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The Association of Cognitive Function and Social Support with Glycemic Control in Adults with Diabetes

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Abstract

OBJECTIVES—To examine whether cognitive impairment among adults with diabetes is associated with worse glycemic control and to assess if level of social support for diabetes care modifies this relationship.

DESIGN—Cross-sectional analysis

SETTING—The 2003 Health and Retirement Study (HRS) Mail Survey on Diabetes and the 2004 wave of the HRS

PARTICIPANTS—Adults age > 50 with diabetes in the United States (N=1097, mean age=69.2)

MEASUREMENTS—Hemoglobin A1c (HbA1c) level, cognitive function measured with the 35-point HRS cognitive scale (HRS-cog), sociodemographic variables, duration of diabetes, depressed mood, social support for diabetes care, self-reported understanding score of diabetes knowledge, diabetes treatments, diabetes-related components of the Total Illness Burden Index, and functional limitations.

RESULTS—In an ordered logistic regression model for the three ordinal levels of HbA1c (<7.0, 7.0–7.9, ≥8.0 mg/dl), respondents with HRS-cog scores in the lowest quartile had significantly higher HbA1c levels compared to those in the highest cognitive quartile (adjusted odds ratio, 1.80; 95% confidence interval, 1.11–2.92). This association was modified by a high level of social support for diabetes care: among respondents in the lowest cognitive quartile, those with high levels of support had significantly lower odds of having higher HbA1c compared to those with low levels of support (1.11 vs. 2.87, p=0.016).

CONCLUSION—Although cognitive impairment was associated with worse glycemic control, higher levels of social support for diabetes care ameliorated this negative relationship. Identifying the level of social support available to cognitively-impaired adults with diabetes may help to target interventions for better glycemic control.

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Keywords

cognitive impairment; glycemic control; diabetes mellitus; social support

INTRODUCTION

Diabetes mellitus is highly prevalent and increasing in the elderly population of the United States. The Centers for Disease Control and Prevention estimated that 18.4% of 65–74 year-olds and 16.6% of those aged 75 or older had diagnosed diabetes in 2006, up from 12.5% and 11.1% in 1996, respectively.¹ These estimates are likely conservative since they do not include the institutionalized population and undiagnosed diabetes. Diabetes in older adults is associated with higher mortality,² worse functional status, and higher prevalence of geriatric syndromes, such as depression and cognitive impairment.³ Diabetes in the elderly population also imposes significant costs on the U.S. healthcare economy; \$47 billion was spent for diabetes care of older adults in 2002.⁴

For successful diabetes management, individuals must commit to lifelong daily self-care tasks such as adhering to dietary, exercise, and medication regimens, checking blood glucose, and keeping provider appointments. The coordination of these tasks often requires complex cognitive functioning. There are several studies to date examining the association between cognitive function and the management of diabetes. One small study of 60 adults with diabetes failed to detect an association of global cognitive function, measured by the Mini Mental State Examination (MMSE), with glycemic control⁵ perhaps due to low statistical power. Another study found that lower MMSE scores were associated with poorer diabetes self-care and greater dependency.⁶ Other studies have shown that impaired executive function - the ability to plan and organize activities - is associated with worse glycemic control.^{5,7} Inadequate health literacy and numeracy have been shown to be associated with worse glycemic control and poorer self-management behaviors, respectively.^{8,9} Finally, social support for diabetes care from family and friends was not associated with glycemic control,⁸ and no prior studies of which we are aware have assessed the value of social support for diabetes care among those with cognitive impairment.

To address these deficiencies of knowledge about the roles of cognitive function and social support in diabetes care, we examined whether cognitive impairment was associated with worse glycemic control in adults with diabetes using a large nationally representative sample of older Americans with diabetes. We also assessed whether social support for diabetes care from family and friends modified the relationship between cognitive function and glycemic control.

