to see progress in expanding the reach of such programs to the broader community. Ultimately the potential for Diabetes Prevention Programs to have population level impacts on incident diabetes depends on our ability to improve access to and engagement in such programs.

Other approaches, including individual-, home-, and population-based behavioral trials have been shown to be efficacious in reducing the incidence of overweight/obesity. Among children, efforts that have focused on health behavior counseling, education and modifying the home and school environments to facilitate a healthy lifestyle have been efficacious (Stark et al., 2011; Waters et al., 2011; Wojcicki & Heyman, 2010). In adults, behavioral weight loss interventions including those with in-person support and others delivered remotely (e.g., telephone, website, emails) have been moderately effective in achieving clinically significant weight loss (Appel et al., 2011; Espeland et al., 2014; Goode et al., 2012).

Diabetes management

The trajectory of diabetes is largely determined by health behaviors including a dietary regimen that has healthy food choices, quantities and composition that facilitates optimal blood glucose control and a healthy weight, engagement in consistent physical activity and maintenance of good glycemic control (American Diabetes Association, 2015c). For individuals living with type 1 diabetes, administration of exogenous insulin (e.g. self-injections or use of an insulin pump) is required. While insulin use is increasingly prescribed in type 2 diabetes, use depends upon individual characteristics such as insulin resistance. Glycemic control must be evaluated by self-monitoring of blood glucose (SMBG) levels using a meter and by obtaining blood tests of HbA1c, which is an indicator of mean blood glucose control over the previous 2–3 months. Studies addressing blood glucose control typically assess HbA1c levels and examine this indicator relative to recommended standards (e.g. 6.5 % mmol by the International Diabetes Federation, 2013 and 7.0 % by the American Diabetes Association 2015a) or more or less stringent individualized or population-based goals. Feedback garnered from consistent SMBG on glycemic control requires decision-making with comparison to a predetermined standard to judge the need for adjustments in diet, activity and/or medication and to evaluate whether a treatment plan is working to maintain optimal glycemic control (Stetson et al., 2011). There has been considerable debate about the effectiveness of the use of SMBG in type 2 diabetics, particularly those who are not prescribed insulin (Kolb et al., 2010). In light of the evidence of SMBG for individuals with type 1 diabetes, future

work is needed to evaluate the efficacy of integrating SMBG into practice for individuals with type 2 diabetes.

Although there is evidence that a large proportion of cases of diabetes and its complications can be prevented by interventions that promote lifestyle change with a healthy diet, regular physical activity, maintenance of normal body weight, avoiding tobacco, SMBG and following prescribed medication regimens, this evidence-based, behavioral approach is not widely implemented in community and clinical settings. In many cases, providers are well-versed in pharmacologic interventions but have not had training in theories of behavior change or implementation of lifestyle change approaches (Peyrot & Rubin, 2007). The constraints and time limitations in many clinical settings also limit provider-patient shared decision making and opportunities for addressing lifestyle change during diabetes clinical encounters (Marrero et al., 2013; Peyrot & Rubin, 2007). As such, educational tools aimed at providers may be needed that address behavior change concepts and theories, thus helping to integrate a patient-centered approach to improving diabetes management.

The demands of lifestyle change and ongoing self-regulation are major components of diabetes care and may result in considerable patient burden and adherence difficulties, indicating the need for future research in this area. Studies indicate that with increasing regimen complexity, adherence is reduced (Ingersoll & Cohen, 2008). Reviews suggest that higher levels of regimen adherence are associated with better blood glucose control, and fewer emergency department visits, decreased hospitalizations and lower medical expenditure. There are significant associations between adherence and clinical outcomes with a number of individual and health system factors impacting rate of adherence. This research demonstrates the potential of insulin adherence to improve patients' lives, but more work is needed to identify the active ingredients of improved adherence among individuals with diabetes.

Persons with type 1 diabetes face multiple daily insulin administrations and SMBG, which can be particularly burdensome. Some populations, such as adolescents with type 1 diabetes, have numerous psychosocial barriers to adherence, making this an important area of concern (Datye et al., 2015). Intervention trials aimed at increasing adherence using a variety of approaches and points of contact such as peer coaching, telehealth, multidisciplinary providers and settings such as primary care, pharmacy and point-of-care testing have shown positive outcomes for both adult and pediatric populations (Capoccia et al., 2015; Hood et al., 2010). Community-based interventions, including peer supporters, have also been found to assist individuals in their diabetes self-management efforts (Heisler, 2007; Tang et al., 2014). Peer support and coaching may offer particular benefits in areas in which health care resources and provider access are lacking. This approach to shared decision making has demonstrated feasibility in varied cultures and settings (Ayala et al., 2015; Safford et al., 2015; Zhong et al., 2015). The World Health Organization has noted that standard features of peer support may be used cross culturally and individual programs can use these features in the development of interventions that best fit the cultures, populations and health systems in which they function (Fisher et al., 2015a). The World Health Organization and International Diabetes Federation note the tremendous potential for global efforts to promote diabetes management (Wientjens, 2008). Essential components of successful peer support for chronic disease management that have been identified by the American Academy of Family Physicians Foundation Peers For Progress Programs (Wientjens, 2008) include: provision of assistance in daily management such as pursuit of goals; emotional and social support to promote effective coping and self-care; facilitation of connections between community resources; and clinical care and support that is ongoing, consistent with the lifelong challenges of chronic disease prevention and care (Fisher et al., 2015a, b). However, the integration of these concepts in the diabetes management regimen is largely unknown.

Also influencing adherence and health outcomes are diabetes distress (Pintaudi et al., 2015), anxiety (Smith et al., 2013) and depression (Anderson et al., 2001), which are higher in those with diabetes compared to those without diabetes. Comorbid diabetes and depression present major clinical challenges, each adversely and reciprocally affecting outcomes (Holt et al., 2014). Depression has also been found to be associated with insulin resistance in the absence of diabetes, as well as the onset of diabetes (Kan et al., 2013), adding to the complexity of diabetes-depression relationship. Shared biological and behavioral mechanisms are important considerations for understanding linkages, onset, treatment response and optimal intervention approaches (Holt et al., 2014), and this area requires additional investigation given the high potential to improve patient-centered diabetes outcomes.

Recent studies also have identified the impact of glycose dysregulation and diabetes on cognitive and executive function—and the need for additional investigation on these topics. A 2015 special series on Diabetes, Obesity and the Brain provides a useful overview along with studies that highlight the role of diabetes in cognitive impairment in childhood and adolescence as well as in midlife and older adulthood (Everson-Rose & Ryan, 2015). Well-controlled imaging studies suggest that both hypoglycemia and hyperglycemia impact brain cognitive function, implicating interventions that impact these fluctuations as influential in these effects. Multiple studies indicate that impairment in cognitive status develops well-before advanced age declines,

with cognitive impairments developing in midlife and diminished executive function observed in prediabetics. Research suggests that elevated glycemia may impact cognitive decline early in the aging process (Everson-Rose & Ryan, 2015; Luchsinger et al., 2015). A large cohort study of associations between race, socioeconomic status and cognitive function found that African American participants with diabetes who lived below the US Federal poverty limit had poorer working memory, verbal memory and attention and had cognitive deficits at a younger age relative to African Americans who had diabetes but were above the poverty threshold. Findings implicate the role of developmental and social determinants in the complex mechanisms contributing to cognitive decline in diabetes (Dore et al. 2015). Efforts to promote decision-making, self-care and adherence are dependent on the ability to execute cognitive steps, making screenings and provision of adequate support systems an important part of care across the lifespan (Everson-Rose & Ryan, 2015; Vincent & Hall, 2015).

Several decades of controlled trials now show that behavioral and pharmacologic interventions that reduce glucose levels help to delay diabetes complications (Holman et al., 2008; Lachin et al., 2014). Patient-centered and multidisciplinary approaches can optimize care (Powell et al., 2015). New technologies aid assessment and management through enhanced self-monitoring tools and insulin delivery methods. However, interventions have also been shown to have deleterious effects. Tight glucose control poses risks, and intense management may lead to hypoglycemia and death (Cryer, 2014). Insulin use may promote improved glycemic control in type 1 and type 2 diabetes but has been found to also be associated with weight gain and increased CVD risk profile (Carver, 2006; Purnell et al., 1998). In this vein, more integrated research is needed to evaluate multidisciplinary approaches to behavior change and technological advances that reduce diabetes-related complications.

These current findings in behavioral medicine and diabetes suggest that diabetes management is a largely behaviorally driven self-care routine and patient involvement in care is critical to achieve optimal glycemic control. Patient-centered approaches to care that include multidisciplinary health care providers and consider social determinants, lifespan factors and gender can optimize care. Moreover, coordinated international and national policies are needed to reduce exposure to the known risk factors for diabetes and to improve access to and quality of care for those with diabetes.

Research recommendations and future directions

This section presents research recommendations and future directions for diabetes prevention and management in behavioral medicine. The topics presented below were informed by our interactions with the membership of the Society of Behavioral Medicine (SBM) Diabetes Special Interest Group, including a web-based survey and events at the annual meeting such as the business meeting and research collaborations (e.g., symposia, panel discussions). A summary of our recommendations is available in Table 1.

