

The Association of Diabetes, Comorbidities, and Hemoglobin A1c with Functional Disability in Older Adults: Results from the National Health and Nutrition Examination Survey (NHANES), 1999-2006

Running Title: Diabetes And Functional Disability In Older Adults

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Objectives: To examine the relationship of diabetes and functional disability in older adults and the possible mediating roles of comorbidities and hemoglobin A1c (A1c).

Research Design and Methods: We analyzed data from a nationally representative sample of 6097 participants aged ≥ 60 years in the National Health and Nutrition Examination Survey 1999-2006. Diabetes was defined by self-report. Disability was defined as difficulty performing a physical task. We evaluated disability by grouping 19 physical tasks into five functional groups: lower extremity mobility (LEM), general physical activities (GPA), activities of daily living (ADL), instrumental activities of daily living (IADL), leisure and social activities (LSA).

Results: Older U.S. adults with diabetes had the greatest disability in GPA (prevalence 73.6%, 95% CI 70.2-76.9), followed by LEM (52.2%, 48.5-55.9), IADL (43.6%, 40.1-47.2), ADL (37.2%, 33.1-41.3), and LSA groups (33.8%, 30.8-36.9). Diabetes was associated with 2 – 3 times increased odds of disability across functional groups (all $p < 0.05$). Comorbidities, mostly cardiovascular disease and obesity, and poor glycemic control ($A1c \geq 8\%$) together explained up to 85% of the excess odds of disability associated with diabetes, while poor glycemic control alone only ~10% of the excess odds. Adjustment for comorbidities, A1c and diabetes duration fully attenuated the associations of diabetes with disability in all functional groups (all $p > 0.05$).

Conclusions: Older adults with diabetes have a high prevalence of disabilities with variable associations attributable to comorbidities and A1c. Aggressive management of cardiovascular risk factors and obesity may significantly reduce the burden of disability in this population.

In the year 2005, over 2 million adults with diabetes in the United States reported having disability (1). Adults with functional disability consume a disproportionate share of health services and are at high risk for dependence, hospitalizations, and death (2,3). Approximately one-third of adults over the age of 65 have diabetes (46% undiagnosed) and, by the year 2030, the elderly will constitute almost 20% of the U.S. population (4,5). Consequently, understanding the factors contributing to functional disability in older adults with diabetes has important clinical and public health implications.

Functional disability, defined as difficulty in performing routine physical tasks, is more common in older adults with diabetes compared to those without diabetes (6-12). Older adults with diabetes have significantly greater difficulty walking a quarter mile, climbing stairs, or doing housework and perform worse on measures of physical performance such as walking speed, muscle strength, chair stands, and tandem stand compared to their counterparts (6-12).

The higher prevalence of functional disability in older adults with diabetes may be a result of diabetes-related comorbidities such as cardiovascular disease, vision loss, obesity, and arthritis (6-12) or poor glycemic control (8,13). However, these factors do not consistently explain the association of diabetes with disability. This inconsistency in the literature may be due to variability in the measures of disability studied or the limited number of physical tasks and comorbidities examined. Previous studies have not specifically addressed the relative associations of comorbidities and glycemic control with disability among older adults with diabetes, or whether these associations differ according to the type of physical task examined. Furthermore, the association of

diabetes with leisure or social difficulties in older adults remains poorly described.

The objectives of the present study were to: (1) compare the prevalence of disability in adults with and without diabetes; (2) assess the relative associations of individual comorbidities and poor glycemic control to the excess disability observed among older adults with diabetes; and (3) determine the independent association of diabetes and disability across a wide range of physical tasks, after accounting for comorbidities and hemoglobin A1c (A1c), in a nationally representative sample of older adults.

RESEARCH DESIGN AND METHODS

Study population: The National Health and Nutrition Examination Survey (NHANES) is a large, cross-sectional survey conducted by the National Center for Health Statistics (NCHS) designed to provide nationally representative estimates of health and disease in the U.S. civilian non-institutionalized population. Details regarding data collection in NHANES are available elsewhere [<http://www.cdc.gov/nchs/nhanes.htm>].