METHODS

Conceptual Model of Glycemic Control in Diabetic Adults with Cognitive Impairment

The conceptual model underlying our analysis of glycemic control in diabetic adults with cognitive impairment is shown in Figure 1. We assume that medical comorbidities (e.g., strokes, congestive heart failure) and sociodemographic factors (e.g., age, education, race) are associated with impairment of memory and the other cognitive domains. Diabetic individuals with cognitive impairment may have difficulties performing daily tasks of diabetes self-care effectively, which may result in worse glycemic control compared to those without cognitive impairment. Depressed mood may be associated with cognitive impairment and may interfere with effective self-management.^{10–13} We hypothesized that adults with cognitive impairment who received help for diabetes self-care from family and friends would achieve better glycemic control.¹⁴ Very frail elderly individuals, especially those with limited life expectancy,

advanced cognitive impairment, or multiple comorbidities may have higher glycemic levels due to less intensive treatment goals.¹⁵

Data

We used data from the 2003 Health and Retirement Study (HRS) Mail Survey on Diabetes, and the 2002 and 2004 waves of the HRS. The HRS is a biennial longitudinal survey of a nationally representative cohort of more than 20,000 U.S. adults. It is sponsored by the National Institute on Aging and performed by the Institute for Social Research at the University of Michigan. The Mail Survey on Diabetes is a supplemental survey which collected self-reported questionnaire data on treatment and self-management of diabetes, and also collected a clinical biomarker of glycemic control: glycosylated hemoglobin (HbA1c). The survey questions were drawn from several sources, including validated instruments from the Michigan Diabetes Research and Training Center. The blood spot assays for HbA1c were performed by Flexsite Diagnostics, Inc. The diabetes survey was sent out to 2350 HRS respondents who reported having diabetes in the 2002 wave of the HRS. 1901 completed the survey (80.9% response rate), and 1285 completed the at-home HbA1c kits, of which 1233 yielded valid samples (52.5% response rate).^{16,17}

The HRS was approved by the Behavioral Sciences Committee institutional review board at the University of Michigan. The data used for this study are publicly available without unique identifiers to ensure respondent anonymity.

Variables and Their Measurement

Cognitive Function—The HRS assesses cognitive function using the 35-point HRS cognitive scale (HRS-cog) for self-respondents in each biennial wave. This is a modified version of the Telephone Interview for Cognitive Status, which is a cognitive screening instrument specifically designed for population-based studies.¹⁸ It includes an immediate and delayed 10-noun free recall test to measure memory; a serial seven subtraction test to measure working memory; a counting backwards test to measure speed of mental processing; an object naming test to measure knowledge and language; and recall of the date, the president, and the vice-president to measure orientation. Detailed information on the measures included in the HRS-cog, including their derivation, reliability, and validity, is available at the HRS website¹⁹. Prior research using the HRS-cog has shown that it is related to: limitations in ADLs and IADLs,²⁰ level of informal caregiving,²¹ likelihood of nursing home admission,²² and mortality.²³

Since the time from the survey date of the 2003 diabetes study to the interview of the 2004 HRS wave was much shorter than from the 2002 wave (mean duration, month (range): 7.5 (0–15) to the 2004 wave vs. 15.5 (8–24) to the 2002 wave), we used the cognitive data from the 2004 wave for the main analysis. We repeated the analyses using cognitive data from the 2002 wave as a sensitivity analysis. We characterized level of cognitive impairment by quartile of HRS-cog score (quartile 1, 0–18; quartile 2, 19–22; quartile 3, 23–25; quartile 4, 26–35).

Glycemic Control—The 2003 Diabetes Study collected HbA1c data using the Flexsite Diagnostics A1c at Home Test Kit (Flexsite Diagnostics, Inc., Palm Beach, FL), cleared by the U.S. Food and Drug Administration (FDA) for home use and over-the-counter sale in 1997.²⁴ The A1c at Home Test Kit has been evaluated against Diabetes Control and Complications Trial (DCCT) reference technology and extensively tested in the laboratory and in company-sponsored supplements to clinical trials. Glycemic control, as measured by HbA1c (higher values indicating worse glycemic control) was the dependent variable for the analysis. We categorized HbA1c into 3 ordinal levels (<7.0, 7.0–7.9, ≥8.0 mg/dl).

