



Published in final edited form as:

Diabetes Res Clin Pract. 2015 November ; 110(2): 193–201. doi:10.1016/j.diabres.2015.09.007.

Social Determinants of Health in Adults with Type 2 Diabetes – Contribution of Mutable and Immutable Factors

Rebekah J. Walker, PhD^{1,2}, Brittany L. Smalls, PhD³, and Leonard E. Egede, MD, MS^{1,2,4}

¹Health Equity and Rural Outreach Innovation Center (HEROIC), Charleston VA HSR&D COIN, Ralph H. Johnson VAMC, Charleston, SC

²Center for Health Disparities Research, Medical University of South Carolina, Charleston, SC

³Center for Surgery and Public Health, Brigham and Women's Hospital, Boston, MA

⁴Division of General Internal Medicine and Geriatrics, Department of Medicine, Medical University of South Carolina, Charleston, SC

Abstract

Aims—Socioeconomic, psychosocial and neighborhood factors influence clinical outcomes and self-care behaviors in diabetes; however, few studies simultaneously assessed the impact of multiple social determinant of health factors on glycemic control. We used an explanatory model to examine the differential contribution of social determinants and clinical factors on glycemic control. Secondly, we examined the contribution of mutable and immutable factors to identify meaningful future interventions.

Methods—615 adults with type 2 diabetes in the southeastern United States were recruited. A hierarchical model was run with HbA1c as the dependent variable and independent variables entered in blocks: demographics (block 1), socioeconomic (block 2), psychosocial (block 3), built environment (block 4), clinical (block 5), and knowledge/self-care (block 6).

Results—Significant associations for HbA1c included self-efficacy ($\beta = -0.10$, $p < 0.001$), social support ($\beta = 0.01$, $p < 0.05$), comorbidity ($\beta = -0.09$, $p < 0.05$), insulin use ($\beta = 0.95$, $p < 0.001$), medication adherence ($\beta = -0.11$, $p < 0.05$), and being a former smoker ($\beta = 0.34$, $p < 0.05$); accounting for 24.4% of the variance.

Corresponding Author: Leonard E. Egede, MD, MS, Medical University of South Carolina, Center for Health Disparities Research, 135 Rutledge Avenue, Room 280, PO Box 250593 Charleston, SC 29425, Tel: 843-792-2969; Fax: 843-876-1201; egedel@muscc.edu.

Conflict of Interest: The authors report no potential conflicts of interest relevant to this article.

Guarantors: LEE and RJW are the guarantors of the study and take full responsibility for the work as a whole, including the study design, access to data, and the decision to submit and publish the manuscript.

Disclaimer: This article represents the views of the authors and not those of NIH, VHA or HSR&D.

Author Contributions: LEE obtained funding for the study. RJW, BLS, and LEE designed the study, acquired, analyzed and interpreted the data, and critically revised the manuscript for important intellectual content. All authors approved the final manuscript.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Conclusions—Important factors that drive glycemic control are mutable, and amenable to health interventions. Greater attention should be given to interventions that increase self-efficacy and social support, reduce the burden of comorbidities, and enhance medication adherence and smoking cessation.

Keywords

Diabetes; social determinants; socioeconomic; psychological; built environment

1. INTRODUCTION

Type 2 diabetes affects more than 29 million people in the US, with an estimated 8.1 million individuals having undiagnosed type 2 diabetes and an estimated 86 million Americans diagnosed with prediabetes [1]. In 2012, costs associated with type 2 diabetes totaled \$245 billion, including direct and indirect costs [1]. The remarkable cost of type 2 diabetes can be attributed to various complications and comorbid conditions associated with this chronic illness, including hypo- and hyperglycemia, high blood pressure, high LDL cholesterol, heart disease, stroke, blindness, kidney disease, and amputations [1]. The American Diabetes Association (ADA) recommends those diagnosed with type 2 diabetes receive diabetes self-management education and support, including training to improve diabetes knowledge and self-care behaviors as well as clinical care to support glycemic control [2]. Furthermore, the ADA emphasizes that diabetes education and support should address psychosocial and other external barriers to attaining optimal health outcomes, for example community factors, cultural barriers, and patient decision support [2,3]. Accordingly, social determinants of health have been shown to influence individuals with chronic illness [4], including those diagnosed with type 2 diabetes [5].

The CDC has characterized social determinants of health as economic and social conditions that influence the health of people and communities [6]. Socioeconomic factors have been shown to influence health, including outcomes and mortality in patients with diabetes. [7–9] In addition, psychosocial and neighborhood factors have been shown to impact health outcomes, including individuals diagnosed with type 2 diabetes [5]. Psychosocial factors address the interaction between individuals and their social environment, and have been shown to be a strong influence in diabetes. [10–11] Poor emotional coping to a diagnosis of type 2 diabetes affects an individual's ability to adhere to self-care behaviors [12] and factors such as fatalism, depression, perceived stress, and serious psychological distress, and social support influence both self-care and diabetes outcomes. [13–17]. Additionally, external influences, such as neighborhood factors, have also been associated with health outcomes including food insecurity, perceived neighborhood problems, neighborhood safety, and walking/exercise environment [18–20]. Studies have found that neighborhood aesthetics and social support affect hemoglobin A1C [20] and residents in neighborhoods with higher income levels and neighborhood stability had better diabetes related self-care behaviors [21]. Neighborhood level socioeconomic factors, in addition to individual socioeconomic levels continue to be the most pervasive social determinant of health [19,22].

