OBJECTIVE — Epidemiological studies have demonstrated that older Mexican Americans are at high risk for type 2 diabetes and its complications. Type 2 diabetes leads to a more rapid decline in functional status among older Mexican Americans with diabetes. This study was designed to examine the impact of diabetes on change in self-reported functional status over a 2-year period among older Mexican Americans with diabetes.

RESEARCH DESIGN AND METHODS — We performed a longitudinal analysis with repeated measurements of functional limitations in a cohort of Mexican Americans aged ≥60 years in the Sacramento Area Latino Study on Aging (SALSA). Diabetes was diagnosed on the basis of self-report of physician diagnosis, medication use, and fasting plasma glucose. Functional status was measured by assessment of activities of daily living (ADL) and instrumental activities of daily living (IADL) at baseline and 1 and 2 years.

RESULTS — Of 1,789 SALSA participants, 585 (33%) had diabetes at baseline. Diabetic subjects reported 74% more limitations than nondiabetic subjects in ADL (summary score for number of limitations, 0.99 vs. 0.57; P = 0.002) and 50% more limitations in IADL (summary score for number of limitations, 7.85 vs. 5.25, P < 0.0001). The annual rate of increase in limitations of ADL and IADL was 0.046 and 0.033 (log scale) on each scale among diabetic subjects compared with 0.013 and 0.003 (log scale) among nondiabetic subjects (P < 0.0005). Complications of diabetes were found to increase ADL and IADL limitations among diabetic subjects. Longer duration of diabetes was also associated with an increase in ADL and IADL limitations.

CONCLUSIONS — There was lower baseline functional status and a more rapid decline in functional status among older Mexican Americans with diabetes versus those without diabetes.

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Abbreviations: ADL, activities of daily living; CES-D scale, Center for Epidemiological Studies Depression scale; FPG, fasting plasma glucose; GEE, generalized estimating equation; IADL, instrumental activities of daily living; NHANES, National Health and Nutrition Examination Survey; SALSA, Sacramento Area Latino Study on Aging.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.
could not capture declines in functional status (11,16–19). Diagnosis of diabetes in some previous studies of functional status was ascertained using self-reporting by the subjects (11). Underreporting of diabetes might be present and might result in nondifferential misclassification bias of diabetes status. In addition, some of the earlier studies involved only small numbers of subjects or substantial non-participation rates (11,16,19). These limitations may affect the generalizability of these studies to other populations. Also, evaluation of the effect of diabetes on functional status in these studies did not focus on some high-risk groups, such as older Mexican Americans.

Older Mexican Americans generally have a higher prevalence of diabetes, its complications, and related comorbid conditions and worse glycemic control than non-Hispanic whites (2–10). Older Mexican Americans with diabetes might have significant decline in functional status compared with nondiabetic subjects. This in turn might lead to disability, diminished quality of life, and an increase in the economic burden for these individuals and society at large. In this article, we examine the association of diabetes with decline in ADL and IADL in a population-based sample of older Mexican Americans.

**RESEARCH DESIGN AND METHODS**

**Study population and recruitment**

Participants in the Sacramento Area Latino Study on Aging (SALSA) were used in this research. The SALSA participants were recruited from the Sacramento Metropolitan area and four surrounding rural counties in California in 1998–1999. An eligible person was 60 years or older in 1998 and self-designated as Latino/a.

The sampling frame in SALSA involved identifying 1990 census tracts in all areas, updating population estimates from 1998 census sources, and characterizing them by the percentage of eligible residents (aged ≥60, Latino/a). These tracts were ranked in order of eligible, and all tracts in which the percent eligible was at least 5% were selected for the target population. Participants were contacted in three stages: by mail, by phone, and finally, by door-to-door neighborhood enumeration. Up to 10 attempts to contact the participants by telephone were allowed and up to five attempts at the household. A separate report contains a detailed description of the sampling frame and recruitment (22).

**Data collection**

Baseline data collection began in 1998 and was completed in 1999. The first and second follow-up visits were completed in 2000 and 2001, respectively. The SALSA participants were interviewed in the language of choice at baseline and annually. All data collection, except for neuromaging, was done at the participants’ homes. In a 2-h interview, each participant answered questions about lifestyle factors, acculturation, and medical diagnosis. A proxy interview was done with caregivers of participants who were deemed too impaired cognitively or otherwise to respond accurately to interview questions. In total, 5% of the participants died, 4% were lost to follow-up, and 11% refused further follow-up at the end of year 2. This study analyzed change in functional status from baseline over the 2 years of follow-up.

**Measurement**

**Diabetes**

Diagnosis of diabetes was ascertained using a combination of medical history, drug use, and fasting blood glucose. Data were collected during interview and blood sample protocol at baseline and at every annual visit. Participants who met any of the following criteria at baseline or follow-up were characterized as having diabetes:

- Fasting plasma glucose (FPG) level ≥126 mg/dl (7.0 mmol/l) (fasting was defined as no caloric intake for at least 8 h).
- Use of an antidiabetic medication.