Sociodemographic Characteristics—Sociodemographic covariates included age (<65, 65–74, ≥75 years), sex, race (white, black, other), years of formal education (<12, 12, >12 years), annual household income (categorized by quartile, <\$17,500, \$17,500–35,000, \$35,001–70,000, ≥\$70,001), and health insurance (insured vs. uninsured).

Clinical Characteristics—Clinical characteristics variables included duration of diabetes (≤10, 11–20, >20 years), and diabetes treatment (no treatment, oral medications, insulin). The HRS Diabetes Study assessed severity and number of diabetes comorbidities using diabetes-related components of the Total Illness Burden Index (TIBI), a validated scale that ranges from 0 to 100.^{25,26} We characterized diabetes comorbidities by quartile of TIBI score. In the HRS 2002 and 2004 waves, depressive symptoms were assessed using 8 items adopted from the Center for Epidemiologic Studies-Depression Scale (CES-D).²⁷ We categorized CES-D score into 3 levels of depressed mood (0, no depressed mood; 1–3, mildly depressed mood; 4–8, moderately/severely depressed mood). We obtained data on functional disability (reported difficulties performing both basic and instrumental activities of daily living) from the HRS core survey. The activities of daily living (ADLs) assessed were dressing, bathing, eating, transferring and toileting. The instrumental activities of daily living (IADLs) assessed were preparing meals, grocery shopping, making telephone calls, taking medications, and handling finances.

Social Support for Diabetes Care—In the Diabetes Study, each respondent was asked 8 questions regarding diabetes-related social support drawn from the Diabetes Care Profile (DCP):²⁸ “How much would you agree that you can count on your family or friends to help and support you a lot with each particular diabetic care (following meal plan, taking medicine, taking care of feet, getting enough physical activity, testing sugar, going to the doctor or nurse, keeping weight under control, and handling feeling about diabetes)?” The possible responses to each question were: “strongly agree,” “agree,” “neither disagree nor agree,” “disagree,” or “strongly disagree.” Since 70–80% of the respondents reported either “agree” or “strongly agree” for each question, we counted the number of diabetic care practices for which the respondent reported “strongly agree” (10–30% of the respondents) to characterize significant social support, and categorized the responses into 3 levels of social support (0, low level; 1–5, intermediate level; 6–8, high level).

Understanding of Diabetes Knowledge—In the Diabetes Study, respondents were asked 10 survey questions drawn from DCP:²⁸ “How well do you understand each of the following areas of diabetes care?” The areas were “How to take your insulin or other medications,” “What each of your prescribed medications do,” “How to choose the food you should eat,” “How to read nutrition labels on food,” “How to exercise,” “How and when to test your blood sugar,” “How to care for your feet,” “What the complications of diabetes are,” “What to do for symptoms of low blood sugar,” and “What your target blood sugar values should be.” The possible responses to each question were: “understand completely,” “understand pretty well,” “it’s still a little confusing,” or “I don’t understand at all.” We counted the number of questions for which a respondent answered “understand completely” or “understand pretty well” (70–90% of the respondents) to characterize good understanding and categorized these responses into 3 levels of understanding (0–5, low level; 6–8, intermediate level; 9–10, high level).