Policy and environmental attributes to reduce diabetes burden

Obesity and diabetes are complex chronic conditions rooted in a dynamic and multilayered environment that necessitates the inclusion of micro-level concepts, such as the individual and family, and macro-level factors, comprised of medical clinics, school and sports and the community, in future health promotion self-management interventions to achieve long-term sustainable impacts (Waters et al., 2011). Nevertheless, much of the research on diabetes prevention and management addresses individual patient and/or provider roles. Social and contextual factors and their influence on diabetes care and life with diabetes are important but less well understood (Marrero et al., 2013). Assessment and intervention approaches that consider the contextual influences that contribute to diabetes risk factors and the greater diabetes burden in ethnic minorities and low-income groups are greatly needed. Development and evaluation of assessments that consider social determinants of health such as the role of community, health care and environmental settings on diabetes-related health behavior, distress, biological markers of health care delivery and health outcomes are recommended. The role of environmental structure and neighborhood has been an important area of research examining healthy food availability (Oppert & Charreire, 2012), physical activity (Haselwandter et al., 2015; McCormack & Shiell, 2011; McGrath et al., 2015) and obesity (Ding & Gebel, 2012), which have implications to diabetes prevention and management. However, there is limited research using social ecological models within diabetes populations. Validated approaches to contextual assessment of the environment and social factors influencing health outcomes using geographic information systems (GIS) technology, built environment and self-report assessment of social and environmental resources (Glasgow et al., 2005; McCormack et al., 2008) and neighborhood structure (Mujahid et al., 2007) are available, and integration into diabetes research would complement research addressing individual patient and provider roles. Such ecologically based studies should draw on the experiences of the larger social ecology evidence and consider the role of moderators and mediators, utilize objective and validated self-report measures and assess causality via

Table 1 Summary of research recommendations and directions

Topic	Recommendation
Policy and environmental attributes to reduce diabetes burden	Consideration of large systems such as government and existing policies in the US and globally
	In addition to the roles of organizations, community and culture is critical to the advancement of global efforts to reduce the burden of the diabetes epidemic
Childhood obesity and transitions of care in emerging adulthood and midlife	Focus on issues pertinent to the burden of living with type 1 diabetes in children, the rise of prediabetes and type 2 diabetes in youth and health care and psychosocial needs associated with emerging adulthood in adolescents and young and midlife adults with diabetes
	Increased research on factors related to enhanced quality of life, such as psychological, emotional, familial or psychosocial concepts and how to best implement them into potential interventions, such as a self-management educational intervention, to ensure the effectiveness of obesity prevention and management programs
	Promotion of attention to social and cultural issues pertinent to emerging adulthood in adolescents and young adults is also needed, such as the transition to adult-oriented medical care among emerging adults and efforts to cope with the demands of diabetes and it's care in the context of work and family and the emergence of health complications in young adults with diabetes
Use of eHealth, technology and big data in diabetes prevention and management	Methods to improve diabetes management in the future include exploring the intersection of behavioral medicine and big data in diabetes research, building private–public partnerships and examining the influence of healthcare reform is warranted. Partnerships that integrate empirically supported approaches such as apps that contain proven behavioral strategies that are appropriate for target users are needed.
Translating therapeutic advance into community care for people with diabetes	Research is needed to identify the optimal points of care for evidence-based diabetes management programs, particularly among diverse age groups, as well as hard-to-reach and medically underserved populations. Translational studies evaluating interactions between peer support, provider-patient communication and decision-making, and established and traditional health care settings are also needed
Translating lifestyle interventions for diabetes prevention into low cost, integrated, and scalable programs	Translational research is critical to understanding how successful clinical trials and interventions, such as those developed for the DPP, might be integrated into community settings to improve reach
	Integrative approaches to understanding strategies to promote weight loss and physical activity and their maintenance are needed for adults, particularly younger and midlife age groups and children with or at risk of diabetes
Addressing psychosocial comorbidities and diabetic complications	Studies assessing optimal delivery approaches to promote effective decision-making, coping and self-care are needed
	Consideration of developmental progression and cognitive and executive function is recommended
Social determinants of health and health disparities in special populations	Social determinants influencing obesity, physical activity, cognitive function, perceived risk and self-efficacy for change may play an important role and are understudied. Greater understanding of the sources of diabetes and associated comorbidity and disparities in minority and low SES groups is needed. Reduction on diabetes-related health disparities is a critical area for future intervention studies

controlled and longitudinal studies. Data from diverse countries and cultures are needed (Ding & Gebel, 2012).

Childhood obesity and transitions of care in emerging adulthood and midlife

While the importance of future studies seeking to improve the self-management, psychological and behavioral outcomes of youth with type 1 diabetes cannot be overstated, there is a call for future work in behavioral medicine to address emerging areas of concern for diabetes among youth. One of these areas pertains to the epidemic of childhood obesity and its association with type 2 diabetes in youth. Although the epidemiological evidence is limited, most studies suggest some 6 % of youth with diabetes comprise those with type 2 diabetes (SEARCH for Diabetes in Youth Study Group, 2006), a finding that is pronounced among adolescents from minority populations

(SEARCH for Diabetes in Youth Study Group, 2007; Liu et al., 2010). In fact, given current incidence estimates, the number of youth with type 2 diabetes is expected to increase by 49 % by 2050 (Imperatore et al., 2012). Additional research is also needed to address the role of health behaviors, including healthy eating, physical activity, sedentary behavior and sleep on overweight or obese youth with type 1 diabetes (Minges et al., 2013). Yet, surprisingly, both descriptive and intervention research focusing on the psychosocial and behavioral aspects of weight gain for type 1 and type 2 diabetes in youth is lacking.

Behavioral medicine scientists and practitioners will need to develop robust obesity prevention interventions through behavior modification, and the development and integration of youth-specific type 2 diabetes self-management techniques in clinical practice to curtail disease progression (Buynitsky & Rhodes, 2014). Importantly, factors related to enhanced quality of life, such as psychological, emotional, familial or psychosocial concepts, must be implemented into potential interventions, such as a self-management educational intervention, to ensure the effectiveness of obesity prevention and management programs. Such insights will also help to prevent the emergence of 'double diabetes', a rare condition in which overweight and obese adolescents have the clinical manifestations of both type 1 and type 2 diabetes (Libman & Becker, 2003). Moreover, additional work is needed to understand the role of multilevel, as opposed to individual-level, obesity prevention interventions that involve families, peers, home, and schools. Currently, research exists on individual-, play-, family-, school-, and community-based interventions (Karnik & Kanekar, 2015), but less is known regarding behavioral medicine interventions that include many or all of these levels of influence. An example of a hypothetical multilevel obesity prevention intervention could be one that seeks to reduce the time youth spend sedentary each day. Such an intervention could target reducing screen time in the home though instituting mutually agreed-upon rules with parents (to reduce leisure screen time, a behavior often synonymous with sedentary behavior), while encouraging students to bike or walk to school if feasible (to reduce time spent sedentary during transport), and integrating standing desks in the school-setting (to reduce time spent sedentary during school)—most of these interventions have demonstrated the potential to individually reduce sedentary time (Minges et al., 2015b; Minges et al., 2016; Salmon et al., 2011). The adoption of this multilevel approach to intervention could result in changes to health behaviors through addressing the individual as well as the "obesogenic" society, resulting in more efficacious and longer-lasting interventions that could also have the potential to tangentially result in the improvement of several health behaviors.

Emerging adulthood in adolescents and young adults with diabetes is an overlooked topic that presents another opportunity for future behavioral medicine research and practice. Emerging adulthood, characterized as the developmental stage from adolescence to young adulthood, is one of competing educational, social and financial demands (Arnett, 2000; Peters & Laffel, 2011). In emerging adults with diabetes, issues related to diabetes self-management, psychosocial adaptation and the transition to adult-oriented medical care further compounds this period (Peters & Laffel, 2011). Emerging adults with diabetes are at risk for adverse health outcomes, including poor glycemic control, acute and chronic disease complications and lower health-related quality of life (Hanna, 2012). Research is needed pertaining to the patient, family and provider perspectives of the transition to adult-oriented medical care, especially among those underserved emerging adults from a low socioeconomic status and ethnic minority perspective, many of whom do not transition to higher education. Such investigation has the potential to design interventions that will strengthen transition preparation and advance health behavior change in emerging adults with diabetes.

Young and midlife adults appear to have poorer responses to diabetes interventions relative to older adults (AHRQ, 2015; Stark Casagrande et al., 2013). Recent data found that younger adults diagnosed with type 2 diabetes exhibited greater diabetes distress, less healthful diet and activity levels, lower diabetes self-efficacy and poorer metabolic control relative to older adults (Hessler et al., 2011). Midlife adults with diabetes also have increased health risks of cognitive decline and obesity-related complications (Everson-Rose & Ryan, 2015). Studies are needed to assess the influence of biobehavioral mechanisms as well as psychosocial factors such as family and employment and adjustment to life with chronic disease and health care demands. Examination of the impact of emerging medical care approaches in primary care settings, patient centered medical home and multidisciplinary teams as well as peer support in community settings offers opportunities for understanding optimal approaches to improving treatment delivery, and outcomes in young adults, before long-term impairments such as cognitive decline or diminished functional status emerge. Behavioral medicine researchers and clinicians have expertise in developmental and psychosocial assessment and may aid in the development of screening approaches and process and outcome measures that are appropriate across the lifespan. Opportunities for behavioral medicine also include the consideration of social and cultural factors in the context of development and dissemination of behavioral interventions for families, in-transition adolescents and young adults and midlife adults who are adjusting to the demands of diabetes. The transition of diabetes care to primary care settings, the

expanding role of multidisciplinary teams and increased reach of community and peer-based interventions raises the need for evaluation of the translation of such approaches beyond specialty care clinics.

Use of eHealth, technology and big data in diabetes prevention and management

Prevention and management of diabetes is often a complex and challenging task for patients, families and providers. However, the near omnipresence of technology, including mobile devices, computers and tablets presents an opportunity to harness such devices to improve intervention delivery and diabetes-related health outcomes.

Technology-mediated behavioral interventions have shown promise in facilitating diabetes prevention and management in behavioral medicine (Bacigalupo et al., 2013; Connelly et al., 2013; Jackson et al., 2006). Technology-assisted and eHealth interventions can capitalize on available technologies that are readily accessible to individuals (e.g., wearables such as Fitbits, internet-based programs, apps) and providers (e.g., electronic medical records, patient portals) to promote diabetes self-care. The use of such technologies must be considered along with advancements in medical devices, such as continuous glucose monitoring and use of artificial beta cell or closed-loop insulin-delivery systems (Thabit et al., 2015). Future research is needed to understand how patients with diabetes, including family members and providers, use technology to assist in diabetes prevention and management goals. There is also a need for industry-academia partnerships to create empirically-supported and scalable apps containing proven behavioral strategies that are appropriate for the target user.

With the advent of 'big data' and precision medicine, behavioral medicine researchers are poised to understand how to harness big data to define how phenotypes of patients with diabetes (Li et al., 2015) vary in terms of treatment and management techniques and customize treatment options. For instance, phenotypes of diabetes could be assessed to determine which benefits most from various self-care techniques related to improved metabolic control, such as coping skills training, motivational interviewing, or goal setting. Other opportunities for big data in behavioral medicine include leveraging existing electronic health record data to predict medication adherence and identify the most useful self-management interventions for individuals or groups, or technology-assisted big data interventions such as an insulin pen that wirelessly connects to a mobile phone or glucometer to evaluate injection trends and set reminders for SMBG (Pennic, 2013).