Though socioeconomic, psychosocial and neighborhood factors have been shown to influence clinical outcomes and self-care behaviors in diabetes, few studies have

simultaneously assessed the impact of multiple social determinant of health factors on glycemic control. This study sought to consider both mutable and immutable factors that influence diabetes outcomes. The concept of mutable factors was first introduced by Aday and Anderson to describe health system factors that can be changed so patients could receive better access to medical care. [23] For the purposes of this study, we defined mutable factors as any influence that is amendable to change via intervention. The primary goal of this study was to use an explanatory model to better understand the differential role of social determinants of health, clinical factors and self-care on glycemic control in individuals with type 2 diabetes. The secondary goal was to understand the role of mutable and immutable factors and identify factors that should be targets for future interventions.

2. MATERIALS AND METHODS

2.1 Subjects

Two adult primary care clinics in the southeastern United States served as the site for recruitment of 615 patients with type 2 diabetes. All procedures were in accordance with ethical standards and approved by the Medical University of South Carolina institutional review board and the VA Research & Development committee prior to study enrollment. Eligibility included (1) ages 18 years or older, (2) diagnosis of type 2 diabetes in their medical record, and (3) able to communicate in English. Ineligibility was determined by interaction or chart documentation of cognitive impairment as a result of significant dementia or active psychosis.

Eligible patients were sent letters or approached in clinic, and those interested were provided an explanation of the study prior to being consented. Validated questionnaires collected demographic information, social determinants of health factors, self-care and clinical factors. Selected social determinant factors were included based on a modified version of the conceptual framework by Brown et al. [19] relating social determinants to health outcomes in patients with diabetes. Outcomes were abstracted from the electronic medical record, including blood pressure, cholesterol (LDL), and HbA1c.

2.2 Demographic Variables

Age was used as a continuous variable. Race was categorized as non-Hispanic Black, non-Hispanic White and Hispanic/other. Marital status was categorized as never married, married, separated/divorced, and widowed. Insurance was categorized as none, private, Medicare, Medicaid, VA and other.

2.3 Socioeconomic Variables

Previously validated items from the 2002 National Health Interview Survey [24] were used to capture household income, years of education and employment status. Household income was categorized into 10 income units and treated as a continuous variable. Years of education and hours worked per week were also treated as continuous variables.

2.4 Psychosocial Factors

Fatalism—Fatalism was assessed with the Diabetes Fatalism Scales (DFS); a 12-item scale where higher scores represent greater diabetes fatalism. [25] The DFS has a Cronbach's alpha of 0.80. [25]

Depression—Depression was assessed with the PHQ-9; a 9-item scale based on the DSM-IV criteria for depression with higher scores indicating more severe depression. [26] Sensitivity is 88% and specificity is 88% for major depression. [27]

Diabetes Distress—Distress was assessed with the Diabetes Distress Scale (DDS); a 17-item measure with questions about disease management, support, emotional burden and access to care. (24) The sensitivity and specificity ranged from 0.85 to 0.97. [28]

Serious Psychological Distress—Serious Psychological Distress (SPD) was assessed with the K6; a 6-item scale with higher scores representing higher probability of severe mental illness. The scale has good precision and consistent psychometric properties across major sociodemographic samples. [29]

Self-Efficacy—Self-efficacy was assessed with the Perceived Diabetes Self-Management Scale (PDSMS); an 8-item measure where higher scores indicate higher self-efficacy. [30] It is a valid and reliable measure of diabetes self efficacy (Cronbach alpha = 0.83). [30]

Social Support—Social Support was assessed with the Medical Outcomes Study (MOS) Social Support Survey; a 19-item scale measuring tangible support, affection, positive social interaction, and emotional or informational support. The total scale has high internal consistency ($\alpha=0.97$), good criterion and discriminant validity, and one-year test-retest reliability (0.72 to 0.76). [31]

Perceived Stress—Stress was assessed with the Perceived Stress Scale (PSS); a 4-item scale assessing the frequency over the previous month with which the respondent finds situations stressful. [32] The Cronbach alpha value is 0.69 and scores are highly correlated with stress, depression and anxiety. [33]

2.5 Built Environment Factors

Evidence from a prior validation study indicated six scales and four indices that can be used to assess the built environment [18]. For each of the scales and indices a higher score indicates more perceived problems in the neighborhood.

Neighborhood Characteristics—Aesthetic quality consisted of 7 items; walking/exercise environment and consisted of 11 items; access to healthy foods and consisted of 11 items; crime/safety (safety had 3 items and crime had 4 items); and social cohesion and consisted of 5 items. The scales included items with response categories ranging from 1 (strongly agree) to 5 (strongly disagree). The violence scale response options ranged from 1 (often) to 4 (never). The recreation facilities index included eight items on the presence of

recreational facilities in the neighborhoods (yes/no) and rating of the facilities from 1 (excellent) to 4 (poor condition).

Neighborhood Participation Index—12 items that measure a person’s participation in civic and political activities with their neighbors. This index counts a “yes” response as 1 point and then summed the responses to indicate a person’s participation.