Statistical Analysis—We compared all sample characteristics by the quartile level of cognitive function using the data obtained from the 2004 wave of the HRS and the 2003 Diabetes study. We then constructed bivariate ordered logistic regression models with ordinal groups of HbA1c level as the dependent variable to examine the unadjusted association of each characteristic with glycemic control. In order to assess confounding or mediating effects on the association between cognitive function and glycemic control, we added different sets of

independent variables (e.g. sociodemographic variables, social support for diabetes care, depressed mood, understanding score, functional disability, and diabetes comorbidities) to the bivariate model. We assessed the change in the odds ratio for higher HbA1c from the unadjusted model. To assess the extent of which level of social support for diabetes care modifies the risk of worse glycemic control among those with cognitive impairment, we examined associations of the twelve mutually exclusive groups categorized based on the level of cognitive function and social support with glycemic control in the fully adjusted model. We used adjusted odds ratios (ORs) to compare the relative strength of the association of each variable with glycemic control. In model checking, we verified that the proportional odds assumption was not violated by checking for the same odds ratio from two logistic regression models with dichotomized dependent variables indicating whether HbA1c level was 1) lower than 7.0 vs. 7.0 or higher; 2) lower than 8.0 vs. 8.0 or higher. The proportional odds assumption was statistically verified with the Score test.²⁹

To assess the robustness of the results, we repeated the same analysis using data from the 2002 wave of the HRS and compared the results with those from the analysis using 2004 data. We imputed independent variables which were missing for more than 10% of observations using proxy rating score of respondent memory for cognitive data and using the conditional mean imputation procedure and missing-value regressions in STATA for the other variables. Then, we compared the results with those from the complete case analysis. Imputation of respondent cognitive data by proxy rating score has been used in previous studies using the HRS.^{3,20} All analyses were weighted and adjusted for the complex sampling design (stratification, clustering, and nonresponse) of the HRS. STATA, version 10.1 (Stata Corp, College Station, TX) was used for data analysis. All reported *P* values are two-tailed, and a *P* value <0.05 was considered statistically significant.

RESULTS

Characteristics of the Study Population

Of the 1233 individuals with valid HbA1c samples, the HRS-cog score was missing for 136 (11%), so the resulting sample size was 1097. The characteristics of the study population by quartile level of cognitive function are shown in Table 1. These data were obtained from the 2004 wave of the HRS and the 2003 Diabetes study. Quartile 4 is individuals with the best cognitive function while quartile 1 is those with the worst cognitive function. Individuals with worse cognitive function were older, more likely to be African-American, less educated, uninsured, and lower-income. Their diabetes history tended to be longer than those with better cognitive function. In addition, diabetics with worse cognitive function tended to have more comorbid medical problems, more significant depressed mood, higher likelihood of receiving insulin therapy, and higher level of support for diabetes care from their family and friends.

Association with Glycemic Control

We performed bivariate ordered logistic regression analyses to examine the unadjusted association between each characteristic and the three ordinal levels of HbA1c (<7.0, 7.0–7.9, ≥8.0 mg/dl) (Table 2, first column). The cognition variables in the first four rows of the table represent the odds for a higher HbA1c level in each lower cognitive quartile group (quartile 3, 2, and 1) compared to the highest HRS-cog quartile group (quartile 4). Individuals with HRS-cog scores in the lowest quartile had significantly higher HbA1c level compared to those in the highest cognitive quartile (unadjusted OR, 2.08; 95% CI, 1.37–3.15). Non-white race (black or other), longer duration of diabetes, higher CES-D score (more significant depressed mood), and taking insulin were all associated with higher HbA1c level. Older age was associated with lower HbA1c level.

