J Immigrant Minority Health (2016) 18:1392–1403
DOI 10.1007/s10903-015-0271-4

ORIGINAL PAPER

Type 2 Diabetes Self-management Among Spanish-Speaking Hispanic Immigrants

Cheryl A. Smith-Miller[1,2] · Diane C. Berry[2] · Darren DeWalt[3] · Cass T. Miller[4]

Published online: 7 November 2015

Abstract This article describes the quantitative findings of a mixed-methods study that examined the relationship among knowledge, self-efficacy, health promoting behaviors, and type 2 diabetes self-management among recent Spanish-speaking, limited English proficient immigrants to the US. This population is at risk for both a higher incidence of disease and increased barriers to successful disease management compared to the general US population. Distinguishing aspects of this study compared to the available literature are the comprehensive nature of the data collected, the theoretical component, and the analysis and modeling approach. Social cognitive theory provides the framework for the study design and analysis. An innovative community-based recruiting strategy was used, a broad range of physiological measures related to health were observed, and instruments related to knowledge, self-efficacy, and healthy lifestyle behaviors were administered orally in Spanish to 30 participants. A broad range of statistical analysis methods was applied to the data, including a set of three structural equation models. The study results are consistent with the importance of education, health knowledge, and healthy lifestyle practices for type 2 diabetes self-management. With the usual cautions associated with applying structural equation modeling to modest sample sizes, multiple elements of the posited theoretical model were consistent with the data collected. The results of the investigation of this under-studied population indicate that, on average, participants were not effectively managing their disease. The results suggest that clinical interventions focused on improving knowledge, nutrition, and physical activity, reducing stress, and leveraging the importance of interpersonal relations could be effective intervention strategies to improve self-management among this population.

Keywords Diabetes management · Health literacy · Self-efficacy · Knowledge · Immigrants · Structural equation modeling

✉ Cheryl A. Smith-Miller
Cheryl.Smith-Miller@unchealth.unc.edu

Diane C. Berry
dberry@email.unc.edu

Darren DeWalt
darren_dewalt@med.unc.edu

Cass T. Miller
casey_miller@unc.edu

1 Nursing Quality and Research, University of North Carolina Hospital, Chapel Hill, NC, USA

2 School of Nursing, UNC-CH, Chapel Hill, NC, USA

3 School of Medicine, UNC-CH, Chapel Hill, NC, USA

4 UNC Gillings School of Global Public Health, UNC-CH, Chapel Hill, NC, USA

Introduction

Type 2 diabetes mellitus (T2DM) affects an estimated 382 million adults throughout the world and accounts for at least 90 % of all diabetes cases [1]. In developed countries, ethnic and racial minorities and immigrant populations are disproportionately negatively affected, suffering higher prevalence, complication rates, and worse clinical outcomes compared to native born populations [2–5].

In the US, there are 21 million diagnosed T2DM cases [6]. While the prevalence rate of T2DM is 7.6 % among non-Hipsanic Whites age 20 and older the rate among Hispanic populations age 18–74 years is 16.9 %, exceeding that of non-Hispanic Blacks (13.2 %) and American

Indians/Alaskan Natives (15.9 %) [6, 7]. Among Hispanic subgroups, persons of Mexican heritage have the highest prevalence rate (18.3 %), followed by Puerto Ricans and Dominicans at 18.0. % [7]. Compared to non-Hispanic Whites, Mexican Americans have an 87 % higher risk of T2DM diagnosis and suffer higher rates of end-stage renal disease, retinopathy, neuropathy, lower limb amputations, and mortality rates from T2DM [8]. These statistics not only illustrate the prevalence of T2DM among Hispanic immigrants in the US and its consequences but also the degree to which it is ineffectively managed in this population [9, 10].

Mexican immigrants make up the largest foreign-born population in the US and, among recent arrivals, an estimated 75 % have limited English language proficiency and low educational achievement [11–14]. Limited English proficiency negatively affects an individual's health literacy within the US healthcare system, contributes to low diabetes knowledge, undermines T2DM self-efficacy and is associated with worse health outcomes [14–21].

Self-efficacy (SE) is defined as the individual's belief a behavior-specific goal can be achieved [22–24]. SE is behavior specific and is not transferable from one domain to another, therefore diabetes SE is limited to diabetes self-management, while exercise and eating self-efficacy are coupled to those behaviors [16, 22, 25].

Though limited language skills, low literacy, and SE are identified as contributing to poor self-management, exploration of the effect of these factors on the T2DM self-management practices among recent limited-English proficient, Spanish-speaking US immigrants is sparse [23, 26]. Health literacy is generally defined as the ability to access health services and understand and act on health information; low health literacy is associated with a decreased ability to self-manage chronic conditions such as diabetes [15, 16, 27]. Although health literacy has been explored among Hispanic populations, the inclusion criterion often requires English-language proficiency and recruits participants from hospital or clinic waiting rooms thereby excluding limited-English proficient immigrants and those who do not regularly access healthcare services [18–20, 28]. Thus, these studies have not elucidated the factors that influence the T2DM self-management practices and outcomes of limited-English language proficient, recent Hispanic immigrants.

The high rates of T2DM, language barriers, and low academic achievement among this population place many at risk for poor health outcomes, yet there has been little exploration of their T2DM self-management behaviors in the context of health literacy and self-efficacy. Therefore, the overall goal of this work was to explore T2DM self-management among limited English proficient Hispanic immigrants and the factors that influence it. The specific objectives were to: (1) propose a theory to guide the design and analysis of this study; (2) develop an effective strategy to recruit the target population; (3) assemble instruments and methods to evaluate the health literacy, diabetes knowledge, health-promoting behaviors, and SE of the study participants; (4) assess the dominant factors affecting T2DM self-management in the participant group; and (5) hypothesize potential interventions for improving health outcomes among the target population.

Theoretical Framework

Nursing research frequently lies at the intersection of physiologic science and social science and as such the questions to be answered can be complex. Determining an appropriate theoretical framework can respond to these challenges by helping to blend disparate areas of science, informing important aspects of a given problem, guiding methods development, assisting in the interpretation of the results, and providing a foundation upon which to generalize the findings. Thus, an appropriately selected theory is woven into multiple aspects of an informed study.

Diabetes self-management is an example of an individual endeavor that occurs within complex social systems; understanding this interaction can be advanced through a realization that the self-management of other conditions share similarities with T2DM. For example, smoking cessation, weight control, and increased physical fitness are important health promoting behaviors in heart failure and arthritis self-management [29, 30]. The commonalities of the self-management of these conditions include behaviors that arise from knowledge, the expectation that desired outcomes will be achieved, and the importance of confidence in one's ability to engage in the behavior given existing social constraints. Social cognitive theory (SCT) has been used as a theoretical framework to guide the study of individual self-management in each of these seemingly different conditions [30–32] as well as T2DM self-management among different cultural groups [18, 33], but its utilization among recent Hispanic immigrants with limited English proficiency is lacking. Because of the parallels that exist between these conditions and the condition of concern in this work, SCT was used as the theoretical framework to guide the design, analysis, and generalization of findings. SCT can be broadly viewed as a Venn diagram with intersections among individual, environment, and behaviors.