Along with advancements in technology, eHealth, and big data, behavioral medicine must investigate the psychological and behavioral implications of these innovations on those who use them. For instance, the misuse or abuse of technology may result in patients deterring from future use of health-related technology, or other unintended consequences (e.g., a patient uses wireless technology for self-monitoring purposes but fails to visit a healthcare provider to clinically evaluate blood glucose trends). Correspondingly, there are segments of the population that do not rely on or utilize technology for diabetes care or prevention, thus traditional education and behavioral interventions must remain a core aspect of care. Nevertheless, the availability of technology-assisted research and interventions in behavioral medicine has the potential to advance the field by improving the reach, feasibility and ultimately outcomes of diabetes management and prevention. Importantly, behavioral medicine scientists and practitioners play an important and unique role in the human-technology interaction to navigate the mechanisms of human behavior that optimize the use of technology in diabetes care (Gonder-Frederick et al., 2002).

Translating therapeutic advances into community care for people with diabetes

The efficacy of diabetes management programs focused on improving diabetes self-care delivered in the medical setting by a multidisciplinary team of providers have the potential to improve glucose control, mental health and costs for individuals with diabetes. However, these complex interventions are expensive and time consuming (Pimouguet et al., 2011; Sherifali et al., 2015; Stock et al., 2010; Sugiyama et al., 2015). Often those most in need of these services do not have access to or engage in such programs. Additionally, individual and communities differ in terms of their educational and behavioral health needs (American Association of Diabetes Educators, 2007). Tools that allow providers to tailor the content of diabetes management programs to individuals or communities are needed in order to improve access and efficacy in underserved populations. Research is needed to identify the optimal points of care for evidence-based diabetes management programs, particularly among diverse age groups, as well as hard-to-reach and medically underserved populations. Translational studies evaluating interactions between peer support, provider-patient communication and decision-making, and established and traditional health care settings are also needed. Translation of structured chronic disease management programs for use with individuals with diabetes to community settings and online formats has been successful (Lorig et al., 2010). Less is known, however, about optimal points of care for these interventions, particularly with hard-to-reach, medically underserved populations.

Age has largely been overlooked as a factor in studies of self-care in adults with type 2 diabetes. Age is often statistically controlled in clinical trials and the specific associations of age with various aspects of the diabetes management are not well studied (Hessler et al., 2011). As noted, younger adults with type 2 diabetes may have greater diabetes distress, and poorer self-care and diabetes self-efficacy relative to older adults with diabetes (Hessler et al., 2011) and have poorer metabolic control (Hessler et al., 2011) and risks of development of cognitive decline and obesity (Everson-Rose & Ryan, 2015). Additional research to further examine the biobehavioral mechanisms influencing these findings and to compare optimal time points, modalities and behavioral strategies of intervention for adults across the life span is needed. Studies examining interactions between age and gender may demonstrate the need for gender tailoring in addition to age tailoring for these interventions.

Provider-patient-interactions that use patient-centered communication and shared decision-making approaches are now recommended by the American Diabetes Association. Motivational interviewing, which uses a patient-centered approach to address intrinsic motivation and behavior change goals, has been incorporated in numerous diabetes intervention trials. However, a recent systematic review highlighted the inconsistent findings for the benefits of motivational interviewing, noting, heterogeneous study designs and measures and limitations in interventionist training. The most notable findings, across 14 studies, were motivational interviewing interventions showing positive outcomes for dietary behavior in adults with type 2 diabetes, with the most favorable clinical change outcomes for weight management (Ekong & Kavookjian, 2015). Ongoing research with this promising intervention approach would benefit from identification of the most effective components and feasibility of training dissemination to primary care and community settings and with diverse diabetes educators in order to promote more widespread reach.

Translating lifestyle interventions for diabetes prevention into low cost, large-scale programs

While there are numerous randomized controlled trials demonstrating that type 2 diabetes can be prevented with lifestyle interventions, many people with prediabetes are not benefiting from this knowledge. The scale of the prediabetes problem is massive (Boyle et al., 2010). Demonstrating that we can prevent diabetes in a cohort of 100 people or even 1000 people is not enough. The next step in this challenge is to develop very large-scale and low-cost programs for the hundreds of millions of individuals worldwide who could benefit from participation in a Diabetes Prevention Program (Ackerman, 2013; Ackermann et al., 2014). But first, research is needed to appropriately address the difficulties of translation and reach by addressing its three central components: identification, recruitment and retention (Institute of Translational Health Sciences, 2010). All three of these components rely heavily on strategies for behavioral activation.

Identification

Superficially, identifying those with prediabetes is a technical problem that can be solved by ordering a blood-screening test. However, there are opportunities for behavioral interventions to change physician behavior with respect to ordering tests and responding to abnormal results. Behavioral medicine scientists must address the following questions to achieve this goal: How do physicians identify individuals who might be at high risk for diabetes? Are there high-risk individuals who are systematically missed when physicians must initiate screening? Are there interventions that can teach patients to accurately self-assess risk and request screening? Is the burden of prediabetes so high that it is more cost effective in some populations to offer diabetes prevention interventions universally rather than using resources to screen large populations for high-risk individuals with prediabetes?

Recruitment

Very large-scale passive recruitment with voluntary participation results in an enrollment rate in the range of 5–10 % of individuals invited to participate in a prediabetes prevention program. In order to achieve the broadest population-based results, behavioral medicine needs to determine how to increase enrollment rates of eligible individuals to the 50–80 % range. Opportunity also exists in public health messaging to identify the most effective ways to frame the diagnosis of prediabetes so that patients understand both the risks of the condition as well as the opportunity for diabetes prevention through lifestyle change (Gallagher & Updegraff, 2012). A focus on behavioral economics strategies, such as incentives or rewards, which have been successfully implemented in trials addressing other health-risk behaviors (Pit et al., 2014; Tappin et al., 2015), may also increase enrollment in Diabetes Prevention Programs. Social support, identified through social networks, has shown success in leveraging to increase enrollment rates (Tanjasiri et al., 2015) and merits study in diabetes prevention trials.

Enrollment into Adaptations of Prevention Programs: The Diabetes Prevention Program (DPP) demonstrated that diet and physical activity substantially impacted delay and prevention of diabetes onset in adults with prediabetes. Less costly group and online adaptations of the DPP appear to be effective. Translation of the DPP to population-level impact on incident diabetes has been slow, but gaining momentum. Community-based interventions and peer support can assist self-care efforts.

Retention

Once individuals are enrolled in the DPP, researchers need to identify the best behavioral practices to keep participants engaged throughout the course of the diabetes prevention curriculum to maximize outcomes, such as physical function and weight loss. Comparative effectiveness research is warranted to assess whether changes to the motivational, dietary or physical activity components of the program will improve outcomes for participants.

Addressing these concerns pertaining to translation and reach will enable a systems approach to managing or preventing diabetes. For both diabetes prevention and treatment, funders and researchers have begun to expand the view of potential research question beyond the traditional doctor-patient dyad (Marrero et al., 2013). A systems view of behavioral research incorporates entities that interact with medical care including environmental factors, community, employers, social services, mass media, industry and the educational system. For example, urban planners and local employers make decisions that impact walkability of a community. There is a particular interest in interventions that impact organizational behavior rather than individual behavior. These complex system-level interactions may be some of the most potent levers we have to impact outcomes related to diabetes prevention and management. Mixed methods research, combining qualitative and quantitative methods, can deliver generalizable knowledge about how such complex and dynamic systems interact (Creswell & Clark, 2011). Frameworks such as the Consolidated Framework for Implementation Research (CFIR) provide a compendium of constructs for such investigations (Damschroder & Lowery, 2013).

Peer support programs to promote diabetes care also offer tremendous potential for improving the reach of behavior change and care support resources for individuals with diabetes. Program development, organization and delivery approaches may vary and while the past decade has demonstrated feasibility, reach and sustainability of peer support in a variety of settings, additional work is needed to assess which types of structures, programs and intervention approaches are optimal in different contexts and with dissimilar populations. Optimal strategies for combining community and peer support programs with other clinical care and outreach are also as yet, unclear (Fisher et al., 2015b; Wientjens, 2008). Future intervention studies using lay and peer delivery approaches are needed in populations, communities and settings in which care may be lacking in order to best assess how to optimize care for individuals who might otherwise fall between the cracks. Intervention studies that include infrastructures to include ongoing management in low-income communities and countries, globally diverse and varied cultural settings are needed. Studies evaluating interactions between peer support and established and traditional health care settings are also needed. In order to understand best approaches to achieving treatment fidelity and reach, studies of and public policy support for efficacious strategies for workforce training and sustaining programs in under-resourced organizations and the utility of technology and eHealth in peer support programs is recommended (Fisher et al., 2015b).

Addressing psychosocial comorbidities and diabetes complications

The majority of research on psychosocial comorbidities and diabetes is on the associations between diabetes and depression. Comorbid diabetes and depression have reciprocal effects and present substantial challenges for diabetes care (Holt et al., 2014). Advances in behavioral and biological research have led to a burgeoning body of literature in the past decade and addressed some of the shared mechanisms of action of diabetes and depression. This has resulted in recommendations for assessment approaches and both behavioral and pharmacological intervention trials to evaluate optimal treatment delivery approaches. Additionally, a number of overviews of diabetes psychosocial intervention approaches and systematic reviews and meta analyses of depression interventions in diabetes have been published in the last decade. Highlights of these findings are described below.