Figure 2 shows ORs and 95% confidence intervals of higher HbA1c level for the lowest-performing cognitive group (quartile 1) compared to the highest-performing cognitive group (quartile 4) derived using different ordered logistic regression models. We examined the change of the OR from the unadjusted model to the models adjusting for different independent variables to assess their confounding or mediating effects on the relationship between cognitive impairment and worse glycemic control. When adjusting for diabetes-related social support (the second line), the OR for worse glycemic control increased from 2.08 in the unadjusted model to 2.20, as the result of a high proportion of individuals receiving a higher level of social support in the lowest cognitive quartile and an association of higher level of social support with better glycemic control. Since depressed mood was significantly associated with both higher HbA1c level (unadjusted model in Table 2) and worse cognitive function (Table 1), the OR dropped from 2.08 to 1.77 when adjusting for depression (the third line). When adjusting for self-reported understanding score about diabetes knowledge (the fourth line), the OR dropped from 2.08 to 1.97, consistent with our hypothesis that understanding acts as a mediator between cognitive impairment and glycemic control. Adjusting for use of diabetes treatment (oral medicines and insulin) (the fifth line) reduced the OR significantly probably due to the high proportion of diabetics taking insulin in the lowest cognitive quartile (Table 1) and the strong association between use of insulin and higher HbA1c level (OR, 3.77). When we adjusted for functional disability and diabetes comorbidity (the sixth line), the OR dropped slightly from 2.08 to 1.96. In the fully adjusted model, the OR of worse glycemic control for the lowest-performing cognitive quartile remained significant (OR, 1.80; 95% CI, 1.11–2.92).

Value of Social Support for Diabetes Care

Figure 3 demonstrate the ORs for the risk of worse glycemic control for mutually exclusive groups categorized based on the level of cognitive function and social support for diabetes care. The ORs indicate risk for each group compared to the group with the best cognitive function and highest level of social support (OR=1.0 as reference). Among individuals in the worst cognitive quartile, the risk of worse glycemic control among those with a high level of social support was considerably lower compared to those with an intermediate level ($p=0.166$) and those with a low level of social support ($p=0.016$). We found a significant trend of lower risk with higher levels of social support in this cognitive group (the test for trend, $p=0.018$).

Sensitivity Analysis

Some of the independent variables included in the analyses (e.g. HRS-cog score, social support for diabetes care, duration of diabetes, and self-reported diabetes understanding score) were missing in more than 10% of observations. For the 11.0% of individuals represented by a proxy, we imputed cognitive function using a proxy rating of respondent memory in a manner similar to previous studies,^{3,20} and imputed the other variables using a conditional mean imputation procedure and missing-value regressions in Stata. For the conditional mean imputation, we used the mean value of the other respondents' observations by each cognitive level. The analyses using these imputation procedures generated similar results as in the complete case analysis.

We also repeated the analysis using data on cognitive function and depressive symptoms from the 2002 wave of the HRS (rather than the 2004 wave) to check the robustness of the results. We obtained similar results for the relationship between cognitive impairment and worse glycemic control (adjusted ORs of higher HbA1c for cognitive quartile 3, 2 and 1 compared to quartile 4 were 1.02, 1.01, and 1.47 ($p=0.144$), respectively).

DISCUSSION

In a nationally-representative sample of U.S. adults, we found that cognitive impairment was associated with worse glycemic control among those with diabetes. In particular, individuals in the worst quartile of cognitive function had significantly higher risk of poor glycemic control compared to the highest cognitive function quartile, independent of sociodemographic characteristics and other clinical factors. We also found that, among those with poor cognitive function, a high level of social support for diabetic care significantly ameliorated the risk of worse glycemic control. Consistent with prior studies,^{10,13} those with depressed mood had higher risk of poor glycemic control, independent of cognitive impairment and level of social support. To our knowledge, this is the first population-based study to examine an association between cognitive function and glycemic control in adults with diabetes, and the modifying effects of a high level of social support on this association.

Effective self-management of diabetes often requires the coordination of multiple daily tasks requiring complex cognitive functioning. Potential mechanisms leading from worse cognitive function to worse glycemic control may include difficulties with: 1) learning and retaining new diabetes knowledge and self-care skills; 2) recognizing the importance of diabetic self-care; 3) planning and organizing daily tasks for glycemic control; and 4) motivation to adhere to self-care plans. Panja et al suggested that understanding of diabetes knowledge was associated with self-management behaviors and glycemic control in diabetics.³⁰ We found that the risk of poor glycemic control for diabetics in the lowest cognitive function quartile remained high even after adjusting for self-reported understanding score of diabetes knowledge. This suggests that understanding and knowledge may be necessary, but not sufficient for successful diabetic self-care,³¹ which is also consistent with other studies suggesting the association of health literacy,⁸ numeracy,⁹ and impairment of executive control function with diabetes management.^{5,7}