Duration of diabetes was ascertained by self-report (“How long have you had this condition?”). Diabetic complications included self-reported retinopathy and renal disease. Amputation was assessed by observation during the interview.

**Functional status**

This study focused on self-reported functional status in personal care (basic ADL) and household management (IADL) (20,21). ADL comprises seven items to measure the abilities to walk across a small room, brush hair or teeth, eat, use the toilet, transfer, dress, and bathe (20). IADL comprises 15 items to measure the ability for household management such as prepare meals, do housework, manage money, and use the telephone (21).

**Other variables**

Diagnosis of hypertension was ascertained using a combination of medical history and measured blood pressure. Participants who met either of the following criteria were characterized as having hypertension:

- Systolic pressure ≥140 mmHg and/or diastolic pressure ≥90 mmHg; and
- Self-report of a doctor’s diagnosis of hypertension or high blood pressure.

Stroke was determined by self-report (“Has a doctor ever told you that you had a stroke?”) followed by “How many months or years ago was this?” and “Were you hospitalized for this?”). Stroke in a subsample (n = 150) of self-reported stroke was validated by medical chart review.

Depressive symptoms were measured with the Center for Epidemiological Studies Depression (CES-D) scale (23). Acculturation was measured by the Acculturation Rating Scale for Mexican Americans (ARSMA-II) (24). Weight, height, and waist and hip circumference were measured using standardized instruments. BMI was calculated as measured weight in kilograms divided by measured height in meters squared. Education, medical insurance, household income, smoking status, and alcohol use as well as physical activities were assessed in home visit.

**Statistical methods**

Statistical analysis was performed using PC-SAS (version 8.1). Baseline analysis was carried out using χ², linear regression, or logistic regression. A longitudinal analysis based on the measurements at three time points was performed using a generalized estimating equation (GEE). A 0.05 level of significance was used for all the analyses.

For baseline linear regression analysis, a summary score was created as a continuous variable for ADL and IADL (range, 7–28 and 15–60, respectively). Each summary score for ADL and IADL was log-transformed to achieve normality for longitudinal analysis. In addition, a bi-
Diabetes and functional status

The logistic regression analysis using the three diagnostic criteria: 207 (35%) by self-report plus FPG ≥126 mg/dl or self-report plus medication use; 10 (2%) by self-report plus diabetes; 37 (7%) met the three diagnostic criteria: 35% by self-report plus FPG ≥126 mg/dl or self-report plus medication use; 10 (2%) by self-report plus medication use; 67 (12%) by either FPG or medication; and only 83 (14%) by self-report alone. Of diabetic patients, 56% were women and 44.1% were men. Men had a slightly higher prevalence of diabetes than women (men 34.5% vs. women 31.4%). The prevalence of diabetes was similar in the age subgroups.

The mean duration of diabetes was 12.5 years (median 10 years, range 1 month to 61 years); 341 diabetic subjects (58.3%) used either oral antidiabetic drugs or insulin. Sulfonylureas were the most common class of diabetic drugs, and 73% of the diabetic drug users (249 subjects) used either a single sulfonylurea drug or the combination of a sulfonylurea drug with other medications. Glyburide was the most common agent used of the sulfonylurea drugs (20.5%).

Baseline characteristics

Diabetic subjects did not differ by age (diabetic vs. nondiabetic, 70.3 ± 0.3 vs. 70.8 ± 0.2 years; P = 0.16), sex (diabetic vs. nondiabetic, 55.9% female vs. 59.3% female; P = 0.17), or education level (diabetic vs. nondiabetic, 7.04 ± 0.22 vs. 7.32 ± 0.15 years; P = 0.31). Diabetic subjects were slightly more likely to have medical insurance (diabetic vs. nondiabetic, 92.9% vs. 89.7%; P = 0.03). Diabetic subjects had lower household incomes (diabetic vs. nondiabetic, 45.6% vs. 44.5% <$1,000 per month; P = 0.47). There was no difference in acculturation scores (diabetics vs. nondiabetics, 17.5 vs. 17.9; P = 0.14). Diabetic subjects had higher BMI, waist-to-hip ratios, and CES-D scores than nondiabetic subjects (diabetic vs. nondiabetic, BMI 30.9 ± 0.5 vs. 29.0 ± 0.5, P < 0.0001; waist-to-hip ratio 0.92 ± 0.004 vs. 0.90 ± 0.003, P < 0.0001; CES-D 10.9 ± 0.5 vs. 9.6 ± 0.3, P = 0.01).

There was no significant difference in self-reported physical activity between diabetic and nondiabetic subjects. A slightly higher percentage of diabetic subjects were former smokers, but this was not statistically significant. Diabetic subjects were more likely to report a history of hypertension (odds ratio [OR] 1.96, 95% CI 1.58–2.43), stroke (2.46, 1.78–3.39), heart attack (2.46, 1.76–3.43), kidney disease (2.29, 1.63–3.21), diabetic retinopathy (7.6% in diabetic group), and amputation (2.81, 1.12–7.02).