Figure 1 depicts a specific conceptual model, based upon the components of SCT. The components include knowledge, healthy behaviors, self-efficacy, and T2DM self-management outcomes. This model was used to design methods to measure each of the model components and the arrows depict the posited paths of influence.

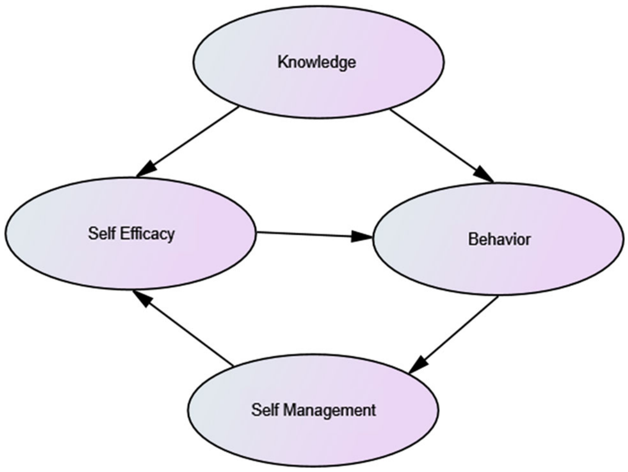

Fig. 1 Posited theoretical model for T2DM management based upon SCT representing proposed paths of influence. The components include knowledge (personal attributes), health promoting behaviors, T2DM self-management outcomes and self-efficacy [22, 24]

Methods

The appropriate Office of Human Research Ethics Institutional Review Board approved the research plan before any study activities began. Participants were recruited using a community-based, snow-ball recruiting strategy in an effort to enroll a diverse sample [34, 35]. Study enrollment was achieved by posting recruitment notices at grocery stores, other businesses, churches, and community centers. Participants were also given postcards that described the study to distribute to others interested in participating. The study inclusion criteria were: Hispanic immigrant to the US within the last 5-years, Spanish-speaking with limited English proficiency, diagnosed with T2DM more than 1 year ago, and without co-morbidities that interfered with the performance of recommended diabetes self-management behaviors (i.e., blindness, peripheral neuropathy).

Potential participants self-identified and contacted the Spanish-speaking research assistant (RA) via a dedicated study cell phone. Language-proficiency and acculturation screening was conducted with potential participants using the four-item Short Acculturation and Language Screening Scale [36]. A score of 2.99 or below was required to participate in the study.

Concurrent data collection was used to gain a more complete understanding of the participants' experience with T2DM, to examine self-management behaviors, and to elucidate cultural and familial influences. Data collection was designed to investigate elements of the individual, the family and social environment, behaviors, and physiological outcomes consistent with the posited model shown in Fig. 1.

Participants scheduled their appointment at one of two locations located approximately 6.5 km apart and within the region in which they were recruited. Data collection was conducted in a private conference room and to prevent interviewer fatigue no more than two sessions were scheduled per day [37]. Childcare was provided on site upon request. Participants received a $50 reimbursement for their time and travel, a record of all physiologic measures, an American Diabetes Association Spanish language recipe booklet, and exercise information.

Upon arrival, participants received a thorough description of the study in Spanish and were provided an opportunity to ask questions. Table 1 summarizes the data collected for each participant, which is detailed in turn. Following the consent process, physiologic measures were taken, demographic questions were asked, the instruments were orally administered, and a semi-structured interview was conducted. Demographic information included gender, age, nationality, last year of formal education completed, age at which formal education ended, country where they attended school, and current and past employment. The principal investigator (PI) performed all physiological measurements; the RA administered all instruments in Spanish and recorded participant responses. Each session followed the same sequence of activities.

Height, weight, waist circumference, blood pressure, a skin-fold body fat estimate, and glycated hemoglobin (HbA1c) were collected as physiological measures of health and indicators of participants' health-promoting behaviors. Measures were obtained according to National Health and Nutrition Examination Survey procedures and required approximately 10–15 min to complete [45]. Waist-to-height ratios (WtHR) were calculated as an indicator of central adiposity and the amount of body fat [46]. Blood pressure (BP) was measured using a Criticon® digital blood pressure meter, Welch Allyn 300 series [47]. The point-of-care finger stick HbA1c was collected with the CLIA waived Cholestech™ GDX point of care machine [48].

Since insulin sensitivity has been correlated with generalized and regional visceral adiposity skin fold thickness was measured at four sites (biceps, triceps, subscapular and supra-iliac) on the right side of the body using Lange® skinfold calipers. The skinfold thicknesses at the four sites were summed and matched to the age and sex criteria described by Durnin and the caliper manufacturer to classify participant's adiposity [49, 50].

Two instruments were used to assess individual's knowledge: (1) the Spanish speaking version of the Short Assessment of Health Literacy for Spanish-Speaking Adults (SAHLSA) [39], and (2) the Spanish speaking version of the Diabetes Knowledge Test (DKT) [40]. All instruments were previously tested for reliability and internal consistency among populations similar to the participants in this study.

Table 1 Measures and data collected

Data	Method	Scale type	Range	Units
Demographic measures	*Questionnaire*			
Gender	Oral question	Nominal	–	Male or female
Age	Oral question	Integer	–	Years
Educational achievement	Oral question	Integer	–	Years
Years since education ceased	Oral question	Integer	–	Years
Nationality	Oral question	Nominal	–	
Occupation	Oral question	Nominal	–	
Physiologic measures				
Systolic BP	Welch Allyn Criticon®, digital blood pressure meter (300 series)	Continuous	–	mmHg
Diastolic BP		Continuous	–	mmHg
HbA1c	Cholestech™ GDX point of care	Continuous	–	mg/dL
Height	Stadiometer	Continuous	–	1/8-cm intervals
Waist	Figure Finder® measuring tape	Continuous	–	1-cm intervals
Weight	Tanita® WB-110A Digital Scale	Continuous	–	lb and kg
Adiposity				
BMI	(Weight in kilograms)/height in meters^2 = BMI	Ratio	–	kg/m^2
Skin folds: triceps, iliac crest, subscapular	Lange® skinfold calipers	Continuous	–	mm
WtHR	Waist/height = WtHR [38]	Ratio	–	
Knowledge				
SAHLSA (50 items)	Instrument [39]	Ordinal	0–50	
Diabetes knowledge (24 items)	Instrument [40]	Categorical ordinal	0–24	
Self-efficacy				
Diabetes self-efficacy (8-items)	Instrument [41]	Likert	8–80	
Exercise self-efficacy (18-items)	Instrument [42]	Likert	18–180	
Eating self-efficacy (25-items)	Instrument [43]	Likert	25–250	
Socially acceptable (10 items)	–		10–100	
Negative affect (15 items)	–		15–150	
Health-promoting lifestyle profile (52 items)	Instrument [44]	Ordinal	52–208	

The 50-question SAHLSA is an orally administered instrument that evaluates comprehension of medical terminology and screens for low health literacy [39]. The instrument was administered according to the developer's instructions. Participants were given a laminated card for each test item. Three choices were printed on each card; the key (correct answer), a distracter, and "I don't know". The research assistant read the stem item and the three choices aloud and the participant then selected one answer. For example—for "*Obesity*", the three answer choices were "weight" (key), "height" (distractor), or "I don't know." One point was awarded for each correct answer and respondents were encouraged to answer "I don't know" rather than guess. Scores can range from 0 to 50, a score of 37 or fewer suggests inadequate health literacy [39].