Neighborhood Problems Index—16 items measuring neighborhood characteristics such as presence of trash and litter. The response categories range from 1 to 3, with 1 indicating that the neighborhood attribute was not a problem, 2 it was somewhat of a problem, and 3 it was a big problem. Responses were summed to construct the neighborhood problems index score.

2.6 Clinical Factors

Duration of diabetes was collected in years and treated as a continuous variable. Body mass index (BMI) was calculated based on the most recent height and weight from the electronic medical record. Comorbidity was calculated using the Charlson comorbidity index and reported as a continuous score. [34] Participants reported use of insulin, kidney problems, or eye problems, and results were dichotomized as yes or no. Self-reported health status was reported on a scale of 1 to 5 with 1 being low and 5 being high. [20]

2.7 Diabetes Knowledge and Self-Care

Diabetes Knowledge—Diabetes knowledge was assessed with the Diabetes Knowledge Questionnaire (DKQ); a 24-item scale where the final score is based on the percentage of correct scores. [35]

Self-Reported Medication Adherence—Medication adherence was assessed with the Morisky Medication Adherence Scale (MMAS); an 8-item scale with higher values indicating poorer adherence. [36]

Behavioral Skills—Diabetes behavior was assessed with the Summary of Diabetes Self-Care Activities (SDSCA) scale; an 11-item scale measuring frequency of self-care activity in the last 7 days for general diet (follow healthy diet), specific diet (ate fruits/low fat diet), exercise, blood glucose testing, and foot care. [37] Smoking was self-reported as never smoked, former smoker or current smoker.

2.8 Outcome Measure

Hemoglobin A1c was abstracted from the electronic medical record using values within the previous 6 months relative to date of completed survey.

2.9 Statistical Analyses

Sample Size—The sample size provides 80% power to detect an association of at least $\rho=0.3$, where ρ represents the population correlation between the HbA1c and each primary independent variable. In multivariate analyses, the sample size provides 80% power to detect an increment of at least 10% in R^2 for a given primary independent variable, while

controlling for covariates. As a result, this sample size has power to detect a small or moderate effect (2% to 13% of the variance).

Analysis—Three sets of analyses were conducted to provide information on the individual and collective contribution of mutable and immutable factors on glycemic control. First, means and percentages for all variables were calculated and normality was assessed. Second, pairwise correlation (for continuous variables) and one-way ANOVA (for categorical variables) were used to test the association among HbA1c and demographics, social determinant of health variables, clinical factors, and knowledge/self-care. Third, a hierarchical multiple linear regression model was run with variables entered in blocks based on theoretical relationships: demographics (block 1), socioeconomic factors (block 2), psychosocial factors (block 3), built environment factors (block 4), clinical factors (block 5), and knowledge/self-care (block 6). All analyses were performed with STATA Version 13. A two-tailed alpha of 0.05 was used to assess for significance.

3. RESULTS

Patient characteristics for this sample of 615 adults with type 2 diabetes are summarized in Table 1. The majority of the population were non-Hispanic Blacks (64.9%) and men (61.6%). The average age was 61.3 years, with an average of 13.4 years of education and 12.5 hours worked per week. Participants had been diagnosed with type 2 diabetes for an average of 12.3 years.

Table 2 shows the correlation between glycemic control and mutable and immutable factors. This model shows that glycemic control has a significant inverse relationship with age (0.15, $p < 0.001$), education (-0.08 , $p < 0.05$), general diet (-0.12 , $p < 0.01$), exercise (-0.10 , $p < 0.05$), medication adherence (0.03, $p < 0.001$), self-efficacy (-0.34 , $p < 0.001$), social support (-0.09 , $p < 0.05$), and perceived neighborhood problems (-0.01 , $p < 0.05$). Contrarily, a significant positive correlation existed between employment status (0.09, $p < 0.05$), health status (0.04, $p < 0.05$), blood sugar testing (0.09, $p < 0.05$), fatalism (0.08, $p < 0.05$), depression (0.16, $p < 0.001$), diabetes distress (0.27, $p < 0.001$), serious psychological distress (0.13, $p < 0.01$), perceived distress (0.12, $p < 0.01$), neighborhood aesthetics (0.10, $p < 0.05$), walking/exercise environment (0.09, $p < 0.05$), neighborhood violence (0.12, $p < 0.01$), neighborhood crime (0.13, $p < 0.01$), self-rating of neighborhood (0.15, $p < 0.001$), neighborhood comparison (0.10, $p < 0.05$), food insecurity (0.15, $p < 0.001$), and diabetes duration (0.16, $p < 0.001$) and glycemic control. Additionally, we found that glycemic control differed significantly by gender (women $7.7\% \pm 1.8$ vs. men $8.1\% \pm 1.9$, $p < 0.05$), site of care (non-VAMC $7.6\% \pm 1.7$ vs. VAMC $8.3\% \pm 1.9$, $p < 0.001$), use of insulin (yes $8.6\% \pm 1.9$ vs. no $7.3\% \pm 1.5$, $p < 0.001$), diabetes-related kidney problems (yes $8.3\% \pm 1.9$ vs. no $7.9\% \pm 1.8$, $p < 0.05$), and diabetes-related eye problems (yes $8.2\% \pm 1.8$ vs. no $7.8\% \pm 1.8$, $p < 0.001$).