The present study was based on NHANES data collected from 1999-2006. In total, there were 39,352 participants in NHANES 1999-2006. There were 6,472 adults aged 60 or older who completed both a questionnaire and a physical examination. We excluded participants who were missing information on diabetes status (n=5), education (n=26), body mass index (n=338), or smoking history (n=6). Thus, our study sample consisted of 6,097 adults aged ≥ 60 years.

Assessment of diabetes: Diabetes was defined by either self-report of a physician diagnosis or insulin use. Only adults who self-reported a history of diabetes were also asked about non-insulin glucose-

lowering medication use. Duration of diabetes was assessed by questionnaire.

Assessment of disability: The interviewer posed questions about physical functioning and asked all participants ≥ 20 years old about difficulties doing certain physical tasks because of any long-term physical, mental, and emotional problems or illness and without the use of any special equipment. A total of 19 physical tasks were assessed and derived from well-validated questionnaires (14-17). Participants were given the option of answering “no difficulty”, “some difficulty”, “much difficulty”, or “unable to do”. The 19 physical tasks were categorized into five functional groups according to published definitions (18). The groups included: *lower extremity mobility* (LEM; walking a quarter mile, walking up ten steps); *general physical activity* (GPA; stooping/crouching/kneeling, standing for 2 hours, sitting for 2 hours, standing up from an armless chair, reaching overhead, grasping/holding small objects, lifting or carrying 10 lbs); *activities of daily living* (ADL; eating, dressing, getting out of bed, walking between rooms on the same floor); *instrumental activities of daily living* (IADL; managing money, doing household chores, preparing meals); and *leisure and social activities* (LSA; going to movies/shopping/events, doing leisure activities at home, participating in social activities).

The primary outcome was functional disability, defined as any difficulty in a physical task, consistent with prior studies (6, 10-12). We also assessed difficulties with fall, dizziness, or balance (1999-2004 only); need for special assistance with walking or special equipment such as a cane, wheelchair, special bed, or special telephone; and having a disability that prevented the participant from working.

Assessment of demographics and comorbidities: Information on age, sex,

race/ethnicity, and smoking was ascertained from the questionnaire portion of the survey. History of arthritis, coronary heart disease (CHD, including history of angina or heart attack), stroke, congestive heart failure (CHF), chronic obstructive pulmonary disease (COPD, including emphysema or chronic bronchitis), and cancer (excluding non-melanoma skin cancer) was also self-reported. We defined visual impairment as self-reported trouble seeing despite wearing glasses or contact lenses. Participants self-reported if they were limited in any way because they have “difficulty remembering” or “experience periods of confusion”. Only participants from 1999-2004 were asked about self-reported history of: 1) hearing difficulties, 2) leg or foot ulcer that took more than four weeks to heal, and 3) hip fracture.

Height, weight, waist circumference and blood pressure were measured. Obesity was defined as a body mass index ≥ 30 kg/m². Hypertension was defined as an average blood pressure of ≥ 140 mmHg (systolic) or ≥ 90 mmHg (diastolic), anti-hypertensive medication use, or self-reported physician diagnosis. Hypercholesterolemia was defined as total cholesterol > 240 mg/dL, use of cholesterol lowering medications, or self-reported physician diagnosis. Chronic kidney disease (CKD) was defined as estimated glomerular filtration rate < 60 mL/min/1.73 m². We defined peripheral arterial disease (PAD) as an ankle-brachial index < 0.90 in either leg, and peripheral neuropathy as ≥ 1 insensate areas in either foot as assessed by monofilament testing (1999-2004 only). Amputations were documented after physical examination.

Measurement of hemoglobin A1c: A1c measurements were performed by the Diabetes Diagnostic Laboratory at the University of Missouri-Columbia using Primus CLC330/CLC 385 (Primus Corporation, Kansas City, MO) for 1999-2004 and by the Diabetes Laboratory at the

University of Minnesota using Tosoh A1c 2.2 Plus Glycohemoglobin Analyzer (Tosoh Medics, San Francisco, CA) for 2005-2006. Both assays are DCCT-aligned.