The DKT instrument was used to measure basic diabetes-related knowledge. Answer choices were "*yes*", "*no*", or "*I don't know* (0 points)" with one point awarded for each correct response [40]. A question example is, "Diabetes can be cured".

Three SE instruments were used. Eating and exercise SE were examined using professionally translated Spanish language instruments, which were also evaluated by bicultural native speakers for appropriateness and clarity for use in this study. The items in each instrument ask participants to rate their perceived confidence (SE) on a scale from 1 to 10 (low to high). The Diabetes Self-Efficacy instrument measures an individual's confidence in their ability to perform T2DM self-management behaviors [41, 51]. "How confident do you feel that you can judge when the changes in your illness means you should visit the doctor?" is an example of the items, with higher scores indicating more confidence in performing the related behaviors. The Self-Efficacy to Regulate Exercise instrument was used to measure confidence in engaging in physical activity [42, 52], and the choices ranged from *cannot do at all* (1) to *completely certain can do* (10). The Eating Self-Efficacy instrument was used to measure confidence of an individual in their ability to control their diet [43], and the choices ranged from *no difficulty* (1) to *a lot of difficulty* (10). This instrument had two subscales, *negative affect and socially acceptable*. Negative affect refers to emotional eating and its triggers (e.g., anger, anxiety). Socially acceptable refers to overeating that occurs within social contexts such as parties and family celebrations.

The Spanish language version of the Health-Promoting Lifestyle Profile II (HPLP II) instrument [44] was used to assess the frequency in which participants performed health-promoting behaviors. This 52-item instrument has six sub-scales indicating levels of: health responsibility, physical activity, nutrition, spiritual growth, interpersonal relations, and stress management. The choices for each question are *never* (1), *sometimes* (2), *often or routinely* (3), or *always* (4).

Data Analysis

Analyses were performed using IBM SPSS®V.23 and AMOS [53]. All data was cleaned and double-checked for accuracy. Descriptive statistics were calculated, the normality of the results from each instrument was assessed, factor analysis was performed, multiple linear regression models were computed and analyzed, and structural equation modeling with bootstrapping was performed [54]. The goal of the statistical analysis was to analyze the data fully, evaluate the posited model, and assess any shortcomings of the collected data.

Results

A study sample of 30 participants was recruited from June to December 2011, and the participant demographics are detailed in Table 2. Descriptive analysis procedures were conducted and revealed that the sample included a majority of female participants. Educational achievement was low, as quantified by a mean of 7.2 years of formal schooling, and the mean time since formal education ceased was 29.7 years. The majority of participants emigrated from Mexico with the remainder from other Latin American countries. Slightly more than half of the participants were employed, while another 10 were homemakers.

Table 2 Participant demographics

Characteristic	Measure
Gender	
Male	11
Female	19
Age range (years)	27–86
Educational achievement:	
Mean (SD) (years)	7.2 (3.9)
Mean (SD) age education ended (years)	14.4 (5.5)
Mean (SD) time since education ceased (years)	29.7 (11.7)
Country of origin	
Mexico	25
Other Latin American countries	5
Occupation	
Retired	2
Unemployed	2
Homemaker/stay at home parent	10
Laborer/service worker/babysitter	15
Professional	1

The physiologic measures for all participants are summarized in Table 3. A majority of participants met the recommendations for BP but did not meet the target glycemic level as indicated by HbA1c measures [55]. The vast majority of participants also exceeded the target value for WtHR with 59 % meeting the criteria for seriously overweight or obese as indicated by a WtHR greater than 0.56 [35, 55]. While adiposity measures ranged from normal to overweight based on the recommendations for age and gender a majority of participants in this study met the criteria for overweight or obese [46, 49].

The results from the instruments and the psychometric analysis scores, which support the level of internal consistency of the instruments, are reported in Table 4. General health knowledge scores, as measured by SAHLSA, exhibited a wide range, although the sample mean (slightly above 37) suggested an adequate literacy level [39]. This result contrasted with DKT scores, which were low and had a relatively low standard deviation and internal consistency.

The participant's diabetes, exercise, and eating SE scores are reported in Table 4. The scores indicate that while most participants were confident in their abilities regarding the control of their diabetes, they had less confidence in exercise and eating. The sub-category scores for eating SE provided information regarding socially acceptable eating and eating under negative circumstances (overeating, frustration, etc.).

Table 3 Physiological measures

Measure	Desired value[a]	Range	Mean	Standard deviation	Met/exceed desired value
Systolic BP (mmHg)	130	82–173	125.2	23.0	19/11
Diastolic BP (mmHg)	80	47–92	68	10.5	19/11
HbA1c[b] (%)	<7	5.1–12.1	7.7	1.9	12/17
WtHR ≤ 0.50	≤0.50	0.44–0.74	0.59	0.08	4/26
Adiposity (skinfold) measures	9.5–29.2[c]	22.9–41.9 mm	31.9	5.59	13/17

[a] Target value per ADA, 2014 guidelines

[b] One female participant HbA1c value missing

[c] Ideal body fat percentage varies by age and sex

Table 4 Instrument results and psychometric properties

Instruments	Number of items	Possible scores	Score range	Mean	Standard deviation	Cronbach's α
Knowledge						
SAHLSA	50	0–50	19–49	38.4	8.5	0.92
Diabetes knowledge test	24	0–24	6–18	12.0	2.5	0.51
Self-efficacy						
Diabetes SE	8	8–80	33–80	60.4	13.2	0.79
Exercise SE	18	18–180	18–179	92.1	37.8	0.94
Eating SE	25	25–250	74–232	152.1	42.4	0.93
Socially acceptable	10	10–100	24–98	59.4	19.9	0.84
Negative affect	15	15–150	42–146	92.6	29.7	0.93
Health promoting						
Behaviors						
Health promoting lifestyle profile II (overall scale)	52	52–208	82–179	127.6	23.5	0.97
Health responsibility	9	9–36	11–34	22.4	5.9	0.91
Physical activity	8	8–32	9–25	18.3	4.5	0.88
Nutrition	9	9–36	18–34	23.2	4.1	0.84
Spiritual growth	9	9–36	15–35	25.1	5.9	0.92
Interpersonal relations	9	9–36	12–31	21.6	4.5	0.84
Stress management	8	8–32	11–26	18.6	4.4	0.86

The assessments of the health promoting behaviors, as reflected in the overall HLPL II score and subscales, are also reported in Table 4. The subscale scores identified a wide distribution in behaviors among study participants. Health responsibility (23 points), spiritual growth (20 points), and interpersonal relations (19 points) varied the most among study participants. The behaviors that varied the least were stress management (15 points), physical activity (16 points) and nutrition (16 points), a finding which indicates greater consistency among the study participants in these behaviors. The computed standard deviations are consistent with the range of scores.