Numerous studies have examined the relationship of diabetes and poor glycemic control to the risk for the development or progression of cognitive impairment, though the causal mechanisms are still unclear.^{32–38} We hypothesized that cognitive impairment leads to poor glycemic control due to less effective diabetes self-management. This hypothesis is supported by our findings both that individuals with low levels of cognition reported higher levels of social support for their diabetes care than those with normal cognition, and that higher levels of social support ameliorated the negative relationship between cognitive function and glycemic control. Prior studies have suggested that social support is associated with better performance of self-care tasks, but not with better glycemic control.^{39,40} This is consistent with our finding that social support for diabetes care was a modifier of the relationship between cognitive function and glycemic control. The results of our study support a recent Institute of Medicine report that highlighted the importance of increased caregiver involvement in chronic illness management for older adults.⁴¹

The strengths of our study include its nationally representative sample of U.S. adults and direct measures of cognitive function and HbA1c. We were able to use important clinical and social information specific to diabetes care obtained from the population-based disease-specific survey. This study also has a number of potential limitations that should be considered when interpreting the results. The HRS-cog has been used consistently in the HRS; however, it has not been calibrated and validated with other commonly-used cognitive scales. A recently completed dementia substudy of the HRS – the ADAMS – administered both the MMSE and HRS-cog to each respondent, so future analyses of these data will allow a calibration and validation of the instrument. For reliability of the cognition test, we repeated the analysis using cognition data from two waves of the HRS two years apart and the results were consistent. Some of the independent variables were based on respondent self-report and thus may be

subject to response bias. While there was some missing data in our study, the results were robust even after repeating the analysis using several different imputation procedures. The difference in timing between the 2003 Diabetes study and the 2002 and 2004 waves of the HRS may have resulted in some measurement error, since the clinical characteristics (e.g. HbA1c, cognitive function, depressed mood) and associated diabetes survey responses may have changed over time. Since this is a cross-sectional study, we can not be sure of the direction of causality between cognitive impairment and glycemic control.

In summary, our findings suggest that cognitive impairment is associated with worse glycemic control in older adults with diabetes, but the presence of a high level of social support for diabetes care may ameliorate this negative relationship. A comprehensive geriatric assessment aimed at identifying the presence of cognitive impairment, depressed mood, and level of social support may be important to identify older adults with diabetes who are at risk for poor glycemic control and need additional support for their diabetic care. The growing number of older adults with diabetes makes targeting interventions to improve glycemic control an especially important public health goal.

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Abbreviation: HbA1c, glycosylated hemoglobin A1c.

Figure 1.
Conceptual Model of Glycemic Control in Diabetic Adults with Cognitive Impairment

Note. *OR indicates the odds ratio of higher HbA1c for the worst cognitive quartile (quartile 1) compared to the best cognitive quartile (quartile 4). ORs greater than 1 indicate increased odds of worse glycemic control. Whiskers indicate 95% confidence intervals.

Figure 2.

Change of Strength of Association between the Worst Cognitive Quartile and Worse Glycemic Control after Adjusting for Different Independent Variables

Note. *Adjusted ORs derived by using an ordered logistic regression model with HbA1c level (<7.0, 7.0-7.9, $\geq$ 8.0 mg/dl) as the dependent variable. The ORs indicate a relative strength of risk for the groups categorized based on the level of cognitive function and social support for diabetes care compared with the group of the best cognition function and the highest level of social support (OR=1.0 as reference). The number on the front side of the bar indicates OR for each group and 95% confidence intervals are in the parentheses. The number on top of the bar indicates the sample size.