Results of the hierarchical multiple linear regression model that included demographics, social determinants, clinical factors and self-care behaviors on glycemic control are shown in Table 3. In the first model assessing patient demographics, age ($\beta = -0.02$, $p < 0.01$) and receiving care at the VAMC ($\beta = 0.75$, $p < 0.01$) were significant. Age ($\beta = -0.02$, $p < 0.05$) and receiving care at a VAMC ($\beta = 0.75$, $p < 0.01$) remained significant after socioeconomic

variables (block 2) were added. Psychosocial factors were added as a third block. We found that receiving care at a VAMC ($\beta = 0.50, p < 0.05$), diabetes distress ($\beta = 0.30, p < 0.05$), self-efficacy ($\beta = -0.11, p < 0.001$), and social support ($\beta = 0.01, p < 0.05$) were significant. The fourth block included factors of the built environment and significant relationships remained for receiving care at a VAMC ($\beta = 0.48, p < 0.05$), diabetes distress ($\beta = 0.31, p < 0.01$), self-efficacy ($\beta = -0.11, p < 0.001$), and social support ($\beta = 0.01, p < 0.05$). When clinical factors (block 5) were added to the regression we found Medicaid insurance ($\beta = -0.66, p < 0.05$), diabetes distress ($\beta = 0.29, p < 0.05$), self-efficacy ($\beta = -0.09, p < 0.001$), social support ($\beta = 0.01, p < 0.05$), and insulin use ($\beta = 1.01, p < 0.001$) were significant. The final model added diabetes knowledge and self-care variables (block 6) and showed, accounting for all factors, the factors that remained significant were self-efficacy ($\beta = -0.10, p < 0.001$), social support ($\beta = 0.01, p < 0.05$), comorbidity ($\beta = -0.09, p < 0.05$), insulin use ($\beta = 0.95, p < 0.001$), medication adherence ($\beta = -0.11, p < 0.05$), and being a former smoker ($\beta = 0.34, p < 0.05$). The final model accounted for 24.4% of the variance observed in glycemic control in the sample population.

4. DISCUSSION

This study sought to identify the mutable and immutable factors independently associated with glycemic control by using an explanatory model to detect incremental effect. After accounting for demographic factors, socioeconomic status, psychosocial factors, the built environment, clinical factors, and knowledge/self-care, the most significant influences were self-efficacy, social support, comorbidity, insulin use, being a former smoker, and medication adherence. As a result, this study found that the majority of factors driving glycemic control are mutable, and amenable to interventions by the healthcare system.

By elucidating the most significant independent factors influencing glycemic control, these results show that mutable social determinants of health are critical to address in patients with type 2 diabetes. These factors most appropriately represent mutable enabling (self-efficacy and social support) and need (comorbidity, insulin use, smoking cessation, medication adherence) components of Aday and Anderson's model for access to health care. [23] These factors, in turn, influence both healthcare utilization and consumer satisfaction, but as all are mutable, they are amenable to policy changes and interventions at the clinical level. [23] The findings of this study suggests that there is need to shift attention from traditional focus on education and skills training in diabetes to broader strategies that incorporate interventions that target important social determinants of health such as social support. There is also a need to develop more effective interventions that reduce the high comorbidity burden in diabetes, enhance smoking cessation and improve medication adherence.

A number of interventions currently exist to address the mutable factors found influential in this study. Psychosocial factors such as self-efficacy and social support can be addressed through psychological interventions aimed at improving glycemic control through therapies such as cognitive behavioral therapy and problem-solving. [38,39] A study by Alam et al. showed that generalists could deliver these psychological interventions with equal effectiveness if trained. [39] Expanding on current recommendations to consider family,

social and community environment in clinical care [40], ADA and health systems should consider provision of training to clinicians to allow delivery of less intensive psychological interventions in a primary care setting. Use of psychological interventions to address self-efficacy and social support will allow additional psychosocial factors to be taken into account, such as depression and stress. Individuals with more depressive symptoms were shown to have greater gains in self-efficacy following self-management training. [41] Additionally, obstructive family behaviors were shown to exacerbate the association between both stress and depression with medication non-adherence. [42] These findings show the importance of considering a comprehensive view of treatment, which includes clinical, behavior, and psychosocial factors together.

Additionally, early and aggressive treatment of diabetes should be considered to limit the impacts of comorbidities resulting from uncontrolled diabetes. Randomized controlled trials show that early and aggressive treatment focused on improving glycemic control are important in addressing progression of diabetes and reducing diabetes-related complications. [43] Effective strategies to enhance medication adherence and smoking cessation need to be employed early in disease onset, as they have been shown to lower HbA1c, improve lipid profiles, and reduce diabetes complications. [44] A number of pharmacist-based intervention models have shown effectiveness, including the pharmacy care model where pharmacists partner with patients to develop a therapeutic plan, and physician/pharmacist collaborative models where pharmacists are part of team-based care. [45,46] Additionally, in a recent meta-analysis it was shown that pharmacist-led interventions using patient activation showed significant improvement in HbA1c. [47] A meta-analysis of pharmacist interventions delivered as part of general practice found significant improvements in blood pressure, HbA1c, and cholesterol. [48] Taken together, this evidence suggests the collaborative use of pharmacists in an effort to aggressively treat diabetes may lead to significant improvement in glycemic control, improved medication adherence, and a reduction in comorbidity burden.