Based on the mixed methods design of this study, qualitative data saturation was achieved with 30 participants, but this sample size posed a challenge for the quantitative data analysis. Because of the substantial amount of data collected for each individual, coupled with the small sample size, selective inclusion of the collected data in the analysis framework was necessary. To screen for the most important components in the demographic, physiological, and instrument data that was collected from each participant, a factor analysis procedure was performed [56]. This analysis guided the identification of three factors that were of primary importance. Tests of normality were performed and bootstrapping methods were used where appropriate to counterbalance the limitations imposed by a small sample size [57].

The posited theoretical model was evaluated using structural equation modeling (SEM) of selected components of the data [58]. Three subsets of the proposed theoretical model were examined building from a simple case to a multi-compartment representation to extract the maximum information possible from the data collected. Maximum likelihood estimation with bootstrapping was used and variables used in model construction were selected based upon factor analysis of the various data measures. A full array of model behavior and model fit statistics were examined as precautions to over-stepping the analysis supported by the data [59]. The results from these three structural equation models are presented in turn using standard accepted measures of model acceptance [54, 60].

Model 1 is depicted in Fig. 2 using the standard SEM format supplied by IBM AMOS [61]. The oval is a latent variable, the rectangles are observed variables, and the circles are unobserved exogenous error variables. The lines illustrate the model dependencies. Instruments are observed variables, which can be measures of an unobserved latent variable. The numbers next to instrument variables, or latent variables, are the squared multiple correlations of the variable, while the numbers adjacent to the lines are standardized direct effects between the pair of connected variables [62].

Model 1 was selected to be a simple subset of the overall model and was specified to explore the relationship between healthy life style behaviors, as measured by the various sub-scales associated with this latent variable, and the HbA1c, which was selected as a sole endogenous variable of interest for T2DM self-management. A maximum number of measures of the latent variable was used to balance the small sample size and the posited model was relatively simple in form [54]. While many other physiological measures were observed and correlated to T2DM management, the time-averaged nature of HbA1c makes this biomarker a particularly good indicator of T2DM management and was also selected to simplify the model; statistical measures of the model fit supported this choice compared to other more complicated iterations that were attempted. Statistical measures of Model 1 are reported in Table 5 and fall within normal acceptable bounds for SEM [63]. Due to possible concerns about sample size, the Hoelter N is also reported, which is an upper bound on the size of the sample for which one would accept the hypothesis that the model is correct [59, 63, 64]. It is desirable that the Hoelter N be larger than the real sample size used in the study. Model 1 evaluates a posited relationship between healthy life style behaviors and HbA1c, and the statistical measures of model fit fall within acceptable bounds. Model 1 is determined to be a reasonable construct to build upon because of the overwhelming evidence supporting this theoretical construct and the results with this population.

Model 2 is summarized in Fig. 3. This model builds upon Model 1 by incorporating knowledge, or literacy, as a latent variable that influences healthy lifestyle behaviors. Because of the small sample size and the richness of information collected, four endogenous variables related to literacy and knowledge measures (years of education, years since education complete, SAHLSA, DKT) were used [65]. As with Model 1, the squared multiple correlations for each variable, and the standardized direct effects are noted on

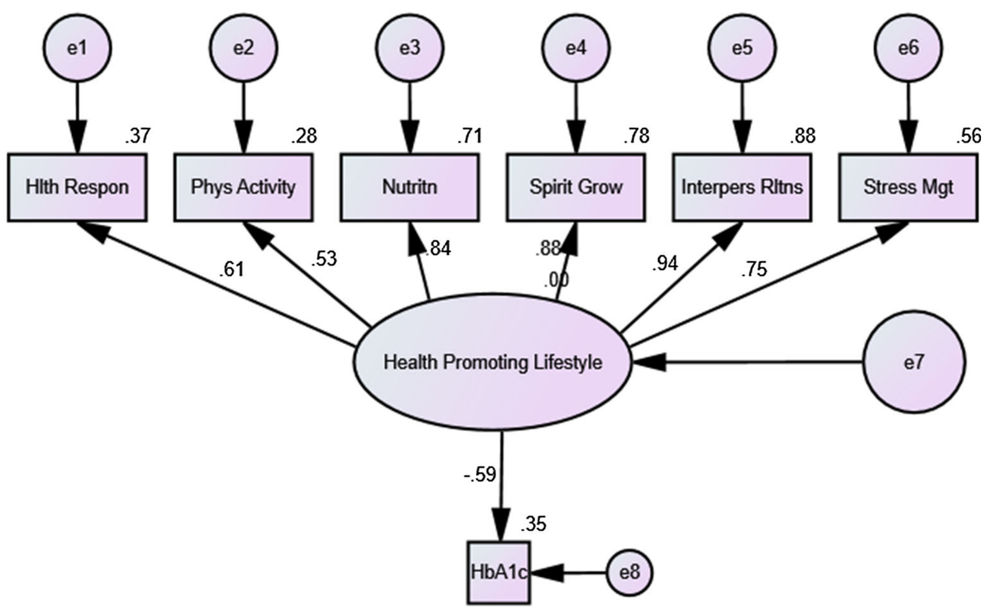

Fig. 2 Model 1. HLPL and HbA1c depicted using standard AMOS notation. The *ovals* represent a latent variable, *rectangles* represent observed variables, *circles* represent unobserved exogenous variables, *lines* represent model dependence, numbers adjacent to lines are standardized direct effects between the pair of connected variables, and the numbers next to the variables are the squared multiple correlations of the variable

Table 5 Structural equation modeling

Measure	Model 1	Model 2	Model 3
Degrees of freedom	14	43	52
Probability	0.571	0.808	0.635
Normalized minimum discrepancy	0.889	0.810	0.922
Tucker–Lewis index	1.000	1.000	1.000
Root mean square error of estimate	0.000	0.000	0.000
Hoelter N ($p = 0.05$)	54	46	40

Fig. 3. Statistical measures of Model 2 are reported in Table 5 and fall within normal acceptable bounds for SEM [56]. The probability of 0.808 for this model is especially encouraging and the Hoelter N is also acceptable. The other measures of model fit are also good. This result supports the importance of knowledge in T2DM self-management and lends support to the posited form of the model.

Model 3 is summarized in Fig. 4, and the statistical measures of this model are reported in Table 5. The purpose of Model 3 was to build upon the success of the Models 1 and 2 by incorporating SE. Diabetes SE was the only SE measure included in the model, a decision that was based on participant scores on the instrument and SE as a contributor to healthy life style behaviors and role in HbA1c [16, 66]. Model 3 was the most complex model, yet still exhibited good statistical properties, including an acceptable Hoelter N. Theory would suggest that SE plays a role in T2DM self-management and the SEM performed is consistent with this theory.