Statistical analysis: All analyses were performed using StataSE (version 10.0; StataCorp College Station, TX) and incorporated population-based sampling weights (6- or 8-year combined weights) to obtain unbiased, nationally representative estimates from the complex NHANES sampling design. Standard errors for all estimates were obtained using the Taylor series (linearization) method following NCHS-recommended procedures (19).

The Wald test was used to compare differences in baseline characteristics by diabetes status. We calculated the excess odds of disability conferred by individual comorbidities and suboptimally controlled glucose (A1c $\geq 8\%$) for each functional group as $[(\text{Odds ratio (OR)}_{\text{adjusted}} - \text{OR}_{\text{base}}) / (\text{OR}_{\text{base}} - 1)] \times 100$; where the base model was adjusted for age, gender, race/ethnicity, education, smoking and diabetes while the adjusted model was also adjusted for individual comorbidities or A1c $\geq 8\%$.

Logistic regression models were created to assess the independent association of diabetes with disability in each functional group as follows: Model 1 was adjusted for diabetes and demographic factors (age, gender, race/ethnicity, education, smoking history); Model 2 was adjusted for model 1 + A1c; Model 3 was adjusted for model 2 + A1c + diabetes duration; Model 4 was adjusted for model 3 + cardiovascular disease and risk factors (CHD, CHF, stroke, hypertension, high cholesterol) + obesity (BMI ≥ 30 kg/m²) + waist circumference; Model 5 was adjusted for model 4 + other diabetes-related comorbidities (leg ulcer, CKD, visual or hearing impairment, memory problems, hip fracture, arthritis, COPD, cancer). Because information on important comorbidities

(hearing impairment, leg ulcer, hip fracture) was not assessed in all years, we conducted regression analyses limited to data from the 1999-2004 survey. We excluded PAD and peripheral neuropathy from this analysis since these were not ascertained on all participants. We performed an F-adjusted mean residual test to assess goodness of fit.

We performed additional analyses to explore correlation between continuous covariates and potential effect modification of the association between diabetes and disability by sex, race/ethnicity or age group (60-69 years, 70-79 years, ≥ 80 years). We also investigated whether prevalence of disability differed by survey year. Sensitivity analyses were performed to examine whether the association between diabetes and disability was similar when disability was defined as inability in a physical task. Among older adults with diabetes, we further explored whether glycemic control (A1c $\geq 8\%$ vs $< 8\%$), duration of diabetes (< 5 , 5-10, ≥ 10 years), or insulin use was independently associated with disability in logistic regression models.

RESULTS

The prevalence of self-reported diabetes in U.S. adults aged ≥ 60 years was 16.2% (95% CI 15.2-17.2%), with no significant secular trends across survey periods. Diabetes was significantly more common in non-Hispanic blacks and Mexican Americans, people with higher BMI or waist circumference and lower attained education level, and non-smokers (Table 1). The mean A1c of older adults with diabetes was 7.1%. Most took oral medications alone, although 26.2% took insulin, including 10.8% on combined therapy. The mean diabetes duration was 13.8 years.

Older adults with diabetes had a greater burden of comorbidities than adults without diabetes. This included a significantly higher prevalence of CHD, CHF,

stroke, hypertension, hypercholesterolemia, neuropathy, PAD, leg ulcers or amputations, visual or hearing impairment, memory problems, obesity and arthritis. CKD prevalence was slightly higher in the diabetes group, but not statistically significant when compared to the no diabetes group.

Older adults with diabetes were more likely to report difficulty performing tasks in each functional group when compared to older adults without diabetes; we did not find significant secular trends or evidence for effect modification by sex, race/ethnicity, or age group. Thus, overall results are presented (online appendix Figure 1, which is available at <http://care.diabetesjournals.org>). Among older adults with diabetes, the greatest difficulty was in GPA (prevalence 73.6%, 95% CI 70.2-76.9), followed by LEM (52.2%, 48.5-55.9), IADL (43.6%, 40.1-47.2), ADL (37.2%, 33.1-41.3), and LSA groups (33.8%, 30.8-36.9). Diabetes was significantly associated with having difficulty in at least one functional group after adjustment for demographic factors (adjusted OR 1.94, 1.57-2.40; prevalence 76.9%, 95% CI 73.4-80.3).