An NIDDK international conference report on diabetes and depression (Holt et al., 2014) summarized shared mechanisms including behavioral changes of sleep disturbances, physical inactivity and poor diet, autonomic dysfunction, inflammation and hypothalamic pituitary adrenal axis activation and environmental and cultural risk factors. This report noted that methodological inconsistencies in the assessment and definitions of depression have contributed to inconsistencies in estimates of the prevalence and incidence of diabetes and depression. Previously researchers have noted the importance of differentiating between diabetes-related distress, such as feeling overwhelmed by the burden of unrelenting self-care demands

and clinical depression (Hermanns et al., 2007). While screening for diabetes distress and depression is recommended in clinical settings, both clinical and research assessments should be specific in their examination of depressive symptomology across the spectrum of depressive disorders (for example differentiating diabetes-related emotional distress from depressive symptomology that is associated with dysthymia, major depressive disorder, bipolar disorder and anxiety and psychotic disorders). Use of validated measures, such as standardized psychiatric interviews is needed in order to standardize reports. Data on prevalence and course in specific age groups, ethnicities and across varied durations of diabetes and presence of comorbidities is needed. Interventions aimed at addressing major depressive disorder and depressive symptomology in adults with diabetes have yielded largely positive outcomes data. A systematic review and meta analysis of 14 randomized controlled trials reported a moderate combined effect of all interventions in clinical impact on depressive symptoms, a moderate effect for pharmacologic intervention and large effect for combined diabetes self-management and psychotherapy interventions (van der Feltz-Cornelis et al., 2010). However, interventions have yielded mixed results in improving glycemic control (van der Feltz-Cornelis et al., 2010), and few controlled interventions have targeted individuals with elevated or specific levels of glycemic control. Other systematic review indicates that cognitive behavior therapy and collaborative care targeting depression in diabetes has beneficial impact on depression management, however also notes mixed evidence for impact on glucose control and highlights a negative impact on glucose monitoring behavior in a well-controlled study (Markowitz et al., 2011). Likewise, interventions focused on improving self-care and adherence have yielded mixed results (Katon et al., 2004; Lustman et al., 1998) and studies addressing depression and self-care in tandem are limited (Markowitz et al., 2011). Data on diabetes-depression comorbidity in children and adolescents and in gestational diabetes is limited. More evaluation of clinical interventions addressing optimal delivery approaches that promote effective problem solving, coping, self-care decision making and highlighting potential mechanisms of action such as health-related cognitions, self-efficacy and studies expanding interventions to encompass novel, recent approaches such as mindfulness or acceptance and commitment therapy are recommended (see Markowitz et al., 2011).

Continued research on the mechanisms of action that link biological and behavioral aspects of diabetes and depression may further enhance the development of additional treatment approaches. The NIDDK report on depression and diabetes recommends continued studies to address research gaps. Recommendations include research designs that include moving from cross-sectional to longitudinal studies with a goal of prospective, life-course studies, with consideration of phenotypic characterization of the intrauterine environment and external environments as well as assessment of biological/behavioral pathways that might be influenced by these environments. Treatment research recommendations include broadening participant trial inclusion criteria to allow for examination of interactions of behavioral and pharmacologic depression treatment approaches in the prevention of diabetes and in diabetes treatment approaches in the prevention of depression (Holt et al., 2014). Further, evaluation of long-term follow-up data for psychological and pharmacological intervention trials are also needed in order to understand the sustainability of these intervention approaches (Baumeister et al., 2014). The reciprocal impact of social factors (Burns et al., 2015) is also an area with intervention potential—a strength of the field of behavioral medicine.

Rates of anxiety disorders appear to be elevated in diabetes, with studies examining both anxiety and depression symptomology in tandem (Collins et al., 2009) and independent of the diabetes-depression association. A large case–control study of adults with and without type 2 diabetes found higher rates of generalized anxiety disorder (GAD), panic disorder and obsessive compulsive disorder in those with diabetes relative to those without diabetes (Santos et al., 2014). Higher rates of GAD and panic disorder have also been noted in a study of type 1 diabetes, with elevations in social phobia also reported (Maia et al., 2014). Anxiety-diabetes associations are less pronounced relative to the diabetes-depression linkages and there have been far fewer studies. The majority of research has been cross-sectional in nature. A recent longitudinal study of a large, community sample of adults with type 2 diabetes (Deschenes et al., 2015) that examined cross lagged-associations between generalized anxiety symptoms and functioning found reciprocal associations between anxiety and function, independent of depression. More longitudinal research, across both type 1 and type 2 diabetes populations and diverse populations and settings is needed. Similar to research on diabetes and depression, specificity in assessment with validated measures is needed and human and animal models of mechanisms of association would help to further research on anxiety and diabetes comorbidity.

Several decades of research have indicated that individuals living with type 1 diabetes, particularly females, have substantially higher rates of disordered eating behaviors when compared to their nondiabetic peers. Studies addressing prevention and treatment of specific aspects of disordered eating such as dieting behaviors, fasting, bingeing and compensatory and purging behaviors that impact diabetes management and health outcomes are needed. Research aimed at understanding longitudinal

predictors of and protective factors for disordered eating behaviors and eating disorders in young women with type 1 diabetes is needed (Colton et al., 2015). Studies of health behavior and psychosocial aspects of functioning in type 1 diabetes have largely focused on children and adolescents and their families. Adults living with type 1 diabetes and the long-term impact of life with this chronic disease should be considered in future research.

Psychosocial interventions, including diabetes self-management education appears to improve glycemic control in adults with type 2 diabetes, with a recent systematic review showing the greatest benefit among those with extensive contact of greater than 10 h, with combined individual and group contact and in those with persistently elevated A1c (Chrvala et al., 2015). Cognitive-behavioral interventions may help improve adherence to diabetes regimen recommendations. Problem-focused skill training has been found to promote self-care (Fitzpatrick et al., 2013) and has been successfully integrated into behavior and emotion-focused interventions, including the DPP (Diabetes Prevention Program (DPP) Research Group, 2002).

The past decade of investigation of behavioral medicine among youth with type 1 diabetes has produced much knowledge pertaining to important self-management techniques to improve metabolic control. Behavior modification techniques, including goal setting, coping skills training, motivational interviewing, multisystemic therapy and self-efficacy have demonstrated improvements in metabolic control, as well as other important patient-centered outcomes, including quality of life, peer relationships, blood glucose awareness, and stress and depression reduction, among others (Cox et al., 2006; Ellis et al., 2008; Grey et al., 2013; Hood et al., 2010; Plack et al., 2010; Snoek et al., 2008). Yet, in these domains, more work is needed to examine the efficacy of diverse methods of intervention delivery and implementation. To improve the rapid translation of knowledge into practice, there is also a need for future self-management interventions to employ diverse research methods, such as pragmatic clinical trials, comparative-effectiveness research and mixed methods research. Future evaluations of interventions aimed at promoting behavior change and adherence to self-care recommendations would benefit from specificity in the behaviors targeted for change and assessment of treatment fidelity (Ekong & Kavookjian, 2015; Miller & Rollnick, 2014). Their applicability to underserved, low literacy and global populations is in need of evaluation.

Aspects of self-care involving self-regulation and decision making would benefit from enhancement of existing theoretical models to better understand problem solving and decision making regarding individual domains of self-care. SMBG, a key component of diabetes self-management and education guidelines, is intended for use in observing blood glucose levels for the purpose of making decisions related to need for change relative to personal goals and problem solving related to adjustment of medications, diet or activity. The extent to which many individuals engage in these decision making steps, as inferred by providers, as opposed to engaging in this self-testing behavior simply to follow structured recommendations in the absence of health-related focus and problem solving is as yet unclear (Ward et al. 2015). Debate remains regarding the effectiveness of use of SMBG in individuals with type 2 diabetes who do not use insulin (Kolb et al., 2010).

The data on the development of neurocognitive changes and diminished executive function in prediabetes and midlife (Luchsinger et al., 2015; Vincent & Hall, 2015) point to a need for cognitive screenings early in the diabetes care plan and ongoing monitoring of executive function in those at risk. Consideration of working memory and executive function when developing self-care plans such as detailed dietary and insulin regimens and SMBG goals is warranted. While it is established that persons with diabetes have greater rates of decrements in executive and cognitive function relative to those without diabetes, there remains much to be learned about the developmental trajectory from childhood through old age in the context of continuum of glucose regulation and diabetes control. Socioeconomic influences, access to medical care and race appear to influence cognitive function in prediabetes and diabetes; however the biobehavioral mechanisms of action are unclear. Interactions between stress, diabetes distress, depression and neurocognitive function are potentially fruitful areas of study. Interdisciplinary teams of behavioral medicine scientists have much to offer towards the study of complex biobehavioral interactions between psychosocial and cognitive function, the reciprocal influences of obesity and impact of the environment and poverty on the development and progression of diabetes and related complications.

Social determinants of health and health disparities in special populations

Factors related to enhanced quality of life, such as psychological, emotional, familial or psychosocial concepts, must be implemented into potential interventions, such as self-management educational intervention, to ensure the effectiveness of obesity prevention and management programs. Focus on psychosocial issues such as the transition to adult-oriented medical care among emerging adults and the impact of day-to-day environmental influences that are pertinent to them such as neighborhood and work influences and demands on diabetes self-care and control is also needed. Development of well-conceived, validated mea-

sures and frameworks that consider contextual influences such as social and environmental supports and resources and more widespread use of social ecological frameworks (Fisher, 2008) and instruments that are already available (Glasgow et al., 2005) is needed to promote greater understanding of social determinants that influence diabetes self-care behaviors and biological outcomes (e.g. King et al., 2010).

Disparities in morbidity and mortality in minority and low-income individuals with diabetes continues to be a major challenge for behavioral medicine. Research designs that have adequate minority representation for consideration of the role of socioeconomic status and social factors and the intersection of sociocultural and biological mechanisms of action are needed across settings. Mixed methods approaches drawing from both qualitative and quantitative methodologies may identify previously undocumented influential social determinants. Behavioral medicine researchers offer expertise in validation of measures in diverse populations and consideration of statistical approaches that permit evaluation of longitudinal data and examine moderators and mediators of change. Intervention studies that promote the inclusion of individuals with health complications and utilize real-world clinic and community settings may foster greater inclusion of low-income and minority participants and help to move the field forward from the limitations of highly controlled, randomized trials. In the US, youth and young adults with obesity, prediabetes and diabetes are more likely to be African American and at-risk for poorly controlled diabetes and related consequences, making engaging physical activity and self-care and outreach programs for minority youth and young adults a high-need area. Social networks and social media, technology and community and peer approaches have shown potential for positive gains, however, more studies are needed. Data demonstrating the most efficacious approaches to prevention and engagement in diabetes care in diverse countries and cultures is also needed (Ding & Gebel, 2012).