Discussion

This study involved five objectives, all of which were met. First, SCT was advanced as an appropriate theoretical framework, a specific model was posited, and this model was refined based upon the data collected. Second, an effective recruitment strategy was developed to identify and enroll participants from the desired T2DM group with limited English language proficiency and a relatively low level of education on average. Third, a comprehensive set of instruments were identified and used to produce a broad range of data. These instruments yielded normal distributions for the study population in all but one case and formed an effective basis for SEM. Fourth, we were able through the SEM to identify factors affecting T2DM self-management. Fifth, the data collected and analysis performed was a sufficient basis upon which to posit potential

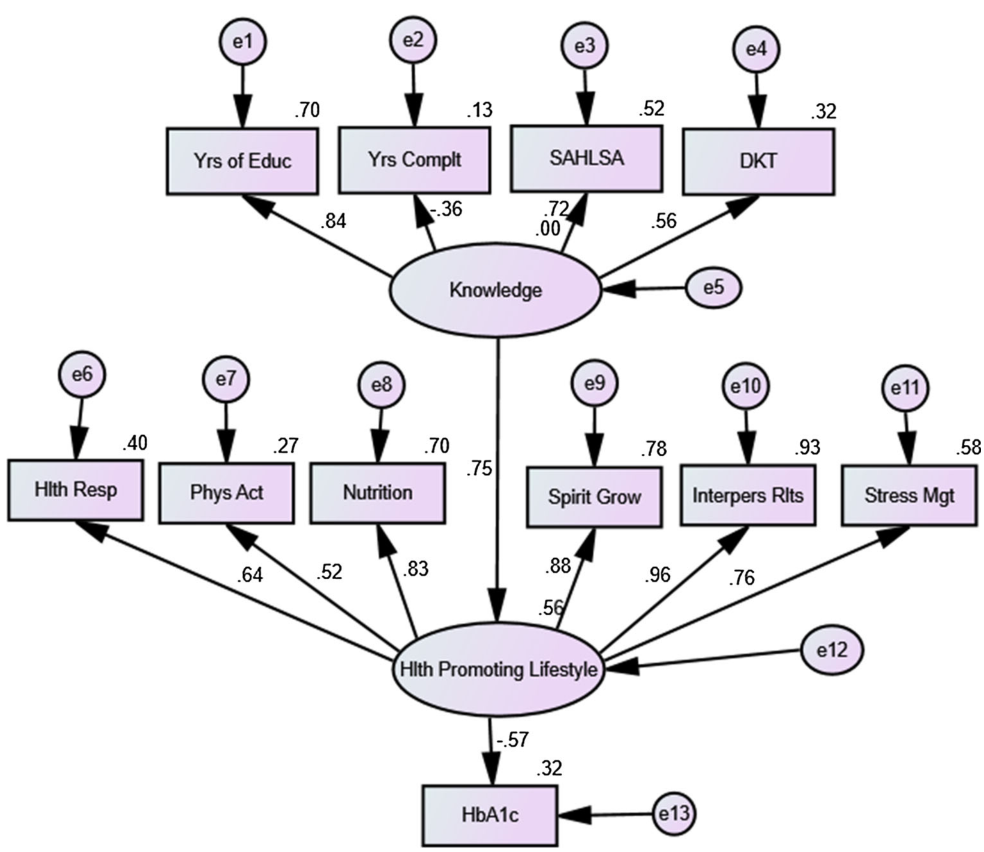

Fig. 3 Model 2. Knowledge, HLPL and HbA1c depicted using standard AMOS notation. *Ovals* represent latent variables, *rectangles* represent observed variables, *circles* represent unobserved exogenous variables, *lines* represent model dependence, numbers adjacent to lines are standardized direct effects between the pair of connected variables, and the numbers next to the variables are the squared multiple correlations of the variable

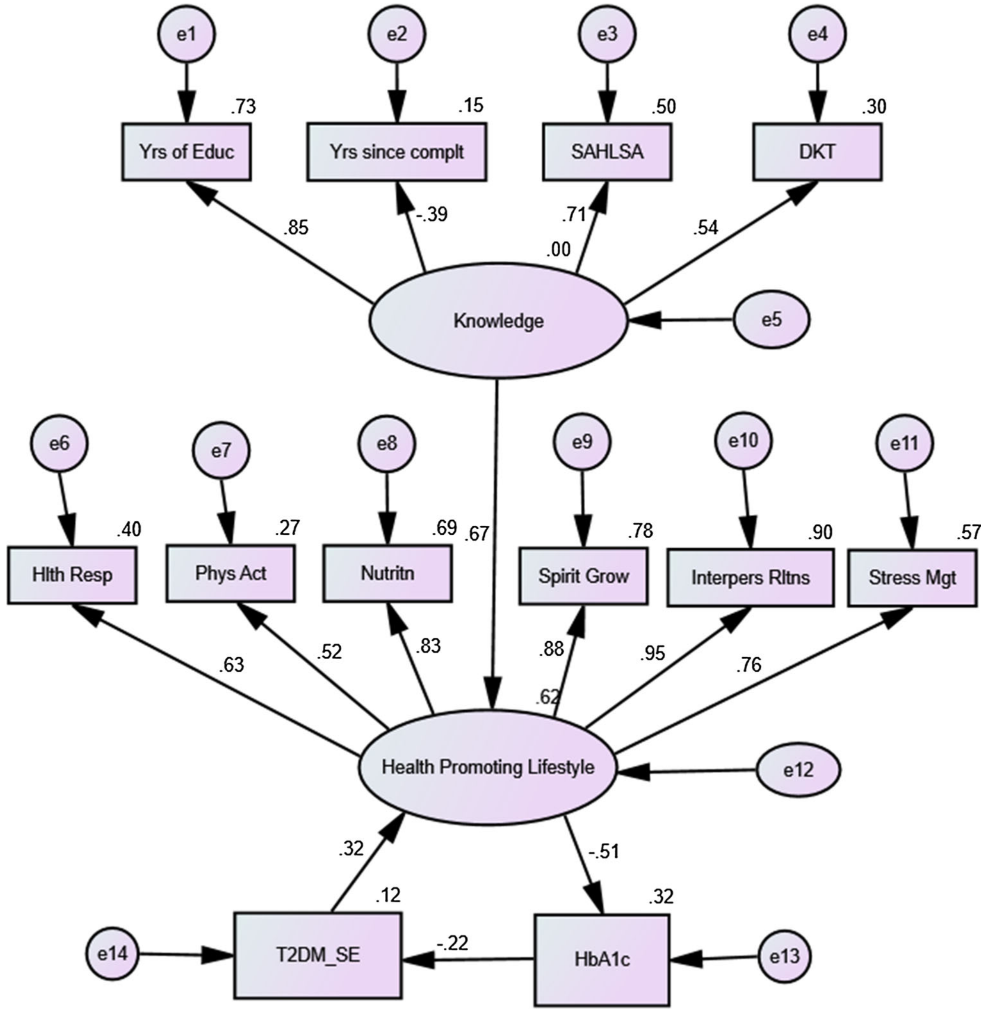

Fig. 4 Model 3. Knowledge, health promoting lifestyle, HbA1c, and diabetes self-efficacy depicted using standard AMOS notation. *Ovals* represent latent variables, *rectangles* represent observed variables, *circles* represent unobserved exogenous variables, *lines* represent model dependence, numbers adjacent to lines are standardized direct effects between the pair of connected variables, and the numbers next to the variables are the squared multiple correlations of the variable

interventions actions. Further details of how these objectives were met are presented in the following discussion.