When taken together, comorbidities and suboptimally controlled glucose (A1c $\geq 8\%$) were associated with: 59% (ADL), 72% (IADL), 79% (GPA), and 85% (LEM, LSA) of the excess odds of disability observed in older adults with diabetes. Cardiovascular disease (including CHD, CHF and stroke) and obesity together were associated with: 37% (ADL), 40% (IADL), 53% (GPA, LEM), and 46% (LSA) of the excess odds of disability associated with diabetes across functional groups. Suboptimally controlled glucose alone was associated with: 0% (IADL), 5% (LEM, ADL), 9% (LSA), and 10% (GPA) of the excess odds of disability.

In logistic regression models, diabetes was associated with significantly higher odds of disability across all functional groups after adjustment for demographic factors (adjusted ORs ranged from 1.97 to 2.53, all $p < 0.05$,

Table 2, Model 1). Adjustment for A1c and diabetes duration moderately attenuated these associations, but they remained statistically significant across all groups (Table 2, Models 2 and 3). However, adjustment for cardiovascular disease and obesity largely attenuated the ORs (Table 2, Model 4), and further adjustment for other comorbidities resulted in non-significant associations between diabetes and disability in all functional groups (Table 2, Model 5). An overall F-adjusted test statistic of 0.70 ($p = 0.71$) represented good model fit.

Odds ratios for the association of other covariates including demographics, A1c, diabetes duration, and comorbidities with disability in fully adjusted models (as described in Table 2, Model 5) across functional groups are provided in online appendix Table 1. Among older adults, the odds ratios for diabetes are weaker than those for comorbidities such as hip fracture, arthritis, and memory problems which all have adjusted ORs > 2 . However, because the odds ratios for these conditions (in particular memory problems) were self-reported, they may not be as reliable. In addition, visual impairment, hearing difficulties and COPD were associated with significantly greater disability across all groups (adjusted ORs ranged between 1.46 – 2.44; all $p < 0.05$). In contrast, the odds ratios for CHD and stroke were weaker and non-significant ($p > 0.05$) for most but not all groups.

In sensitivity analyses, when disability was defined as inability to perform a task, we found that diabetes remained significantly associated with disability across functional groups as follows: LEM (demographics adjusted OR 2.91, 95% CI 2.39-3.54); GPA (2.64, 2.14-3.27); ADL (3.93, 2.39-6.47); IADL (2.58, 1.87-3.56); and LSA (3.67, 2.54-5.31).

Diabetes was also associated with an increased odds of having a history of falls, dizziness, or balance problems (adjusted OR

1.75, 95% CI 1.40-2.19; prevalence 40.3%, 95% CI 35.6-44.9), needing special assistance or an assistive device (adjusted OR 2.60, 2.02-3.35; prevalence 22.7%, 18.9-26.5) or having a disability that prevented the participant from working (adjusted OR 2.12, 1.80-2.51; prevalence 27.1%, 23.7-30.5) after adjustment for demographic factors.

Among older adults with diabetes, we found that neither glycemic control, insulin use, nor duration of diabetes was significantly associated with disability in any functional group after adjustment for demographics and comorbidities (all $p > 0.05$).

CONCLUSIONS

Our results suggest that older community-dwelling U.S. adults with diagnosed diabetes are more likely to have difficulties in each of the five physical functioning groups and a significantly higher prevalence of comorbidities compared to adults without diabetes. Adjustment for A1c, diabetes duration, and comorbidities fully attenuated the association of diabetes and disability in all functional groups. Together, A1c and comorbidities accounted for up to 85% of the excess odds of disability, largely due to cardiovascular disease and obesity, while poor glycemic control ($A1c \geq 8\%$) alone only accounted for up to 10% of the excess odds of disability associated with diabetes across all groups.