Conclusion

The field of behavioral medicine in diabetes prevention and management is growing exponentially. With the advent of new technologies, modes of intervention delivery and policy considerations, among others, behavioral medicine is poised to improve diabetes outcomes for future generations. In this position paper we have discussed several of the evolving areas of diabetes prevention and management, including new populations, subgroups, theoretical approaches that have been helpful in promoting effective change and issues to be tackled. Our recommendations are not meant to include an exhaustive list of future directions for the field; rather, they provide a roadmap of potential opportunities for behavioral medicine scientists and practitioners based on current areas of interest and need identified among behavioral medicine professionals whose research and clinical practice focus on those with or at risk of diabetes. For instance, we have identified that there is an urgent need for innovative ways to improve diabetes management and prevention for global and diverse populations. Greater understanding of the biological, sociocultural and individual influences on its rapid escalation and of optimal interventions across the lifespan is needed. There is insufficient information on the costs relative to benefits of technology in diabetes care. Given the dearth of youth and adults meeting public health recommendations for healthy eating, physical activity and sedentary behavior (Cooper et al., 2014; Minges et al., 2015a), future behavioral medicine efforts could target modifying the "obesogenic" environment (Wall et al., 2012). Integrative approaches to understanding strategies to promote weight loss and physical activity and their maintenance are urgently needed for young adults and children with or at risk of diabetes. Behavioral medicine scientists and practitioners are uniquely positioned at the intersection of integrating complex concepts such as these with human behavior to advance the field and improve the health of those with or at risk of diabetes. This includes drawing on expertise in the development and psychometric evaluation of measurement instruments to screen those at-risk and assess process and outcome variables in patient-centered health care settings and community venues and tailored interventions that address social and environmental challenges that contribute to ethnic and racial health disparities and address the psychosocial and behavioral demands of diabetes.

As noted throughout this paper, interventions addressing behavior change in diabetes have reflected a number of behavior change concepts and theories that are effective in improving diabetes outcomes. The increasing transition of diabetes care from specialty clinics to primary care and patient centered medical home settings has resulted in increased dispersion of the chronic care model. Self-regulation theory and social cognitive theory and related motivational approaches have been widely integrated into interventions that include goal-setting and development of personalized strategies for overcoming barriers to optimal self-care and address self-efficacy. Evaluation of active ingredients of change and consideration of novel conceptual approaches would move the field forward. Theoretically informed, interdisciplinary studies that consider social ecological models of diabetes care are needed to develop a roadmap for diabetes policies and care recommendations. Frameworks such as the Consolidated Framework for Implementation Research (CFIR) may further inform

research agendas. From a practical, interventionist standpoint, structured materials supported in cognitive-behavioral trials may be used to provide standardized content for program evaluation and for assessing treatment fidelity. Manualized content for the lifestyle change interventions used in the DPP is available. Structured self-management interventions that address chronic disease, such as the US National Diabetes Education Program (http://www.niddk.nih.gov/health-information/health-communication-programs/ndep/am-i-at-risk/Pages/index.aspx) have been successful in promoting behavior change as well as improved metabolic control. Adopting an approach that builds on the past success of behavioral medicine research and interventions is pivotal to ensuring that the field progresses forward. Importantly, behavioral medicine scientists and practitioners should integrate advances in technology, big data and translational research, among others, to prevent diabetes and improve the lives of patients with or at risk of diabetes. Consideration of social determinants of diabetes risk and progression and adaptation of successful strategies and development of new approaches to fit the needs of minority and cultural groups at elevated risk for diabetes, poor control and diabetes complications and comorbidities remains a priority. Behavioral medicine scientist's and practitioner's skills in multidisciplinary team care, theoretical foundations, research methodology, developmental perspectives and biopsychosocial approaches leave them poised to address these and other proposed future research directions to advance diabetes prevention and management.

Acknowledgments The authors wish to thank the Society of Behavioral Medicine Diabetes Special Interest Group for their guidance and suggestions on research recommendations and future direction of behavioral medicine in diabetes prevention and management.

Funding KM was funded by a pre-doctoral fellowship from the National Institute of Diabetes and Digestive and Kidney Disease/NIH (T32DK097718).

Compliance with ethical standards

Conflict of interest Barbara Stetson, Karl E. Minges, and Caroline R. Richardson declare that they have no conflict of interest.

Human and animal rights and Informed consent All procedures followed were in accordance with ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Informed consent was obtained from all patients for being included in the study.

References

Ackerman, R. (2013). Working with the YMCA to implement the Diabetes Prevention Program. *American Journal of Preventive Medicine, 44*, S352–S356.

Ackermann, R. T., Finch, E. A., Schmidt, K. K., Hoen, H. M., Hays, L. M., Marrero, D. G., et al. (2014). Rationale, design, and baseline characteristics of a community-based comparative effectiveness trial to prevent type 2 diabetes in economically disadvantaged adults: The RAPID Study. *Contemporary Clinical Trials, 37*, 1–9. doi:10.1016/j.cct.2013.10.003

AHRQ. (2015). Selecting structure measures for clinical quality measurement. Retrieved May 20, 2016, from http://www.qualitymeasures.ahrq.gov/tutorial/StructureMeasure.aspx

Ali, M. K., Echouffo-Tcheugui, J., & Williamson, D. F. (2012). How effective were lifestyle interventions in real-world settings that were modeled on the Diabetes Prevention Program? *Health Affairs, 31*, 67–75. doi:10.1377/hlthaff.2011.1009

American Association of Diabetes Educators. (2007). AADE position statement. Individualization of diabetes self-management education. *The Diabetes Educator, 33*, 45–49. doi:10.1177/0145721706298308

American Diabetes Association. (2013). Economic costs of diabetes in the U.S. in 2012. *Diabetes Care, 36*, 1033–1046. doi:10.2337/dc12-2625

American Diabetes Association. (2015a). Foundations of care: Education, nutrition, physical activity, smoking cessation, psychosocial care, and immunization. *Diabetes Care, 38*, S20–S30. doi:10.2337/dc15-S007

American Diabetes Association. (2015b). Microvascular complications and foot care. *Diabetes Care, 38*, S58–S66. doi:10.2337/dc15-S012

American Diabetes Association. (2015c). Professional Practice Committee for the Standards of Medical Care in Diabetes—2015. *Diabetes Care, 38*, S88–S89. doi:10.2337/dc15-S018

Anderson, R. J., Freedland, K. E., Clouse, R. E., & Lustman, P. J. (2001). The prevalence of comorbid depression in adults with diabetes: A meta-analysis. *Diabetes Care, 24*, 1069–1078.

Appel, L. J., Clark, J. M., Yeh, H.-C., Wang, N.-Y., Coughlin, J. W., Daumit, G., et al. (2011). Comparative effectiveness of weight-loss interventions in clinical practice. *New England Journal of Medicine, 365*, 1959–1968. doi:10.1056/NEJMoa1108660

Arnett, J. J. (2000). Emerging adulthood: A theory of development from the late teens through the twenties. *American Psychologist, 55*, 469.

Ayala, G. X., Ibarra, L., Cherrington, A. L., Parada, H., Horton, L., Ji, M., et al. (2015). Puentes hacia una mejor vida (bridges to a better life): Outcome of a diabetes control peer support intervention. *The Annals of Family Medicine, 13*, S9–17. doi:10.1370/afm.1807

Bacigalupo, R., Cudd, P., Littlewood, C., Bissell, P., Hawley, M. S., & Buckley Woods, H. (2013). Interventions employing mobile technology for overweight and obesity: An early systematic review of randomized controlled trials. *Obesity Reviews, 14*, 279–291. doi:10.1111/obr.12006

Bartoli, F., Carra, G., Crocamo, C., Carretta, D., La Tegola, D., Tabacchi, T., et al. (2016). Association between depression and neuropathy in people with type 2 diabetes: A meta-analysis. *International Journal of Geriatric Psychiatry*. doi:10.1002/gps.4397

Baumeister, H., Hutter, N., & Bengel, J. (2014). Psychological and pharmacological interventions for depression in patients with diabetes mellitus: An abridged Cochrane review. *Diabetic Medicine, 31*, 773–786. doi:10.1111/dme.12452

Boyle, J. P., Thompson, T. J., Gregg, E. W., Barker, L. E., & Williamson, D. F. (2010). Projection of the year 2050 burden of diabetes in the US adult population: Dynamic modeling of incidence, mortality, and prediabetes prevalence. *Population Health Metrics, 8*, 29. doi:10.1186/1478-7954-8-29

Burns, R. J., Deschenes, S. S., & Schmitz, N. (2015). Associations between depressive symptoms and social support in adults with diabetes: Comparing directionality hypotheses with a longitudi-

nal cohort. *Annals of Behavioral Medicine*. doi:10.1007/s12160-015-9760-x

Buynitsky, T., & Rhodes, E. T. (2014). Behavioral interventions for youth with type 2 diabetes. In D. I. Mostofsky (Ed.), *The handbook of behavioral medicine* (pp. 711–736). Chichester, West Sussex, England: Wiley Blackwell.

Capoccia, K., Odegard, P. S., & Letassy, N. (2015). Medication adherence with diabetes medication: A systematic review of the literature. *The Diabetes Educator*. doi:10.1177/0145721715619038

Carver, C. (2006). Insulin treatment and the problem of weight gain in type 2 diabetes. *The Diabetes Educator, 32*, 910–917. doi:10.1177/0145721706294259

Centers for Disease Control and Prevention. (2014). *National diabetes statistics report: Estimates of diabetes and its burden in the United States, 2014*. Atlanta, GA: US Department of Health and Human Services.

Chrvala, C. A., Sherr, D., & Lipman, R. D. (2015). Diabetes self-management education for adults with type 2 diabetes mellitus: A systematic review of the effect on glycemic control. *Patient Education and Counseling*. doi:10.1016/j.pec.2015.11.003

Collins, M. M., Corcoran, P., & Perry, I. J. (2009). Anxiety and depression symptoms in patients with diabetes. *Diabetic Medicine, 26*, 153–161. doi:10.1111/j.1464-5491.2008.02648.x

Colton, P. A., Olmsted, M. P., Daneman, D., Farquhar, J. C., Wong, H., Muskat, S., et al. (2015). Eating disorders in girls and women with type 1 diabetes: A longitudinal study of prevalence, onset, remission, and recurrence. *Diabetes Care, 38*, 1212–1217. doi:10.2337/dc14-2646

Connelly, J., Kirk, A., Masthoff, J., & MacRury, S. (2013). The use of technology to promote physical activity in type 2 diabetes management: A systematic review. *Diabetic Medicine, 30*, 1420–1432.