Figure 3.
Odds Ratios for Risk of Worse Glycemic Control by Level of Cognitive Function and Social Support for Diabetes Care

Table 1

Respondent Characteristics by Quartile of Performance on the HRS Cognitive Scale

Variable	All Respondents	HRS Cognitive Scale, Weighted %				P-Value [*]
		Quartile 4 (Best)	Quartile 3	Quartile 2	Quartile 1 (Worst)	
Sample (Weighted %)	1,097(100)	229(19)	275(23)	310(29)	283(29)	
Age (y)						
≤64	342(37)	88(47)	71(30)	96(39)	87(36)	<0.001
65 to 74	450(34)	103(36)	143(47)	120(31)	84(24)	
≥75	305(29)	38(17)	61(23)	94(30)	112(40)	
Gender						0.609
Male	523(48)	109(48)	132(49)	162(50)	120(45)	
Female	574(52)	120(52)	143(51)	148(50)	163(55)	
Race						<0.001
White	879(80)	202(87)	246(89)	246(82)	185(67)	
Black	164(14)	18(7)	23(8)	44(12)	79(26)	
Other	54(6)	9(6)	6(3)	20(6)	19(7)	
Education (y)						<0.001
< 12	316(30)	19(9)	46(15)	98(32)	153(54)	
= 12	375(33)	69(33)	109(38)	108(33)	89(30)	
> 12	406(37)	141(58)	120(47)	104(35)	41(16)	
Annual Household Income (\$)						<0.001
< 17,500	275(28)	31(15)	46(17)	77(29)	121(46)	
17,500 to 35,000	325(28)	49(20)	96(33)	86(26)	94(30)	
35,001 to 70,000	336(30)	93(41)	86(33)	100(29)	57(20)	
>70,000	161(14)	56(24)	47(17)	47(16)	11(4)	
Uninsured	32(3)	4(1)	3(0)	10(4)	15(6)	<0.001
Duration of Diabetes (y)						<0.001
≤10	528(56)	139(70)	142(61)	138(53)	109(46)	
11 to 20	226(25)	42(18)	62(27)	68(28)	54(24)	
≥21	163(19)	25(12)	27(12)	51(19)	60(30)	
Diabetes Treatment						

Variable	HRS Cognitive Scale, Weighted %					P-Value*
	All Respondents	Quartile 4 (Best)	Quartile 3	Quartile 2	Quartile 1 (Worst)	
No medication	151(15)	43(22)	53(23)	36(11)	19(9)	<0.001
Oral medications	719(72)	164(70)	194(68)	227(74)	206(75)	0.416
Insulin	256(25)	45(19)	44(16)	72(27)	95(34)	<0.001
Diabetes Comorbidities (TIBI Score)						<0.001
Quartile 1	238(19)	69(28)	68(22)	61(19)	40(12)	
Quartile 2	297(27)	55(21)	75(30)	94(32)	73(25)	
Quartile 3	273(24)	57(30)	73(24)	72(21)	71(22)	
Quartile 4	289(30)	48(21)	59(24)	83(28)	99(41)	
No. of ADL Limitations						<0.001
0	847(74)	196(81)	217(76)	242(77)	192(63)	
1 to 2	192(19)	28(16)	52(21)	56(18)	56(23)	
3 to 5	58(7)	5(3)	6(3)	12(5)	35(14)	
No. of IADL Limitations						<0.001
0	903(80)	215(93)	236(84)	257(81)	195(66)	
1 to 2	163(16)	13(7)	33(14)	49(16)	68(25)	
3 to 5	31(4)	1(0)	6(2)	4(3)	20(9)	
Depressed Mood (CES-D Score (0–8))						<0.001
No (0)	432(36)	110(43)	137(47)	119(38)	66(20)	
Mild (1–3)	475(45)	95(45)	107(42)	141(48)	132(46)	
Moderate/severe (4–8)	190(19)	24(12)	31(11)	50(14)	85(34)	
Social Support (Diabetes-related Social Support Score (0–8))						0.05
Low Level (0)	664(63)	145(66)	168(68)	189(63)	162(59)	
Intermediate Level (1–5)	245(23)	47(23)	59(21)	77(25)	62(21)	
High Level (6–8)	143(14)	25(11)	30(11)	36(12)	52(20)	
Understanding (Self-reported Understanding Score (0–10))						0.304
Low Level (0–5)	146(13)	24(9)	37(15)	41(13)	44(16)	
Intermediate Level (6–8)	244(25)	52(26)	55(24)	70(22)	67(27)	
High Level (9–10)	674(62)	146(65)	175(61)	193(65)	160(57)	