Our findings are consistent with previous studies that also reported a 2-3 times greater odds of difficulty in performing mobility, upper extremity, ADL and IADL tasks among older adults with diabetes compared to adults without diabetes (6-12). The prevalence of disability we report is consistent with findings in other nationally representative samples of similar age (6). We also found a high degree of difficulty in performing leisure and social activity tasks, which has not been examined in previous studies. However, we found that our results

were similar when we defined disability as inability in a physical task, a more specific measure.

In addition, past studies did not explore the relative associations of multiple comorbidities and poor glycemic control to the relationship between diabetes and disability nor examine whether these associations varied by type of task, which were both important aims of our study. Comorbidities contribute greatly to the health-related quality of life in adults with diabetes, although social and environmental factors are likely also important. Glycemic control is an important goal of diabetes management although higher A1c targets (e.g. $A1c < 8\%$) may be reasonable in an older population (20). Our data suggest that, in contrast to poor glycemic control ($A1c \geq 8\%$), comorbidities are more greatly associated with excess disability in diabetes across all functional groups. In contrast, De Rekeneire *et al.* (2003) and Bossoni *et al.* (2008) reported that poor glycemic control was significantly associated with the excess subclinical LEM limitations and IADL disability observed in diabetes (8, 13). Diabetes duration was also associated with disability in our study, similar to previous reports (6). We found that the greater difficulties in LEM, GPA, ADL and IADL groups observed in older adults with diabetes compared to those without diabetes are largely associated with comorbidities, and corroborate prior findings that diabetes-associated cardiovascular disease and obesity are associated with much of the excess disability observed in these tasks (6, 7, 11). Interestingly, the higher prevalence of disability we report in leisure and social activities among older adults with diabetes was also largely associated with prevalent comorbidities.

Diabetes may be associated with functional disability through mechanisms linked to decreased cardiopulmonary reserve,

restricted physical movement, inflammatory/sarcopenic processes, extremes of blood glucose, or inflexible treatment regimens. We confirm that older adults with diabetes have a high burden of cardiovascular disease and obesity; both these conditions are associated with limited cardiopulmonary reserve and exercise tolerance. Further, other prevalent comorbidities in adults with diabetes such as visual impairment or stroke may restrict physical movement and participation in routine activities. Decreased muscle strength, lower muscle quality, and accelerated loss of muscle mass, especially in the lower extremities, have all been documented in people with diabetes (21).

Through these mechanisms, older adults with diabetes may be more likely to develop frailty (22), a clinical condition in which an older individual is coping just above the disability threshold, but is liable to become disabled in response to a physiologic or psychologic stressor. Hyperglycemia may activate inflammatory pathways that subsequently cause muscle catabolism and disability as part of the frailty process (21-22). On the other hand, physical and cognitive impairment may lead to difficulties in diabetes self-management and subsequent hyperglycemia; thus, the relationship between hyperglycemia and disability is potentially bidirectional. Due to limitations of the study design, we were unable to address the directionality of the observed associations. A1c may also reflect health care access, patient self-management, and physician prescribing practices. Support for an association between hyperglycemia and disability comes from previous studies reporting a significant correlation between higher A1c levels and disability (8, 13). However, our findings suggest that among older adults with diagnosed diabetes, poor glycemic control is not greatly associated with the excess disability observed. Interestingly, even among a population of

older adults with diabetes and relatively well-controlled glucose levels such as ours, there exists a significantly increased risk of falling, balance, and dizziness difficulties when compared to older adults without diabetes. Further, restrictive treatment regimens, especially for patients on insulin, may be associated with greater difficulty participating in leisure activities.