Cooper, J., Stetson, B., Bonner, J., Spille, S., Krishnasamy, S., & Mokshagundam, S. P. (2014). Self-reported physical activity in medically underserved adults with type 2 diabetes in clinical and community settings. *Journal of Physical Activity and Health*. doi:10.1123/jpah.2013-0475

Cox, D. J., Gonder-Frederick, L., Ritterband, L., Patel, K., Schächinger, H., Fehm-Wolfsdorf, G., et al. (2006). Blood glucose awareness training: What is it, where is it, and where is it going? *Diabetes Spectrum, 19*, 43–49. doi:10.2337/diaspect.19.1.43

Creswell, J. W., & Plano Clark, V. L. (2011). *Designing and conducting mixed methods research*. Thousand Oaks, CA: Sage.

Cryer, P. E. (2014). Glycemic goals in diabetes: trade-off between glycemic control and iatrogenic Hypoglycemia. *Diabetes, 63*, 2188–2195. doi:10.2337/db14-0059

Damschroder, L. J., & Lowery, J. C. (2013). Evaluation of a large-scale weight management program using the consolidated framework for implementation research (CFIR). *Implementation Science, 8*, 51.

Datye, K. A., Moore, D. J., Russell, W. E., & Jaser, S. S. (2015). A review of adolescent adherence in type 1 diabetes and the untapped potential of diabetes providers to improve outcomes. *Current Diabetes Reports, 15*, 621. doi:10.1007/s11892-015-0621-6

de Groot, M., Anderson, R., Freedland, K. E., Clouse, R. E., & Lustman, P. J. (2001). Association of depression and diabetes complications: a meta-analysis. *Psychosomatic Medicine, 63*, 619–630.

DeJoy, D. M., Padilla, H. M., Wilson, M. G., Vandenberg, R. J., & Davis, M. A. (2013). Worksite translation of the Diabetes Prevention Program: Formative research and pilot study results from FUEL your life. *Health Promotion Practice, 14*, 506–513. doi:10.1177/1524839912461014

Deschenes, S. S., Burns, R. J., & Schmitz, N. (2015). Anxiety symptoms and functioning in a community sample of individuals with type 2 diabetes: A longitudinal study. *Journal of Diabetes*. doi:10.1111/1753-0407.12368

Diabetes Prevention Program (DPP) Research Group. (2002). The Diabetes Prevention Program (DPP): Description of lifestyle intervention. *Diabetes Care, 25*, 2165–2171.

Ding, D., & Gebel, K. (2012). Built environment, physical activity, and obesity: What have we learned from reviewing the literature? *Health and Place, 18*, 100–105. doi:10.1016/j.healthplace.2011.08.021

Dore, G. A., Waldstein, S. R., Evans, M. K., & Zonderman, A. B. (2015). Associations between diabetes and cognitive function in socioeconomically diverse African American and white men and women. *Psychosomatic Medicine, 77*, 643–652. doi:10.1097/psy.0000000000000196

Eckel, R. H., Kahn, S. E., Ferrannini, E., Goldfine, A. B., Nathan, D. M., Schwartz, M. W., et al. (2011). Obesity and type 2 diabetes: What can be unified and what needs to be individualized? *Diabetes Care, 34*, 1424–1430. doi:10.2337/dc11-0447

Ekong, G., & Kavookjian, J. (2015). Motivational interviewing and outcomes in adults with type 2 diabetes: A systematic review. *Patient Education and Counseling*. doi:10.1016/j.pec.2015.11.022

Ellis, D., Naar-King, S., Templin, T., Frey, M., Cunningham, P., Sheidow, A., et al. (2008). Multisystemic therapy for adolescents with poorly controlled type 1 diabetes: Reduced diabetic ketoacidosis admissions and related costs over 24 months. *Diabetes Care, 31*, 1746–1747. doi:10.2337/dc07-2094

Espeland, M. A., Glick, H. A., Bertoni, A., Brancati, F. L., Bray, G. A., Clark, J. M., et al. (2014). Impact of an intensive lifestyle intervention on use and cost of medical services among overweight and obese adults with type 2 diabetes: The action for health in diabetes. *Diabetes Care, 37*, 2548–2556. doi:10.2337/dc14-0093

Everson-Rose, S. A., & Ryan, J. P. (2015). Diabetes, obesity, and the brain: New developments in biobehavioral medicine. *Psychosomatic Medicine, 77*, 612–615. doi:10.1097/psy.0000000000000223

Fisher, E. B. (2008). The importance of context in understanding behavior and promoting health. *Annals of Behavioral Medicine, 35*, 3–18. doi:10.1007/s12160-007-9001-z

Fisher, E. B., Ayala, G. X., Ibarra, L., Cherrington, A. L., Elder, J. P., Tang, T. S., et al. (2015a). Contributions of peer support to health, health care, and prevention: Papers from Peers for Progress. *The Annals of Family Medicine, 13*, S2–S8. doi:10.1370/afm.1852

Fisher, E. B., Ballesteros, J., Bhushan, N., Coufal, M. M., Kowitt, S. D., McDonough, A. M., et al. (2015b). Key features of peer support In chronic disease prevention and management. *Health Affairs, 34*, 1523–1530. doi:10.1377/hlthaff.2015.0365

Fitzpatrick, S. L., Schumann, K. P., & Hill-Briggs, F. (2013). Problem solving interventions for diabetes self-management and control: A systematic review of the literature. *Diabetes Research and Clinical Practice, 100*, 145–161. doi:10.1016/j.diabres.2012.12.016

Gallagher, K. M., & Updegraff, J. A. (2012). Health message framing effects on attitudes, intentions, and behavior: A meta-analytic review. *Annals of Behavioral Medicine, 43*, 101–116. doi:10.1007/s12160-011-9308-7

Glasgow, R. E., Toobert, D. J., Barrera, M., Jr., & Strycker, L. A. (2005). The Chronic Illness Resources Survey: Cross-validation and sensitivity to intervention. *Health Education Research, 20*, 402–409. doi:10.1093/her/cyg140

Gonder-Frederick, L. A., Cox, D. J., & Ritterband, L. M. (2002). Diabetes and behavioral medicine: The second decade. *Journal of Consulting and Clinical Psychology, 70*, 611–625.

Goode, A. D., Reeves, M. M., & Eakin, E. G. (2012). Telephone-delivered interventions for physical activity and dietary behavior

change: An updated systematic review. *American Journal of Preventive Medicine, 42*, 81–88. doi:10.1016/j.amepre.2011.08.025

Grey, M., Whittemore, R., Jeon, S., Murphy, K., Faulkner, M. S., & Delamater, A. (2013). Internet psycho-education programs improve outcomes in youth with type 1 diabetes. *Diabetes Care, 36*, 2475–2482. doi:10.2337/dc12-2199

Hanna, K. M. (2012). A framework for the youth with type 1 diabetes during the emerging adulthood transition. *Nursing Outlook, 60*, 401–410.

Haselwandter, E. M., Corcoran, M. P., Folta, S. C., Hyatt, R., Fenton, M., & Nelson, M. E. (2015). The built environment, physical activity, and aging in the United States: A state of the science review. *Journal of Aging and Physical Activity, 23*, 323–329. doi:10.1123/japa.2013-0151

Heisler, M. (2007). Overview of peer support models to improve diabetes self-management and clinical outcomes. *Diabetes Spectrum, 20*, 214.

Hermanns, N., Kubiak, T., Kulzer, B., & Haak, T. (2007). Clinical depression versus distress among patients with type 2 diabetes: Not just a question of semantics. *Diabetes Care, 30*(9), e100; author reply e101. doi:10.2337/dc07-1019

Hessler, D. M., Fisher, L., Mullan, J. T., Glasgow, R. E., & Masharani, U. (2011). Patient age: A neglected factor when considering disease management in adults with type 2 diabetes. *Patient Education and Counseling, 85*, 154–159. doi:10.1016/j.pec.2010.10.030

Hofmann, M., Kohler, B., Leichsenring, F., & Kruse, J. (2013). Depression as a risk factor for mortality in individuals with diabetes: A meta-analysis of prospective studies. *PLoS One, 8*, e79809. doi:10.1371/journal.pone.0079809

Holman, R. R., Paul, S. K., Bethel, M. A., Matthews, D. R., & Neil, H. A. (2008). 10-year follow-up of intensive glucose control in type 2 diabetes. *New England Journal of Medicine, 359*, 1577–1589. doi:10.1056/NEJMoa0806470

Holt, R. I., de Groot, M., Lucki, I., Hunter, C. M., Sartorius, N., & Golden, S. H. (2014). NIDDK international conference report on diabetes and depression: Current understanding and future directions. *Diabetes Care, 37*, 2067–2077. doi:10.2337/dc13-2134

Hood, K. K., Rohan, J. M., Peterson, C. M., & Drotar, D. (2010). Interventions with adherence-promoting components in pediatric type 1 diabetes: Meta-analysis of their impact on glycemic control. *Diabetes Care, 33*, 1658–1664. doi:10.2337/dc09-2268

Imperatore, G., Boyle, J. P., Thompson, T. J., Case, D., Dabelea, D., Hamman, R. F., et al. (2012). Projections of type 1 and type 2 diabetes burden in the U.S. population aged <20 years through 2050: Dynamic modeling of incidence, mortality, and population growth. *Diabetes Care, 35*, 2515–2520. doi:10.2337/dc12-0669

Ingersoll, K. S., & Cohen, J. (2008). The impact of medication regimen factors on adherence to chronic treatment: A review of literature. *Journal of Behavioral Medicine, 31*, 213–224. doi:10.1007/s10865-007-9147-y

Institute of Translational Health Sciences. (2010). About translational research. Retrieved October 9, 2016, from https://www.iths.org/about

International Diabetes Federation. (2013). IDF Atlas. Retrieved December 16, 2015, from http://www.idf.org/diabetesatlas

Jackson, C. L., Bolen, S., Brancati, F. L., Batts-Turner, M. L., & Gary, T. L. (2006). A systematic review of interactive computer-assisted technology in diabetes care. *Journal of General Internal Medicine, 21*, 105–110.

Kan, C., Silva, N., Golden, S. H., Rajala, U., Timonen, M., Stahl, D., et al. (2013). A systematic review and meta-analysis of the association between depression and insulin resistance. *Diabetes Care, 36*, 480–489. doi:10.2337/dc12-1442

Karnik, S., & Kanekar, A. (2015). Childhood obesity: A global public health crisis. *International Journal of Preventive Medicine, 3*, 1–7.