Note. The data were obtained from the 2004 wave of the Health and Retirement Study and the 2003 Diabetes Study. Values in parentheses are weighted percentages derived by using the study population weights to adjust for the complex sampling design of the HRS survey.

Abbreviation: HRS, Health and Retirement Study. TIBI, Total Illness Burden Index. ADL, activity of daily living. IADL, instrumental activity of daily living. CES-D, Center for Epidemiologic Studies Depression.

* P-values were derived from the χ^2 test for association between the indicated variable and cognitive quartile levels.

Table 2**Odds Ratios for Risk of Worse Glycemic Control**

Variable	Unadjusted Model	Fully Adjusted Model
	OR* (95% CI)	OR* (95% CI)
Cognitive Function		
Quartile 4 (Best)	Reference	Reference
Quartile 3	1.10 (0.70–1.73)	1.29 (0.79–2.10)
Quartile 2	1.36 (0.90–2.06)	1.22 (0.75–2.00)
Quartile 1 (Worst)	2.08 (1.37–3.15)	1.80 (1.11–2.92)
Age, per Level	0.84 (0.70–1.00)	0.76 (0.63–.091)
Female Sex	1.05 (0.80–1.37)	1.14 (0.79–1.63)
White Race	Reference	Reference
Black Race	2.05 (1.34–3.14)	1.50 (0.96–2.34)
Other Race	3.33 (1.90–5.83)	2.89 (1.49–5.60)
Education, per Level	0.89 (0.75–1.05)	1.05 (0.84–1.31)
Annual Household Income, per Level	0.92 (0.80–1.05)	1.10 (0.93–1.29)
Uninsured	0.89 (0.45–1.77)	0.77 (0.34–1.75)
Duration of Diabetes, per Level	1.65 (1.39–1.97)	1.70 (1.40–2.07)
Social Support for Diabetes Care		
High Level	Reference	Reference
Intermediate Level	1.37 (0.84–2.23)	1.50 (0.82–2.74)
Low Level	1.31 (0.86–1.98)	1.41 (0.83–2.41)
Depressed Mood		
No	Reference	Reference
Mild	1.61 (1.21–2.13)	1.54 (1.09–2.18)
Moderate/Severe	2.40 (1.61–3.57)	2.42 (1.48–3.97)
Diabetes Understanding		
Low Level	Reference	Reference
Intermediate Level	1.20 (0.69–2.07)	0.83 (0.46–1.49)
High Level	1.06 (0.69–1.64)	0.87 (0.49–1.55)
Hyperglycemic Treatment		
Oral Medicines	1.21 (0.81–1.81)	N/A
Insulin	3.77 (2.84–5.00)	N/A
Functional Limitations		
ADL Limitations	1.04 (0.90–1.20)	N/A
IADL Limitations	1.08 (0.93–1.25)	N/A
Diabetes Cormorbidity		
TIBI Score, per Quartile	1.24 (1.09–1.41)	N/A

* Note. Odds Ratios derived by using an ordered logistic regression model with HbA1c level (<7.0, 7.0–7.9, ≥8.0 mg/dl) as the dependent variable. ORs greater than 1 indicate increased odds of worse glycemic control. 95% confidence intervals are in parentheses.

Abbreviation: ADL, activity of daily living. IADL, instrumental activity of daily living. TIBI, Total Illness Burden Index.