Strengths of this study include the relatively large sample size, detailed information on key mutable and immutable factors including extensive data on different components of social determinants of health, and the use of an explanatory model in which variables were entered into the model sequentially based on theoretical relationships from prior research. Limitations include the cross-sectional nature of the data, which precludes discussion of causation and the regional sample from the southeastern United States. In addition, most recent HbA1c values were collected from medical records, rather than taking a new sample at the time of completion of the questionnaire.

Based on this comprehensive analysis of the socioeconomic, psychosocial, and built environment determinants of health, clinical factors, and knowledge/self-care behaviors, it appears interventions that target self-efficacy and social support, reducing the burden of comorbidities, and supporting patients in medication adherence and smoking cessation will lead to greater improvements in glycemic control. Use of psychological and pharmacist interventions in an effort to provide aggressive clinical treatment may lower the burden of disease, and address mutable social determinants. While the collaborative model of care is

gaining momentum, these results provide data-driven information on important factors to consider when planning collaborative care teams for patients with type 2 diabetes.

Acknowledgments

Funding Source: This study was supported by Grant K24DK093699-01 from The National Institute of Diabetes and Digestive and Kidney Disease (PI: Leonard Egede).

References

- Centers for Disease Control and Prevention. National diabetes fact sheet: national estimates and general information on diabetes and prediabetes in the United States. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention; 2011.
- American Diabetes Association [ADA]. Foundations of care: education, nutrition, physical activity, smoking cessation, psychosocial care, and immunization. *Diabetes Care*. 2015; 38(Suppl 1):S20–S30. [PubMed: 25537702]
- American Diabetes Association [ADA]. Strategies for improving care. *Diabetes Care*. 2015; 38(Suppl 1):S5–S7. [PubMed: 25537709]
- Marmot M. Social determinants of health inequalities. *Lancet*. 2005; 365:1099–1104. [PubMed: 15781105]
- Walker RJ, Smalls BL, Campbell JA, Strom Williams JL, Egede LE. Impact of social determinants of health on outcomes for type 2 diabetes: a systematic review. *Endocrine*. 2014; 47(1):29–48. [PubMed: 24532079]
- Healthy People. Secretary's Advisory Committee on Health Promotion and Disease Prevention Objectives for 2020. . Healthy People 2020: An Opportunity to Address the Societal Determinants of Health in the United States. Jul 26. 2010 Available from: <http://www.healthypeople.gov/2020/topicsobjectives2020/overview.aspx?topicid=39>
- Adler NE, Stewart J. Health disparities across the lifespan: meaning, methods, and mechanisms. *Ann NY Acad Sci*. 2010; 1186:5–23. [PubMed: 20201865]
- Agardh E, Allebeck P, Hallqvist J, Moradi T, Sidorchuk A. Type 2 diabetes incidence and socio-economic position: a systematic review and meta-analysis. *Int J Epidemiol*. 2011; 40(3):804, e18. [PubMed: 21335614]
- Saydah S, Lochner K. Socioeconomic status and risk of diabetes-related mortality in the U.S. *Public Health Report*. 2010; 125(3):377–388.
- Skinner TC. Psychological barriers. *European Journal of Endocrinology*. 2004; 151:T13–T17. [PubMed: 15487979]
- Jack L Jr, Liburd L, Vinicor F, Brody G, Murry VM. Influence of the environmental context on diabetes self-management: a rationale for developing a new research paradigm in diabetes education. *The Diabetes Educator*. 1999; 25:775–790. [PubMed: 10646474]
- Smalls BL, Walker RJ, Hernandez-Tejada MA, Campbell JA, Davis KS, Egede LE. Associations between coping diabetes knowledge, medication adherence and self-care behaviors in adults with type 2 diabetes. *General Hospital of Psychiatry*. 2012; 43(4):385–389.
- Egede LE, Dismuke CE. Serious psychological distress and diabetes: a review of the literature. *Curr Psychiatry Rep*. 2012; 14(1):15–22. [PubMed: 22002804]
- Egede LE, Ellis C. Diabetes and depression: global perspectives. *Diabetes Res Clin Pract*. 2010; 87(3):302–312. [PubMed: 20181405]
- Williams ED, Magliano DJ, Tapp RJ, Oldenburg BF, Shaw JE. Psychosocial stress predicts abnormal glucose metabolism: the Australian Diabetes, Obesity and Lifestyle (AusDiab) study. *Ann Behav Med*. 2013; 46(1):62–72. [PubMed: 23389687]
- Walker RJ, Gebregziabher M, Martin-Harris B, Egede LE. Independent Effects of Socioeconomic and Psychological Social Determinants of Health on Self-Care and Outcomes in Type 2 Diabetes. *General Hospital Psychiatry*. 2014 Nov-Dec;36(6):662–668. [PubMed: 25103544]