Katon, W. J., Von Korff, M., Lin, E. H., Simon, G., Ludman, E., Russo, J., et al. (2004). The Pathways Study: A randomized trial of collaborative care in patients with diabetes and depression. *Archives of General Psychiatry, 61*, 1042–1049. doi:10.1001/archpsyc.61.10.1042

King, D. K., Glasgow, R. E., Toobert, D. J., Strycker, L. A., Estabrooks, P. A., Osuna, D., et al. (2010). Self-efficacy, problem solving, and social-environmental support are associated with diabetes self-management behaviors. *Diabetes Care, 33*, 751–753. doi:10.2337/dc09-1746

Knowler, W. C., Barrett-Connor, E., Fowler, S. E., Hamman, R. F., Lachin, J. M., Walker, E. A., et al. (2002). Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *New England Journal of Medicine, 346*, 393–403. doi:10.1056/NEJMoa012512

Kolb, H., Kempf, K., Martin, S., Stumvoll, M., & Landgraf, R. (2010). On what evidence-base do we recommend self-monitoring of blood glucose? *Diabetes Research and Clinical Practice, 87*, 150–156.

Lachin, J. M., Orchard, T. J., & Nathan, D. M. (2014). Update on cardiovascular outcomes at 30 years of the diabetes control and complications trial/epidemiology of diabetes interventions and complications study. *Diabetes Care, 37*, 39–43. doi:10.2337/dc13-2116

Lee, R., Wong, T. Y., & Sabanayagam, C. (2015). Epidemiology of diabetic retinopathy, diabetic macular edema and related vision loss. *Eye and Vision, 2*, 17. doi:10.1186/s40662-015-0026-2

Li, L., Cheng, W.-Y., Glicksberg, B. S., Gottesman, O., Tamler, R., Chen, R., et al. (2015). Identification of type 2 diabetes subgroups through topological analysis of patient similarity. *Science Translational Medicine, 7*, 311ra174. doi:10.1126/scitranslmed.aaa9364

Libman, I. M., & Becker, D. J. (2003). Coexistence of type 1 and type 2 diabetes mellitus: "Double" diabetes? *Pediatric Diabetes, 4*, 110–113. doi:10.1034/j.1399-5448.2003.00012.x

Liu, L. L., Lawrence, J. M., Davis, C., Liese, A. D., Pettitt, D. J., Pihoker, C., et al. (2010). Prevalence of overweight and obesity in youth with diabetes in USA: The SEARCH for Diabetes in Youth study. *Pediatric Diabetes, 11*, 4–11.

Lorig, K., Ritter, P. L., Laurent, D. D., Plant, K., Green, M., Jernigan, V. B., et al. (2010). Online diabetes self-management program: A randomized study. *Diabetes Care, 33*, 1275–1281. doi:10.2337/dc09-2153

Luchsinger, J. A., Cabral, R., Eimicke, J. P., Manly, J. J., & Teresi, J. (2015). Glycemia, diabetes status, and cognition in Hispanic adults aged 55-64 years. *Psychosomatic Medicine, 77*, 653–663. doi:10.1097/psy.0000000000000208

Lustman, P. J., Griffith, L. S., Freedland, K. E., Kissel, S. S., & Clouse, R. E. (1998). Cognitive behavior therapy for depression in type 2 diabetes mellitus. A randomized, controlled trial. *Annals of Internal Medicine, 129*, 613–621.

Maia, A. C., Braga Ade, A., Paes, F., Machado, S., Nardi, A. E., & Silva, A. C. (2014). Psychiatric comorbidity in diabetes type 1: A cross-sectional observational study. *Revista Da Associacao Medica Brasileira, 60*, 59–62.

Markowitz, S. M., Gonzalez, J. S., Wilkinson, J. L., & Safren, S. A. (2011). A review of treating depression in diabetes: Emerging findings. *Psychosomatics, 52*, 1–18. doi:10.1016/j.psym.2010.11.007

Marrero, D. G., Ard, J., Delamater, A. M., Peragallo-Dittko, V., Mayer-Davis, E. J., Nwankwo, R., et al. (2013). Twenty-first century behavioral medicine: A context for empowering clini-

cians and patients with diabetes: a consensus report. *Diabetes Care, 36*, 463–470. doi:10.2337/dc12-2305

McCormack, G. R., & Shiell, A. (2011). In search of causality: A systematic review of the relationship between the built environment and physical activity among adults. *International Journal of Behavioral Nutrition and Physical Activity, 8*, 125. doi:10.1186/1479-5868-8-125

McCormack, L. A., Williams-Piehota, P. A., Bann, C. M., Burton, J., Kamerow, D. B., Squire, C., et al. (2008). Development and validation of an instrument to measure resources and support for chronic illness self-management: A model using diabetes. *The Diabetes Educator, 34*, 707–718. doi:10.1177/0145721708321021

McGrath, L. J., Hopkins, W. G., & Hinckson, E. A. (2015). Associations of objectively measured built-environment attributes with youth moderate-vigorous physical activity: A systematic review and meta-analysis. *Sports Medicine, 45*, 841–865. doi:10.1007/s40279-015-0301-3

Miller, W. R., & Rollnick, S. (2014). The effectiveness and ineffectiveness of complex behavioral interventions: Impact of treatment fidelity. *Contemporary Clinical Trials, 37*, 234–241. doi:10.1016/j.cct.2014.01.005

Minges, K. E., Chao, A. M., Irwin, M. L., Owen, N., Park, C., Whittemore, R., et al. (2016). Classroom standing desks and sedentary behavior: A systematic review. *Pediatrics, 137*, 1–18.

Minges, K. E., Chao, A., Nam, S., Grey, M., & Whittemore, R. (2015a). Weight status, gender, and race/ethnicity: Are there differences in meeting recommended health behavior guidelines for adolescents? *The Journal of School Nursing, 31*, 135–145. doi:10.1177/1059840514554089

Minges, K. E., Owen, N., Salmon, J., Chao, A., Dunstan, D. W., & Whittemore, R. (2015b). Reducing youth screen time: Qualitative metasynthesis of findings on barriers and facilitators. *Health Psychology, 34*, 381.

Minges, K. E., Whittemore, R., & Grey, M. (2013). Overweight and obesity in youth with type 1 diabetes. *Annual Review of Nursing Research, 31*, 47–69. doi:10.1891/0739-6686.31.47

Morrish, N. J., Wang, S. L., Stevens, L. K., Fuller, J. H., & Keen, H. (2001). Mortality and causes of death in the WHO multinational study of vascular disease in diabetes. *Diabetologia, 44*, S14–S21.

Mujahid, M. S., Diez Roux, A. V., Morenoff, J. D., & Raghunathan, T. (2007). Assessing the measurement properties of neighborhood scales: From psychometrics to ecometrics. *American Journal of Epidemiology, 165*, 858–867. doi:10.1093/aje/kwm040

National Center for Health Statistics. (2015). Data from the National Health Interview Survey. Statistical analysis by the Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Division of Diabetes Translation. Retrieved December 10, 2015, from http://www.cdc.gov/diabetes/statistics/prev/national/figpersons.htm

National Diabetes Education Program. (2011). *Redesigning the Health Care Team: Diabetes prevention and lifelong management*. Bethesda, MD: U.S. Department of Health and Human Services.

Oppert, J. M., & Charreire, H. (2012). The importance of the food and physical activity environments. *Nestle Nutrition Institute Workshop Series, 73*, 113–121. doi:10.1159/000341306

Osthus, T. B., von der Lippe, N., Ribu, L., Rustoen, T., Leivestad, T., Dammen, T., et al. (2012). Health-related quality of life and all-cause mortality in patients with diabetes on dialysis. *BMC Nephrology, 13*, 78. doi:10.1186/1471-2369-13-78

Pennic, F. (2013). Five start-ups using big data to tackle diabetes. Retrieved January 9, 2016, from http://hitconsultant.net/2013/04/22/5-startups-using-big-data-to-tackle-diabetes/

Perreault, L., Temprosa, M., Mather, K. J., Horton, E., Kitabchi, A., Larkin, M., et al. (2014). Regression from prediabetes to normal glucose regulation is associated with reduction in cardiovascular risk: Results from the Diabetes Prevention Program outcomes study. *Diabetes Care, 37*, 2622–2631. doi:10.2337/dc14-0656

Peters, A., & Laffel, L. (2011). Diabetes care for emerging adults: recommendations for transition from pediatric to adult diabetes care systems: a position statement of the American Diabetes Association, with representation by the American College of Osteopathic Family Physicians, the American Academy of Pediatrics, the American Association of Clinical Endocrinologists, the American Osteopathic Association, the Centers for Disease Control and Prevention, Children with Diabetes, The Endocrine Society, the International Society for Pediatric and Adolescent Diabetes, Juvenile Diabetes Research Foundation International, the National Diabetes Education Program, and the Pediatric Endocrine Society (formerly Lawson Wilkins Pediatric Endocrine Society). *Diabetes Care, 34*, 2477–2485.

Peterson, K. A., Brown, M. T., & Warren-Boulton, E. (2015). Responding to the challenges of primary diabetes care through the national diabetes education program. *Diabetes Care, 38*, 343–344. doi:10.2337/dc14-1922

Peyrot, M., & Rubin, R. R. (2007). Behavioral and psychosocial interventions in diabetes: A conceptual review. *Diabetes Care, 30*, 2433–2440. doi:10.2337/dc07-1222

Pimouguet, C., Le Goff, M., Thiebaut, R., Dartigues, J. F., & Helmer, C. (2011). Effectiveness of disease-management programs for improving diabetes care: A meta-analysis. *Canadian Medical Association Journal, 183*, E115–E127. doi:10.1503/cmaj.091786

Pintaudi, B., Lucisano, G., Gentile, S., Bulotta, A., Skovlund, S. E., Vespasiani, G., et al. (2015). Correlates of diabetes-related distress in type 2 diabetes: Findings from the benchmarking network for clinical and humanistic outcomes in diabetes (BENCH-D) study. *Journal of Psychosomatic Research, 79*, 348–354. doi:10.1016/j.jpsychores.2015.08.010

Pit, S. W., Vo, T., & Pyakurel, S. (2014). The effectiveness of recruitment strategies on general practitioner's survey response rates—A systematic review. *BMC Medical Research Methodology, 14*, 76. doi:10.1186/1471-2288-14-76

Plack, K., Herpertz, S., & Petrak, F. (2010). Behavioral medicine interventions in diabetes. *Current Opinion in Psychiatry, 23*, 131–138. doi:10.1097/YCO.0b013e3283366555

Powell, P. W., Corathers, S. D., Raymond, J., & Streisand, R. (2015). New approaches to providing individualized diabetes care in the 21st century. *Current Diabetes Review, 11*, 222–230.