The oral administration of all instruments and recording the answers strengthened the results in two ways. First, the comprehension of each item on every instrument was enhanced by participants being able to ask for clarification if they did not understand a question, which standardized the understanding of concepts and enhanced the reliability and consistency of the results. Second, this procedure minimized the potential for test-taking abilities and reading abilities to affect the responses, which is an important consideration among low-literacy populations such as the one targeted in this study.

The physiological measures showed that, on average, the group adequately controlled their blood pressure but most of the participants were overweight. HbA1c levels were generally above the guidelines for most participants. Factor analysis supported the use of HbA1c as the sole measure of T2DM management.

Diabetes knowledge, as measured by DKT, was relatively low as was the Cronbach α, suggesting low understanding of diabetes among the population but also potential issues of instrument suitability for this population [40]. Overall knowledge—quantified by level of academic achievement, years since education ceased, the SAHLSA and DKT—was found to be an important component of T2DM self-management based upon factor analysis and SEM. Despite concerns about the internal reliability of the DKT measure, the consistency of incorrect responses to some items indicate areas where a general lack of understanding or common attitudes existed among the study sample. The incorrect responses were primarily those related to medication and nutrition, findings which suggest that ongoing education about these topic are warranted. The fact that insulin dependent participants were unsure of the signs and symptoms of hypoglycemia was of particular concern. All participants considered a '*diabetic diet'* to consist '*mostly of special foods',* revealing how they construed the recommended diabetes diet compared to eating *normal* food.

Healthy lifestyle behaviors were assessed with the HLPL II, an instrument containing six subscales that spanned a wide range of behavior including health responsibility, physical activity, nutrition, spiritual growth, interpersonal growth, and stress management. All of these subscales were included individually as measures of behavior and found to be significant for T2DM self-management.

Based upon a rich literature of support for the importance of SE, it was posited to play an important role in the theoretical model hypothesized for the study [22, 24, 42, 43]. The reported scores for the participants were on average relatively high for diabetes SE, followed by eating SE, and exercise SE. Factor analysis and SEM revealed that SE is a complex construct that was not easy to include in the model. Attempts to define SE as a latent variable, with all three SE instruments as measures, were not successful for several combinations of variable connection. This could be concluded to be a sample size problem, but the factor analysis showed a complex, and different, relation for each of the measures of SE. In the end, only diabetes SE was included in the SEM because of these challenges. This is an area worthy of future study. The exercise SE results also indicate another aspect of the participants of interest. On average, the participants have an intermediate level of confidence in their ability to exercise routinely but their reported HLPL physical activity subscale scores suggest that they are not doing so; this behavior may be culturally influenced [67, 68].

SEM procedures were used as a part of the data analysis to evaluate the posited theoretical model that guided the study. The statistical outcomes were encouraging given sample size limitations. The sample size was limited because of the broad range of data collected for each participant, which also included an extensive qualitative component that is not relied upon for this work and will be reported elsewhere. One aspect of the SEM that deserves mention is that HbA1c was taken as the sole measure of glycemic control, and efforts to model the data using a latent variable for T2DM management were not successful. This was deemed a reasonable result, as HbA1c is a time-averaged measure of glycemic control that is a primary indicator of blood glucose control [55].

The study population was on average not successfully managing their T2DM and is unlikely to do so without linguistically and culturally appropriate interventions. Knowledge was found to be important in HbA1c control, but education levels and especially diabetes knowledge, were very low. All behavior measures were significant with spiritual growth and interpersonal relations the most highly weighted, suggesting a social-environmental component consistent with SCT. Based upon these considerations, potentially effective clinical interventions for improving T2DM management among similar populations should target improving diabetes knowledge, developing interventions that enhance physical activity, leveraging the importance of interpersonal relations, targeting improved nutrition, and developing strategies to reduce stress.

A comprehensive investigation of the published literature was performed to design this study and to place the findings in an appropriate context. Within the general context of T2DM self-management among Spanish-speaking immigrant populations much has been written. The topic is well-known to be extraordinarily complex and multi-faceted and the extant health disparities of this group are well documented [2, 4, 8, 10]. While many studies contribute knowledge to certain aspects of the problem, comprehensive investigations examining physiological measures, knowledge, self-efficacy, and health behaviors related to T2DM self-management are limited [17, 22, 69–73]. Compared to these other studies the physiological measures of health, such as BMI, blood pressure, and HbA1c, in this study are similar. Within this set of studies, only Latham et al. [71] had a complete theoretical component, a limitation that has been noted more broadly in health literacy in general [74]. A theoretical component is important because it provides a foundation for a broad interpretation of the relationships among the many components believed to be important in T2DM self-management.

Unique aspects of this study were the subject population, as they were recruited from the community, and the SEM analysis that was used to probe the importance of the many factors investigated. Latham et al. [71] also advanced a comprehensive conceptual model and performed preliminary SEM to analyze their data although the forms of these models and those presented here are much different. Latham and colleagues used quality of life as the sole latent variable and a limited connection of HbA1c to other variables, whereas in this analysis HbA1c was the self-management outcome measure, which was related to knowledge, health behavior, and T2DM self-efficacy. Differences aside, the complexity of the problem and the diversity of the population poses obstacles to developing a comprehensive understanding, but the use of advanced methods like SEM can help advance our understanding of the inherent complexity in the self-management of T2DM.

This study had limitations. The sample size of 30 was small for the quantitative analysis compared to the complexity of the issue involved, but necessary because of the data-rich approach used for each participant. While the standard statistical measures of a successful model were within normal bounds for all models and the form of the models were consistent with theory, SEM may not be generally applicable to small sample sizes although appropriate use of these procedures for small sample sizes has been documented in the recent literature [59, 64]. Alternative measures of acculturation may be more reliable than the one used here, however this measure was considered adequate as one component in the screening process [35]. The quantitative portion of this study did not collect data related to other impediments to T2DM self-management, such as barriers to access, communication issues, or immigration status [21, 23, 28].

Acknowledgements This study was supported by grants from the Academy of Medical-Surgical Nurses, North Carolina Nurses Association—Triangle Region, and Sigma Theta Tau—Alpha Alpha Chapter. The UNC School of Nursing Bio-behavioral Laboratory and the Family Partners provided equipment for the physiological measures.