A strength of our study is the evaluation of disability in diabetes across different functional groups. Fried *et al.* (1994) previously provided a strong rationale for categorizing physical tasks into functional groups (23), and self-reported physical functioning has been demonstrated to be a reliable measure (24). Our study was based on difficulty in 19 individual tasks, including leisure and social activities, which has not been ascertained in most previous studies. This comprehensive assessment allowed us to explore the association of diabetes-related comorbidities and A1c with disability in each functional group. Other strengths of our study include the rigorous data collection procedures in NHANES and the ability to generate nationally representative estimates, which allows for comparison to other studies that used national samples (6).

Limitations of our study include the cross-sectional design, which does not permit us to draw conclusions regarding the temporality of the observed associations and renders our study vulnerable to survival bias. Persons with diabetes are more likely to die at younger ages as compared to their counterparts without diabetes and may be systematically missing from this study of older adults (survival bias). Also, NHANES does not include institutionalized persons who likely have a more severe and higher prevalence of disability than the general population. As a result, the prevalence of disability may be underestimated in our study.

While highly specific for most outcomes, self-reported information for

cardiovascular disease and other comorbidities is a limitation and likely underestimates the true prevalence of these conditions. This is of particular concern for our measure of cognitive function; the critical relationship between cognitive impairment and disability cannot be fully accounted for in this study and is a crucial area where additional work is needed. Subclinical or undiagnosed cases of disease are also not captured by these self-reported measures. In particular, subclinical cardiovascular disease is likely prevalent among older adults with diabetes but may be missed by self-reported measures. Because this study focused on diagnosed diabetes, individuals with undiagnosed disease are included in the no diabetes group. Those with undiagnosed diabetes likely have disability intermediate between that of individuals with diagnosed diabetes and without true diabetes; consequently, the prevalence of disability in both groups (diabetes, no diabetes) may be overestimated in our study. Analyses using different definitions of diabetes may result in different findings. Furthermore, diabetes in the older adult population is heterogeneous and includes individuals with both middle-age and elderly-onset diabetes; the latter group has been shown to have a lower burden of complications, especially microvascular disease (25), and has less disability in our study (data not shown).

In summary, there is growing recognition that the presence of functional disability significantly influences the clinical care of older adults with diabetes. Our data demonstrate that older adults with diabetes have a high prevalence of disabilities, across a range of physical tasks, with variable associations attributable to diabetes-related comorbidities and A1c. Our results suggest that cardiovascular disease and obesity, in particular, are associated with a greater burden of disability in this population, while the association of hyperglycemia with

disability needs further investigation. Future studies which examine the prospective association of diabetes and disability should provide greater insight into the direction of this relationship; in particular, how diabetes leads to disability and how disability, in turn, can lead to worsening hyperglycemia.

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Table 1: Nationally representative demographic and clinical characteristics of older adults with and without diabetes, NHANES 1999 – 2006