17. Gao J, Wang J, Zheng P, Haardorfer R, Kegler MC, Zhu Y, Fu H. Effects of self-care, self-efficacy, social support on glycemic control in adults with type 2 diabetes. *BMC Fam Pract.* 2013; 14:66. [PubMed: 23705978]
18. Echeverria SE, Diez-Roux AV, Link BG. Reliability of self-reported neighborhood characteristics. *Journal of Urban Health.* 2004; 81(4):682–701. [PubMed: 15466849]
19. Brown AF, Ettner SL, Piette J, Weinberger M, Gregg E, Shapiro MF, Karter AJ, Safford M, Waitzfelder B, Prata PA, Beckles GL. Socioeconomic position and health among persons with diabetes mellitus: a conceptual framework and review of the literature. *Epidemiologic Reviews.* 2004; 26:63–77. [PubMed: 15234948]
20. Smalls BL, Gregory CM, Zoller JS, Egede LE. Direct and indirect effects of neighborhood factors and self-care on HbA1c levels in adults with type 2 diabetes. *J Diabetes Complication; March.* 2015; 29(2):186–191.
21. de Vries McClintock HF, Wiebe DJ, O'Donnell AJ, Morales KH, Small DS, Bogner HR. Neighborhood social environment and patterns of adherence to oral hypoglycemic agents among patients with type 2 diabetes mellitus. *Family and Community Health.* 2015; 38(2):169–179. [PubMed: 25739064]
22. Gary-Webb TL, Baptiste-Roberts K, Pham L, Wesche-Thobaben J, Patricio J, Pi-Sunyer FX, Brown AF, Jones-Corneille L, Brancati FL. for the Look AHEAD Research Group. Neighborhood socioeconomic status, depression and health status in the Look AHEAD (Action for Health in Diabetes) study. *BMC Public Health.* 2011; 11:349–356. [PubMed: 22182286]
23. Aday LA, Anderson R. A framework for the study of access to medical care. *Health Serv Res.* 1974; 9(3):208–220. [PubMed: 4436074]
24. National Center for Health Statistics. Survey Questionnaire, National Health Interview Survey, 2002. National Center for Health Statistics; Hyattsville, Maryland: 2004. Available at: cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/2002/
25. Egede LE, Ellis C. Development and psychometric properties of the 12-item diabetes fatalism scale. *J Gen Intern Med.* 2010; 25:61–66. [PubMed: 19908102]
26. Kroenke K, Spitzer RL, Williams JB. The PHQ-9: validity of a brief depression severity measure. *J Gen Intern Med.* 2001; 16:606–13. [PubMed: 11556941]
27. Gilbody S, Richards D, Brealey S, Hewitt C. Screening for depression in medical settings with the Patient Health Questionnaire (PHQ): a diagnostic meta-analysis. *J Gen Intern Med.* 2007; 22:1596–602. [PubMed: 17874169]
28. Fisher L, Glasgow RE, Mullan JT, Skaff MM, Polonsky WH. Development of a brief diabetes distress screening instrument. *Annals Fam Med.* 2008; 6(3):246–252.
29. Kessler RC, Andrews G, Colpe LJ, Hiripi E, Mroczek DK, Normand SLT, Walters EE, Zaslavsky AM. Short screening scales to monitor population prevalence and trends in non-specific psychological distress. *Psychological Medicine.* 2002; 32:959–976. [PubMed: 12214795]
30. Wallston K, Rothman R, Cherrington A. Psychometric Properties of the Perceived Diabetes Self-Management Scale (PDSMS). *J Behav Med.* 2007; 30:395–401. [PubMed: 17522972]
31. Sherbourne CD, Stewart AL. The MOS Social Support Survey. *Social Science and Medicine.* 1991; 32:705–714. [PubMed: 2035047]
32. Cohen, S.; Williamson, G. Perceived Stress in a Probability Sample of the United States. In: Spacapan, S.; Oskamp, S., editors. *The Social Psychology of Health.* Newbury Park, CA: Sage; 1988.
33. Andreou E, Alexopoulos EC, Lionis C, Varvogli L, Gnardellis C, Chrousos GP, Darviri C. Perceived stress scale: reliability and validity study in Greece. *Int J Environ Res Public Health.* 2011; 8:3287–3298. [PubMed: 21909307]
34. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis.* 1987; 40:373–383. [PubMed: 3558716]
35. Garcia AA, Villagomez ET, Brown SA, Kouzekanani K, Hannis CL. The Starr County Diabetes Education Study: development of the Spanish-language diabetes knowledge questionnaire. *Diabetes Care.* 2001; 24:16–21. [PubMed: 11194219]