Purnell, J., Hokanson, J. E., Marcovina, S. M., Steffes, M. W., Cleary, P. A., & Brunzell, J. D. (1998). Effect of excessive weight gain with intensive therapy of type 1 diabetes on lipid levels and blood pressure: Results from the DCCT. *JAMA, 280*, 140–146. doi:10.1001/jama.280.2.140

Regensteiner, J. G., Golden, S., Huebschmann, A. G., Barrett-Connor, E., Chang, A. Y., Chyun, D., et al. (2015). Sex differences in the cardiovascular consequences of diabetes mellitus: A scientific statement from the American Heart Association. *Circulation*. doi:10.1161/cir.0000000000000343

Rittenhouse, D. R., & Shortell, S. M. (2009). The patient-centered medical home: Will it stand the test of health reform? *JAMA, 301*, 2038–2040. doi:10.1001/jama.2009.691

Safford, M. M., Andreae, S., Cherrington, A. L., Martin, M. Y., Halanych, J., Lewis, M., et al. (2015). Peer coaches to improve diabetes outcomes in rural Alabama: A cluster randomized trial. *The Annals of Family Medicine, 13*, S18–S26. doi:10.1370/afm.1798

Salmon, J., Tremblay, M. S., Marshall, S. J., & Hume, C. (2011). Health risks, correlates, and interventions to reduce sedentary

behavior in young people. *American Journal of Preventive Medicine, 41*, 197–206.

Santos, M. A., Ceretta, L. B., Reus, G. Z., Abelaira, H. M., Jornada, L. K., Schwalm, M. T., et al. (2014). Anxiety disorders are associated with quality of life impairment in patients with insulin-dependent type 2 diabetes: A case–control study. *Revista Brasileira de Psiquiatria, 36*, 298–304. doi:10.1590/1516-4446-2013-1230

SEARCH for Diabetes in Youth Study Group. (2006). The burden of diabetes mellitus among US youth: Prevalence estimates from the SEARCH for Diabetes in Youth Study. *Pediatrics, 118*, 1510–1518. doi:10.1542/peds.2006-0690

SEARCH for Diabetes in Youth Study Group. (2007). Incidence of diabetes in youth in the United States. *JAMA, 297*, 2716–2724. doi:10.1001/jama.297.24.2716

Shaw, J. E., Sicree, R. A., & Zimmet, P. Z. (2010). Global estimates of the prevalence of diabetes for 2010 and 2030. *Diabetes Research and Clinical Practice, 87*, 4–14. doi:10.1016/j.diabres.2009.10.007

Sherifali, D., Bai, J. W., Kenny, M., Warren, R., & Ali, M. U. (2015). Diabetes self-management programmes in older adults: A systematic review and meta-analysis. *Diabetic Medicine, 32*, 1404–1414. doi:10.1111/dme.12780

Shojania, K. G., McDonald, K. M., Wachter, R. M., & Owens, D. K. (2004). *Closing the quality gap: A critical analysis of quality improvement strategies* (Vol. 1: Series overview and methodology). Technical Reviews, No. 9.1. Rockville, MD: Agency for Healthcare Research and Quality. Retrieved October 9, 2016, from https://www.ncbi.nlm.nih.gov/books/NBK43908/

Smith, K. J., Beland, M., Clyde, M., Gariepy, G., Page, V., Badawi, G., et al. (2013). Association of diabetes with anxiety: A systematic review and meta-analysis. *Journal of Psychosomatic Research, 74*, 89–99. doi:10.1016/j.jpsychores.2012.11.013

Snoek, F. J., van der Ven, N. C., Twisk, J. W., Hogenelst, M. H., Tromp-Wever, A. M., van der Ploeg, H. M., et al. (2008). Cognitive behavioural therapy (CBT) compared with blood glucose awareness training (BGAT) in poorly controlled type 1 diabetic patients: Long-term effects on HbA moderated by depression. A randomized controlled trial. *Diabetic Medicine, 25*, 1337–1342. doi:10.1111/j.1464-5491.2008.02595.x

Spanakis, E. K., & Golden, S. H. (2013). Race/ethnic difference in diabetes and diabetic complications. *Current Diabetes Reports, 13*, 814–823. doi:10.1007/s11892-013-0421-9

Stark Casagrande, S., Fradkin, J. E., Saydah, S. H., Rust, K. F., & Cowie, C. C. (2013). The prevalence of meeting A1C, blood pressure, and LDL goals among people with diabetes, 1988-2010. *Diabetes Care, 36*, 2271–2279. doi:10.2337/dc12-2258

Stark, L. J., Spear, S., Boles, R., Kuhl, E., Ratcliff, M., Scharf, C., et al. (2011). A pilot randomized controlled trial of a clinic and home-based behavioral intervention to decrease obesity in preschoolers. *Obesity, 19*, 134–141.

Stetson, B., Schlundt, D., Peyrot, M., Ciechanowski, P., Austin, M. M., Young-Hyman, D., et al. (2011). Monitoring in diabetes self-management: Issues and recommendations for improvement. *Population Health Management, 14*, 189–197. doi:10.1089/pop.2010.0030

Stock, S., Drabik, A., Buscher, G., Graf, C., Ullrich, W., Gerber, A., et al. (2010). German diabetes management programs improve quality of care and curb costs. *Health Affairs, 29*, 2197–2205. doi:10.1377/hlthaff.2009.0799

Sugiyama, T., Steers, W. N., Wenger, N. S., Duru, O. K., & Mangione, C. M. (2015). Effect of a community-based diabetes self-management empowerment program on mental health-related quality of life: A causal mediation analysis from a randomized controlled trial. *BMC Health Services Research, 15*, 115. doi:10.1186/s12913-015-0779-2

Tang, T. S., Funnell, M., Sinco, B., Piatt, G., Palmisano, G., Spencer, M. S., et al. (2014). Comparative effectiveness of peer leaders and community health workers in diabetes self-management support: Results of a randomized controlled trial. *Diabetes Care, 37*, 1525–1534. doi:10.2337/dc13-2161

Tanjasiri, S. P., Weiss, J. W., Santos, L., Flores, P., Flores, P., Lacsamana, J. D., et al. (2015). CBPR-informed recruitment and retention adaptations in a randomized study of pap testing among Pacific Islanders in Southern California. *Progress in Community Health Partnerships, 9*, 389–396. doi:10.1353/cpr.2015.0067

Tappin, D., Bauld, L., Purves, D., Boyd, K., Sinclair, L., MacAskill, S., et al. (2015). Financial incentives for smoking cessation in pregnancy: Randomised controlled trial. *BMJ, 350*, h134. doi:10.1136/bmj.h134

Thabit, H., Tauschmann, M., Allen, J. M., Leelarathna, L., Hartnell, S., Wilinska, M. E., et al. (2015). Home use of an artificial beta cell in type 1 diabetes. *New England Journal of Medicine, 373*, 2129–2140. doi:10.1056/NEJMoa1509351

van der Feltz-Cornelis, C. M., Nuyen, J., Stoop, C., Chan, J., Jacobson, A. M., Katon, W., et al. (2010). Effect of interventions for major depressive disorder and significant depressive symptoms in patients with diabetes mellitus: A systematic review and meta-analysis. *General Hospital Psychiatry, 32*, 380–395. doi:10.1016/j.genhosppsych.2010.03.011

Vincent, C., & Hall, P. A. (2015). Executive function in adults with type 2 diabetes: A meta-analytic review. *Psychosomatic Medicine, 77*, 631–642. doi:10.1097/psy.0000000000000103

Wall, M. M., Larson, N. I., Forsyth, A., Van Riper, D. C., Graham, D. J., Story, M. T., et al. (2012). Patterns of obesogenic neighborhood features and adolescent weight: A comparison of statistical approaches. *American Journal of Preventive Medicine, 42*, e65–e75. doi:10.1016/j.amepre.2012.02.009

Ward, A., Alvarez, P., Vo, L., & Martin, S. (2014). Direct medical costs of complications of diabetes in the United States: Estimates for event-year and annual state costs (USD 2012). *Journal of Medical Economics, 17*, 176–183. doi:10.3111/13696998.2014.882843

Ward, J. E., Stetson, B. A., & Mokshagundam, S. P. (2015). Patient perspectives on self-monitoring of blood glucose: Perceived recommendations, behaviors and barriers in a clinic sample of adults with type 2 diabetes. *Journal of Diabetes and Metabolic Disorders, 14*, 43. doi:10.1186/s40200-015-0172-z

Waters, E., de Silva Sanigorski, A., Hall, B., Brown, T., Campbell, K., Gao, Y., et al. (2011). Interventions for preventing obesity in children. *Cochrane Collaboration, 12*, 1–212.

Weinstock, R. S., Drews, K. L., Caprio, S., Leibel, N. I., McKay, S. V., & Zeitler, P. S. (2015). Metabolic syndrome is common and persistent in youth-onset type 2 diabetes: Results from the TODAY clinical trial. *Obesity, 23*, 1357–1361. doi:10.1002/oby.21120

Whittemore, R., Melkus, G., Wagner, J., Northrup, V., Dziura, J., & Grey, M. (2009). Translating the Diabetes Prevention Program to primary care: A pilot study. *Nursing Research, 58*, 2–12. doi:10.1097/NNR.0b013e31818fcef3

Wientjens, W. (2008). Peer support in diabetes management—Time for a change. *Diabetes Voice, 53*, 45–48.

Wojcicki, J. M., & Heyman, M. B. (2010). Let's move—Childhood obesity prevention from pregnancy and infancy onward. *New England Journal of Medicine, 362*, 1457–1459. doi:10.1056/NEJMp1001857

World Health Organization. (2014). *Global status report on noncommunicable diseases 2014*. Geneva: World Health Organization.

World Obesity Federation. (2015). About obesity. http://www.worldobesity.org/aboutobesity/

Zhong, X., Wang, Z., Fisher, E. B., & Tanasugarn, C. (2015). Peer support for diabetes management in primary care and community settings in Anhui Province, China. *The Annals of Family Medicine, 13*, S50–S58. doi:10.1370/afm.1799