	History of Diagnosed Diabetes (n=1166) % ± SE [†]	No History of Diagnosed Diabetes (n=4931) % ± SE [†]	<i>p value</i>
Demographics			
Age group			<0.001
60 – 69 years	50.6 ± 0.2	48.0 ± 0.1	
70 – 79 years	36.0 ± 0.2	34.2 ± 0.1	
≥ 80 years	13.4 ± 0.1	17.8 ± 0.1	
Mean age (years)	70.4 ± 0.3	70.9 ± 0.2	0.05
Male gender	54.9 ± 1.8	56.3 ± 0.7	0.48
Race/ethnicity*			<0.001
White	72.0 ± 2.2	84.0 ± 1.3	
Black	13.3 ± 1.4	7.2 ± 0.8	
Mexican-American	5.6 ± 1.0	2.8 ± 0.5	
Education level (< high school)	36.9 ± 1.9	27.0 ± 1.3	<0.001
Current Smoker	10.2 ± 0.1	12.7 ± 0.6	0.04
Metabolic Status			
Mean BMI (kg/m ²)	30.8 ± 0.2	27.8 ± 0.1	<0.001
Mean waist circumference (cm)	107.5 ± 0.6	98.9 ± 0.2	<0.001
Mean hemoglobin A1c (%)	7.1 ± 0.06	5.6 ± 0.02	<0.001
Diabetes medication use			
Orals only	58.6 ± 2.1	--	--
Insulin only	15.4 ± 1.6	--	--
Orals and insulin	10.8 ± 1.3	--	--
Mean diabetes duration (years)	13.8 ± 0.5	--	--
Comorbidities			
Coronary heart disease	29.9 ± 1.9	16.6 ± 0.7	<0.001
Stroke	14.0 ± 1.3	5.9 ± 0.4	<0.001
Congestive heart failure	15.6 ± 1.3	5.5 ± 0.4	<0.001
Hypertension	71.9 ± 1.9	51.0 ± 0.9	<0.001
Hypercholesterolemia	59.6 ± 2.1	54.4 ± 0.8	0.03
Neuropathy**	33.9 ± 1.8	19.4 ± 0.7	<0.001
Visual impairment	34.2 ± 1.7	21.4 ± 0.8	<0.001
Chronic kidney disease	40.0 ± 2.3	36.6 ± 0.7	0.17
Hearing impairment**	50.5 ± 2.1	43.6 ± 1.2	0.01
Memory problems	17.8 ± 1.6	11.1 ± 0.6	<0.001
PAD**	21.1 ± 3.2	12.1 ± 0.8	0.01
Leg ulcer or amputation**	9.4 ± 1.1	3.0 ± 0.3	<0.001
Obesity (BMI ≥30 kg/m ²)	48.6 ± 1.9	29.0 ± 0.8	<0.001
Arthritis	56.8 ± 1.9	49.6 ± 0.8	0.001
Hip fracture**	2.1 ± 0.6	2.5 ± 0.3	0.54
COPD	13.2 ± 1.5	11.7 ± 0.7	0.30
Cancer	14.9 ± 1.5	15.4 ± 0.6	0.77

[†]Unless otherwise indicated; *Other ethnicity not shown; **1999-2004 only

Table 2: Nationally representative odds ratios for the association of diabetes and disability* among older adults after adjustment for hemoglobin A1c, diabetes duration and diabetes-related comorbidities**, NHANES 1999 - 2004

	Model 1: Demographics	Model 2: Hemoglobin A1c	Model 3: Diabetes Duration	Model 4: Cardiovascular Disease/Obesity	Model 5: Other Comorbidities
LEM	2.06 (1.65 – 2.55)	1.91 (1.49 – 2.45)	1.51 (1.09 – 2.10)	1.23 (0.75 – 1.39)	0.90 (0.62 – 1.29)
GPA	1.97 (1.52 – 2.54)	1.78 (1.36 – 2.33)	1.80 (1.26 – 2.55)	1.37 (0.92 – 2.03)	1.20 (0.81 – 1.77)
ADL	2.53 (1.98 – 3.24)	2.37 (1.75 – 3.21)	2.07 (1.41 – 3.04)	1.49 (1.00 – 2.24)	1.33 (0.84 – 2.09)
IADL	2.10 (1.68 – 2.61)	2.23 (1.77 – 2.83)	1.72 (1.27 – 2.34)	1.19 (0.87 – 1.64)	1.08 (0.76 – 1.54)
LAS	2.38 (1.94 – 2.91)	2.25 (1.83 – 2.76)	1.85 (1.42 – 2.42)	1.16 (0.89 – 1.51)	1.11 (0.79 – 1.56)

* At least one task in specified functional group was answered as “some difficulty”, “much difficulty” or “unable”.

**Model 1: Adjusted for diabetes and demographics (age, gender, race/ethnicity, education, smoking history); Model 2: Adjusted for Model 1 + hemoglobin A1c; Model 3: Adjusted for Model 2 + hemoglobin A1c + diabetes duration; Model 4: Adjusted for Model 3 + cardiovascular disease and risk factors (CHD, CHF, stroke, hypertension, high cholesterol) + obesity (BMI ≥ 30 kg/m²) + waist circumference; Model 5: Adjusted for Model 4 + other comorbidities (leg ulcer, CKD, visual impairment, hearing impairment, memory problems, hip fracture, arthritis, COPD, cancer)