36. Morisky DE, Green LW, Levine DM. Concurrent and predictive validity of a self reported measure of medication adherence. *Med Care*. 1986; 24:67–74. [PubMed: 3945130]
37. Toobert DJ, Hampson SE, Glasgow RE. The summary of diabetes self-care activities measure: results from 7 studies and a revised scale. *Diabetes Care*. 2000; 23:943–950. [PubMed: 10895844]
38. Ismail K, Winkley K, Rabe-Hesketh S. Systematic review and meta-analysis of randomized controlled trials of psychological interventions to improve glycaemic control in patients with type 2 diabetes. *Lancet*. 2004; 363:1589–1597. [PubMed: 15145632]
39. Alam R, Sturt J, Lall R, Winkley K. An updated meta-analysis to assess the effectiveness of psychological specialists and generalist clinicians on glycaemic control and on psychological status. *Patient Education and Counseling*. 2009; 75:25–36. [PubMed: 19084368]
40. Marrero DG, Ard J, Delamater AM, Peragallo-Dittko V, Mayer-Davis EJ, Nwankwo R, Fisher EB. Twenty-first century behavioral medicine: a context for empowering clinicians and patients with diabetes: a consensus report. *Diabetes Care*. 2013 Feb; 36(2):463–470. [PubMed: 23349150]
41. Jerant A, Kravitz R, Moore-Hill M, Franks P. Depressive symptoms moderated the effect of chronic illness self-management training on self-efficacy. *Medical Care*. 2008; 46(5):523–531. [PubMed: 18438201]
42. Mayberry LS, Egede LE, Wagner JA, Osborn CY. Stress, depression, and medication nonadherence in diabetes: test of the exacerbating and buffering effects of family support. *J Behav Med*. 2015; 38:363–371. [PubMed: 25420694]
43. Chan JL, Abrahamson MJ. Pharmacological management of type 2 diabetes mellitus: rationale for rational use of insulin. *Mayo Clin Proc*. 2003; 78:459–467. [PubMed: 12683698]
44. Hassali MA, Nazir S, Saleen F, Masood I. Literature Review: Pharmacists' interventions to improve control and management in type 2 diabetes mellitus. *Altern Ther Health Med*. 2015; 21(1):28–35. [PubMed: 25599430]
45. Chung WW, Chua SS, Lai P, Chan SP. Effects of a pharmaceutical care model on medication adherence and glycemic control of people with type 2 diabetes. *Patient Preference and Adherence*. 2014; 8:1185–1194. [PubMed: 25214772]
46. Carter BL, Coffey CS, Ardery G, Uribe L, Ecklund D, James P, Egan B, Vander Weg M, Chrischilles E, Vaughn T. Cluster-randomized trial of a physician/pharmacist collaborative model to improve blood pressure control. *Circ Cardiovasc Qual Outcomes*. 2015 Mar 24. Epub ahead of print.
47. Bollen SD, Chandar A, Falck-Ytter C, Tyler C, Perzynski AT, Gertz AM, Sage P, Lewis S, Cobabe M, Ye Y, Menegay M, Windish DM. Effectiveness and safety of patient activation interventions for adults with type 2 diabetes: systematic review, meta-analysis, and meta-regression. *J Gen Intern Med*. 2014; 29(8):1166–1176. [PubMed: 24733301]
48. Tan EC, Stewart K, Elliott RA, George J. Pharmacist services provided in general practice clinics: a systematic review and meta-analysis. *Res Social Adm Pharm*. 2014; 10(4):608–622. [PubMed: 24161491]

HIGHLIGHTS

Examined differential contribution of social determinants and clinical factors on HbA1c.

Explanatory model with variables entered in blocks (n=615)

Variables: demographics, SES, psychosocial, environment, clinical, and knowledge/self-care.

HbA1c associated with self-efficacy, social support, comorbidity, and medication adherence

Important social determinants are mutable and amenable to health interventions.

Table 1

Sample demographic characteristics (n=615)

	% or Mean \pm standard deviation
Age (years)	61.3 \pm 10.9
Education (years)	13.4 \pm 2.8
Employment (hours worked per week)	12.5 \pm 18.9
Diabetes Duration (years)	12.3 \pm 9.1
Comorbidity (Charlson score)	25.7 \pm 2.2
Health Status (score)	3.4 \pm 0.9
Gender	
Women	38.4
Men	61.6
Race/Ethnicity	
Non-Hispanic Black	64.9
Non-Hispanic Whites	33.0
Hispanic/Other	2.1
Marital Status	
Never Married	11.2
Married	49.7
Separated/Divorced	28.2
Widowed	10.9
Site of Care	
Non-VAMC	51.2
VAMC	48.8
Annual income level	
<\$10,000	20.2
\$10,000–\$14,999	11.3
\$15,000–\$19,999	10.1
\$20,000–\$24,999	10.4
\$25,000–\$34,999	14.7
\$35,000–\$49,999	13.8
\$50,000–\$74,999	10.1
\$75,000+	9.4

Table 2

Pearson's Correlation for Association between HbA1c and demographics, social determinant of health variables, clinical factors, and knowledge/self-care

	Correlation coefficient
Age ***	-0.15
Education *	-0.08
Income	-0.06
Employment *	0.09
Diabetes duration ***	0.16
BMI	-0.03
Comorbidity	0.04
Health status *	0.10
Diabetes knowledge	0.05
Self-care	
General Diet **	-0.12
Specific Diet	-0.07
Exercise *	-0.10
Blood Sugar Testing *	0.09
Foot Care	0.03
Medication Adherence ***	-0.20
Psychosocial Factors	
Fatalism *	0.08
Depression ***	0.16
Diabetes Distress ***	0.27
Serious Psychological Distress **	0.13
Self-efficacy ***	-0.34
Social Support *	-0.09
Perceived Stress **	0.12
Neighborhood Factors	
Neighborhood Aesthetics *	0.10
Walking/Exercise Environment *	0.09
Neighborhood Safety	0.07
Access to Healthy Foods	0.06
Social Cohesion	-0.04
Neighborhood Violence **	0.12
Neighborhood Crime **	0.13
Self-rating of Neighborhood ***	0.15
Neighborhood Comparison *	0.10