References

1. International Diabetes Federation. IDF diabetes atlas. 6th ed. 2013. http://www.idf.org/sites/default/files/DA6_Regional_factsheets_0.pdf. Accessed Apr 2015.
2. Office of Minority Health and Health Disparities. Fact sheet: Hispanic or Latino populations. 2014. http://www.cdc.gov/minorityhealth/populations/REMP/hispanic.html. Accessed Apr 2015.
3. Creatore MI, Moineddin R, Booth G, Manuel DH, DesMeules M, McDermott S, Glazier RH. Age- and sex-related prevalence of diabetes mellitus among immigrants to Ontario, Canada. CMAJ. 2010;182(8):781–9.
4. Ujcic-Voortman JK, Schram MT, Jacobs-van der Bruggen MA, Verhoeff AP, Baan CA. Diabetes prevalence and risk factors among ethnic minorities. Eur J Public Health. 2009;19(5):511–5.
5. Plockinger U, Topuz M, Langer M, Reuter T. Problems of diabetes management in the immigrant population in Germany. Diabetes Res Clin Pract. 2010;87(1):77–86.
6. Centers for Disease Control and Prevention. National diabetes statistics report: estimates of diabetes and its burden in the United States. Atlanta, GA.: U.S. Department of Health and Human Services, Editor; 2014. http://www.cdc.gov/diabetes/pubs/statsreport14/national-diabetes-report-web.pdf. Accessed Apr 2015.
7. Schneiderman N, Llabre M, Cowie CC, Barnhart J, Carnethon M, Gallo LC, Avilés-Santa ML. Prevalence of diabetes among Hispanics/Latinos from diverse backgrounds: the Hispanic community health study/study of Latinos (HCHS/SOL). Diabetes Care. 2014;37(8):2233–9.
8. Umpierrez GE, Gonzalez A, Umpierrez D, Pimentel D. Diabetes mellitus in the Hispanic/Latino Population: an increasing health care challenge in the United States. Am J Med Sci. 2007;334(4):274–82.
9. Ding H, Hargraves L. Stress-associated poor health among adult immigrants with a language barrier in the United States. J Immigr Minor Health. 2009;11(6):446–52.
10. Vega WA, Rodriguez MA, Gruskin E. Health disparities in the Latino population. Epidemiol Rev. 2009;31(1):99–112.
11. Hakimzadeh S, Cohn D. English usage among Hispanics in the United States. Washington DC: Pew Hispanic Center; 2007. http://www.pewhispanic.org/2007/11/29/english-usage-among-hispanics-in-the-united-states/. Accessed Apr 2015.
12. U.S. Census Bureau. State and county quickfacts—North Carolina. Profile of general population and housing characteristics: 2010 summary file 1, table PCT 11. Demographic profile data. 2010. http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk. Accessed Apr 2015.
13. Vaccaro J, Feaster D, Lobar S, Baum M, Magnus M, Huffman F. Medical advice and diabetes self-management reported by Mexican-American, Black- and White-non-Hispanic adults across the United States. BMC Public Health. 2012;12(1):185.
14. Pew Hispanic Center. Statistical profiles of the Hispanic and Foreign-Born Populations in the U.S. 2010. http://pewhispanic.org/reports/report.php?ReportID=120. Accessed Aug 2015.
15. Pleis JR, Lucas JW, Ward BW. Summary health statistics for U.S. adults: National Health Interview Survey, 2008. National Center for Health Statistics. 2009;10(242):158. http://www.cdc.gov/nchs/data/series/sr_10/sr10_242.pdf. Accessed Aug 2015.
16. Rustveld L, Pavlik V, Jibaja-Weiss M, Kline K, Gossey JT, Volk R. Adherence to diabetes self-care behaviors in English- and Spanish-speaking Hispanic men. Patient Prefer Adherence. 2009;3:123–30.
17. Wallace AS, Seligman HK, Davis TC, et al. Literacy-appropriate educational materials and brief counseling improve diabetes self-management. Patient Educ Couns. 2009;75(3):328–33.
18. McCleary-Jones V. Health literacy and its association with diabetes knowledge, self-efficacy and disease self-management among African Americans with diabetes mellitus. ABNF J. 2011;22(2):25–32.
19. Cavanaugh K, Huizinga MM, Wallston KA, et al. Association of numeracy and diabetes control. Ann Intern Med. 2008;148(10):737–46.
20. Paasche-Orlow M, Parker R, Gazmararian J, Nielsen-Bohlman L, Rudd R. The prevalence of limited health literacy. J Gen Intern Med. 2005;20(2):175–84.
21. Nam S, et al. Barriers to diabetes management: patient and provider factors. Diabetes Res Clin Pract. 2011;93(1):1–9.
22. Sarkar U, Fisher L, Schillinger D. Is self-efficacy associated with diabetes self-management across race/ethnicity and health literacy? Diabetes Care. 2006;29(4):823–9.
23. Sudore RL, Landefeld CS, Perez-Stable EJ, Bibbins-Domingo K, Williams BA, Schillinger D. Unraveling the relationship between literacy, language proficiency, and patient-physician communication. Patient Educ Couns. 2009;75(3):398–402.
24. Bandura A. Self-efficacy: toward a unifying theory of behavioral change. Psychol Rev. 1977;84(2):191–215.
25. Wen LK, Shepherd MD, Parchman ML. Family support, diet, and exercise among older Mexican Americans with type 2 diabetes. Diabetes Educ. 2004;30(6):980–93.
26. Pew Charitable Trust. Statistical portrait of Hispanics in the United States, 2008. 2010. http://pewhispanic.org/factsheets/factsheet.php?FactsheetID=58. Accessed Aug 2015.
27. White RO, Wolff K, Cavanaugh KL, Rothman R. Addressing health literacy and numeracy to improve diabetes education and care. Diabetes Spectr. 2010;23(4):238–43.
28. Ershow AG. Environmental influences on development of type 2 diabetes and obesity: challenges in personalizing prevention and management. J Diabetes Sci Technol. 2009;3(4):727–34.
29. DeWalt DA, et al. Comparison of a one-time educational intervention to a teach-to-goal educational intervention for self-management of heart failure: design of a randomized controlled trial. BMC Health Serv Res. 2009;9:99.
30. Peeters GG, Brown WJ, Burton NW. Psychosocial factors associated with increased physical activity in insufficiently active adults with arthritis. J Sci Med Sport. 2015;18(5):558–64.
31. Riegel B, Moser DK, Anker SD, et al. State of the science: promoting self-care in persons with heart failure: a scientific statement from the American Heart Association. Circulation. 2009;120(12):1141–63.
32. Basen-Engquist K, Carmack CL, Li Y, et al. Social-cognitive theory predictors of exercise behavior in endometrial cancer survivors. Health Psychol. 2013;32(11):1137–48.