	Correlation coefficient
Recreational Facilities	0.06
Neighborhood Activity Index	0.03
Perceived Neighborhood Problems *	-0.01
Food insecurity ***	0.15

*
p<0.05,

**
p<0.01,

p<0.001

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Table 3

Hierarchical regression models for influence of social determinants, clinical factors and self-care on glycemic control

	Model 1 (Demographics)	Model 2 (Socioeconomic)	Model 3 (Psychosocial)	Model 4 (Built Environment)	Model 5 (Clinical)	Model 6 (Knowledge and Self-care)
Age	-0.02 **	-0.02 *	-0.01	-0.01	-0.01	-0.07
Gender						
Female (ref)	---	---	---	---	---	---
Male	0.04	-0.07	0.13	0.15	0.20	0.19
Race						
Non-Hispanic White (ref)	---	---	---	---	---	---
Non-Hispanic Black	0.15	-0.01	0.09	-0.04	-0.13	-0.15
Hispanic/Other	0.10	0.05	-0.21	-0.24	-0.52	-0.61
Marital Status						
Never married (ref)	---	---	---	---	---	---
Married	0.01	0.08	0.01	0.01	-0.01	-0.01
Separated/Divorced	0.07	0.05	0.06	0.10	0.12	0.13
Widowed	-0.04	-0.12	-0.18	-0.21	0.03	-0.03
Insurance						
None (ref)	---	---	---	---	---	---
Private	0.16	0.10	0.12	0.12	-0.16	-0.10
Medicare	-0.04	-0.13	-0.12	-0.09	-0.26	-0.21
Medicaid	-0.15	-0.32	-0.33	-0.41	-0.66 *	-0.63
VA	-0.28	-0.27	-0.36	-0.33	-0.43	-0.37
Other	0.03	-0.17	-0.17	-0.15	-0.18	-0.17
Site						
Non-VAMC (ref)	---	---	---	---	---	---
VAMC	0.75 ***	0.75 ***	0.50 *	0.48 *	0.24	0.20
Education		-0.05	-0.03	-0.03	-0.02	-0.02
Income		-0.04	-0.12	-0.001	-0.03	-0.04
Employment		0.01	0.01	0.005	0.01	0.01

	Model 1 (Demographics)	Model 2 (Socioeconomic)	Model 3 (Psychosocial)	Model 4 (Built Environment)	Model 5 (Clinical)	Model 6 (Knowledge and Self-care)
Fatalism			-0.01	-0.01	-0.02	-0.01
Depression			-0.01	-0.01	0.01	0.004
Diabetes Distress			0.30 *	0.31 *	0.29 *	0.27
Serious Psychological Distress			0.01	0.01	0.005	0.003
Self-efficacy			-0.11 ****	-0.11 ****	-0.09 ****	-0.10 ****
Social Support			0.01 *	0.01 *	0.01 *	0.01 *
Perceived Stress			-0.02	-0.03	-0.03	-0.04
Neighborhood Aesthetics				0.05	0.03	0.04
Walking/Exercise Environment				0.01	0.01	0.001
Neighborhood Safety				-0.01	0.003	-0.008
Access to Healthy Food				-0.01	-0.01	-0.01
Social Cohesion				-0.04	-0.04	-0.04
Neighborhood Violence				0.01	0.02	0.02
Neighborhood Crime				0.18	0.14	0.17
Self-rating of Neighborhood				0.01	0.08	0.10
Neighborhood Comparison				0.005	-0.08	-0.04
Recreational Facilities				0.02	0.03	0.03
Neighborhood Activity Index				-0.04	-0.03	-0.03
Neighborhood Problems				0.03	0.03	0.03
Food Insecurity				0.07	0.07	0.07
Duration of diabetes					0.01	0.01
BMI					-0.01	-0.01
Comorbidity					-0.07	-0.09 *
Insulin use						
No (ref)					---	---
Yes					1.01 ****	0.95 ****
Kidney problems						
No (ref)					---	---

	Model 1 (Demographics)	Model 2 (Socioeconomic)	Model 3 (Psychosocial)	Model 4 (Built Environment)	Model 5 (Clinical)	Model 6 (Knowledge and Self-care)
Yes					-0.04	-0.09
Eye problems						
No (ref)					---	---
Yes					-0.05	0.08
Health status					-0.01	-0.05
Diabetes knowledge						0.01
General diet						0.05
Specific diet						0.01
Exercise						-0.05
Blood sugar testing						0.04
Foot care						0.03
Medication adherence						-0.11 *
Smoking						
Never smoke (ref)						---
Former smoker						0.34 *
Current smoker						-0.02
Adjusted R ²	0.0393	0.0446	0.1529	0.1541	0.2334	0.2442

* p<0.05,

** p<0.01,

*** p<0.001,

ref = reference group

Adjusted beta estimates are given for final multiple linear regression model for influence on glycemic control. variables were entered in blocks based on theoretical relationships: demographic factors (block 1), socioeconomic factors (block 2), psychosocial factors (block 3), built environment (block 4), clinical factors (block 5), and knowledge/self-care (block 6).