33. Abdoli S, Ashktorab T, Ahmadi F, Parvizy S, Dunning T. Religion, faith and the empowerment process: stories of Iranian people with diabetes. Int J Nurs Pract. 2011;17(3):289–98.
34. Gorard S. Research design, as independent of methods. In: Tashakkori A, Teddlie C, editors. SAGE handbook of mixed methods in social and behavioral research. Los Angeles: SAGE; 2010. p. 237–51.
35. Morse J. Procedures and practice of mixed method design. Maintaining control, rigor, and complexity. In: Tashakkori A, Teddlie C, editors. Handbook of mixed methods in social and behavioral research. 2nd ed. Thousand Oaks, CA: Sage Publications; 2010. p. 339–77.
36. Marin G, Sabogal F, Marın BV, Otero-Sabogal R, Perez-Stable EJ. Development of a short acculturation scale for Hispanics. Hisp J Behav Sci. 1987;9:183–205.
37. Kvale S, Brinkman S. Interviews: learning the craft of qualitative research interviewing. 2nd ed. Thousand Oaks: Sage; 2008.
38. Ashwell M, Gunn P, Gibson S. Waist-to-height ratio is a better screening tool than waist circumference and BMI for adult cardiometabolic risk factors: systematic review and meta-analysis. Obes Rev. 2012;13(3):275–86.
39. Lee SY, Bender DE, Ruiz RE, Cho YI. Development of an easy-to-use Spanish health literacy test. Health Serv Res. 2006;41:1392–412.
40. Garcia A, Villagomez E, Brown S, Kouzekanani K, Hanis C. The Starr County Diabetes Education Study: development of the Spanish-language diabetes knowledge questionnaire. Diabetes Care. 2001;24(1):16–21.
41. Lorig KR, Ritter PL, Jacquez A. Outcomes of border health Spanish/English chronic disease self-management programs. Diabetes Educ. 2005;31(3):401–9.
42. Everett B, Salamonson Y, Davidson PM. Bandura's exercise self-efficacy scale: validation in an Australian cardiac rehabilitation setting. Int J Nurs Stud. 2009;46(6):824–9.
43. Glynn S, Ruderman A. The development and validation of an eating self-efficacy scale. Cognit Ther Res. 1986;10(4):403–20.
44. Walker SN, Kerr MJ, Pender NJ, Sechrist KR. A Spanish language version of the health-promoting lifestyle profile. Nurs Res. 1990;39(5):268–73.
45. Centers for Disease Control and Prevention. National health and nutrition examination survey: anthropometry procedures manual. 2007.
46. Ashwell M. Charts based on body mass index and waist-to-height ratio to assess the health risks of obesity: A review. Open Obes J. 2011;3:78–84.
47. Ostchega Y, Dillon C, Carroll M, Prineas RJ, McDowell M. US demographic trends in mid-arm circumference and recommended blood pressure cuffs: 1988–2002. J Hum Hypertens. 2005;19(11):885–91.
48. Bode BW, Irvin BR, Pierce JA, Allen M, Clark AL. Advances in hemoglobin A1c point of care technology. J Diabetes Sci Technol. 2007;1(3):405–11.
49. Durnin JVGA, Womersley J. Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 years. Br J Nutr. 1974;32:77–97.
50. BetaTechnology. Lange skinfold caliper: operators manual caliper. 2008. http://www.beta-technology.com/documents/caliper/080514%20Caliper%20Manual.pdf. Accessed Apr 2015.
51. Lorig KR, Holman HR. Self-management education: history, definition, outcomes, and mechanisms. Ann Behav Med. 2003;26(1):1–7.
52. Bandura A. Guide for constructing self-efficacy scales. In: Pajares F, Urdan TC, editors. Self-efficacy beliefs of adolescents charlotte. NC: Information Age Publishing; 2006. p. 307–37.
53. IBM SPSS Statistics for Windows. Version 19.0. Armonk, NY: IBM Corp; 2010.
54. Bentler PM. Structural equation modeling with small samples: test statistics. Multivar Behav Res. 1999;34(2):181–97.
55. American Diabetes Association. Standards of medical care in diabetes—2014. Diabetes Care. 2014;37(Supplement 1):S14–80.
56. Schreiber JB, et al. Reporting structural equation modeling and confirmatory factor analysis results: a review. J Educ Res. 2006;99(6):323–38.
57. Suhr D. The basics of structural equation modeling. University of North Colorado; 2006. http://www.lexjansen.com/wuss/2006/tutorials/TUT-Suhr.pdf. Accessed Aug 2015.
58. Iacobucci D. Structural equations modeling: fit indices, sample size, and advanced topics. J Consum Psychol. 2010;20(1):90–8.
59. Wolf EJ, et al. Sample size requirements for structural equation models: an evaluation of power, bias, and solution propriety. Educ Psychol Meas. 2013;76(6):913–34.
60. Bagozzi RP. On the evaluation of structural equation models. JAMS. 1988;16(1):74–94.
61. The Division of Statistics + Scientific Computation The University of Texas at Austin. Structural equation modeling using AMOS: an introduction. 2012. https://stat.utexas.edu/images/SSC/Site/AMOS_Tutorial.pdf. Accessed Apr 2015.
62. Hair JF. An assessment of the use of partial least squares structural equation modeling in marketing research. JAMS. 2012;40(3):414–33.
63. Grace JB, Bollen KA. Interpreting the results from multiple regression and structural equation models. Bull Ecol Soc Am. 2005;86(4):283–95.
64. Sideridis G, et al. Using structural equation modeling to assess functional connectivity in the brain: power and sample size considerations. Educ Psychol Meas. 2014;74(5):733–58.
65. Barton D. Literacy: an introduction to the ecology of written language Malden. MA: Wiley; 2007.
66. Osborn CY, Cavanaugh K, Wallston KA, Rothman RL. Self-efficacy links health literacy and numeracy to glycemic control. J Health Commun. 2010;15(Suppl 2):146–58.
67. Evenson KR, et al. Personal, social, and environmental correlates of physical activity in North Carolina Latina immigrants. Am J Prev Med. 2003;25(3 Suppl 1):77–85.
68. Larsen BA, et al. Physical activity in Latinas: social and environmental influences. Womens health (Lond Engl). 2013;9(2):201–10. doi:10.2217/whe.13.9.
69. White RO, et al. Development and validation of a Spanish diabetes-specific numeracy measure: DNT-15 Latino. Diabetes Technol Ther. 2011;13(9):893–8.
70. White RO, et al. Health literacy, physician trust, and diabetes-related self-care activities in Hispanics with limited resources. J Health Care Poor Underserved. 2013;24(4):1756–68.
71. Latham CL, Calvillo E. Predictors of diabetes outcomes in Mexico: testing the Hispanic health protection model. J Transcult Nurs. 2013;24(3):271–81.
72. Gerber BS, et al. Implementation and evaluation of a low-literacy diabetes education computer multimedia application. Diabetes Care. 2005;28(7):1574–80.
73. Compean Ortiz, LG, et al., Self-care behaviors and glycemic control in low-income adults in Mexico with type 2 diabetes mellitus may have implications for patients of Mexican heritage living in the United States. Clin Nurs Res. 2015. doi:10.1177/1054773815586542.
74. Wallace LS, et al. Use of theory in low-literacy intervention research from 1980 to 2009. Am J Health Behav. 2012;36(2):145–52.