Functional status: baseline analysis

Figure 1 shows the baseline ADL and IADL scores by age and diabetes status. ADL and IADL limitations increased with age. Diabetic subjects had higher ADL and IADL scores than nondiabetic subjects across age-groups. Female subjects had higher ADL and IADL scores than male subjects (summary score for number of ADL limitations: diabetic women, 1.15 ± 0.16; diabetic men, 0.78 ± 0.14; nondiabetic women, 0.67 ± 0.11; nondiabetic men, 0.43 ± 0.10; summary score for number of IADL limitations: diabetic women, 9.22 ± 0.43; diabetic men, 6.05 ± 0.42; nondiabetic women, 6.05 ± 0.29; nondiabetic men, 4.09 ± 0.30). Overall, diabetic subjects reported 74% more limitations than nondiabetic subjects in ADL (summary score for number of limitations 0.99 vs. 0.57; P = 0.002) and 50% more limitations in IADL (summary score for number of limitations 7.83 vs. 5.25; P < 0.0001).
twice as likely to report difficulty in at least one ADL item (or at least three IADL items) compared with nondiabetic subjects, when controlled for age, sex, BMI, waist-to-hip ratio, household income, CES-D score, hypertension, and history of stroke (ADL, OR 1.91, 95% CI 1.54–2.36; IADL, 1.74, 1.51–2.01).

### Functional status: longitudinal analysis

Table 1 presents multivariate regression analysis using the GEE method based on the five complete datasets from multiple imputation. The rate of increase in ADL and IADL scores among nondiabetic subjects was very small or not significant (ADL, OR 0.013, 95% CI 0.001–0.024; IADL, 0.003, −0.010–0.016). However, there was a significant increase in ADL and IADL scores among diabetic subjects (ADL, 0.046, 0.029–0.063; IADL, 0.033, 0.010–0.056). Effect modification of hypertension (stroke or age) was assessed by including in the model a three-way interaction term, e.g., diabetes × time × hypertension. The results indicated that hypertension, stroke, and age were not significant effect modifiers on the association of diabetes with the decline in ADL and IADL. Therefore, these terms were included in the model a three-way interaction term, e.g., diabetes × time × hypertension. The results indicated that hypertension, stroke, and age were not significant effect modifiers on the association of diabetes with the decline in ADL and IADL. Therefore, these terms were not reported (hypertension × diabetes × year: ADL, \( P = 0.45 \); IADL, \( P = 0.35 \); stroke × diabetes × year: ADL, \( P = 0.59 \); IADL, \( P = 0.42 \); age × diabetes × year: ADL, \( P = 0.11 \); IADL, \( P = 0.08 \)).

#### Table 1—Functional limitations from regression models using GEE

<table>
<thead>
<tr>
<th>Variables</th>
<th>ADL Estimate</th>
<th>95% CI</th>
<th>IADL Estimate</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60–64</td>
<td>Reference</td>
<td>—</td>
<td>Reference</td>
<td>—</td>
</tr>
<tr>
<td>65–69</td>
<td>0.036</td>
<td>0.012–0.060</td>
<td>0.025</td>
<td>0.001–0.050</td>
</tr>
<tr>
<td>70–74</td>
<td>0.038</td>
<td>0.011–0.066</td>
<td>0.066</td>
<td>0.039–0.094</td>
</tr>
<tr>
<td>75–79</td>
<td>0.099</td>
<td>0.069–0.129</td>
<td>0.125</td>
<td>0.095–0.153</td>
</tr>
<tr>
<td>≥80+</td>
<td>0.266</td>
<td>0.227–0.306</td>
<td>0.281</td>
<td>0.247–0.315</td>
</tr>
<tr>
<td>Gender (Female = 1)</td>
<td>−0.016</td>
<td>−0.051 to −0.018</td>
<td>0.045</td>
<td>0.006–0.085</td>
</tr>
<tr>
<td>Income</td>
<td>−0.008</td>
<td>−0.015 to −0.002</td>
<td>−0.022</td>
<td>−0.030 to −0.014</td>
</tr>
<tr>
<td>BMI</td>
<td>0.003</td>
<td>−0.0003 to 0.007</td>
<td>0.006</td>
<td>0.004–0.007</td>
</tr>
<tr>
<td>Waist-to-hip ratio</td>
<td>−0.086</td>
<td>−0.338 to 0.167</td>
<td>0.082</td>
<td>−0.085 to 0.248</td>
</tr>
<tr>
<td>CES-D score</td>
<td>0.007</td>
<td>0.006–0.007</td>
<td>0.010</td>
<td>0.009–0.011</td>
</tr>
<tr>
<td>Hypertension</td>
<td>0.003</td>
<td>−0.015 to 0.021</td>
<td>0.034</td>
<td>0.012–0.056</td>
</tr>
<tr>
<td>Stroke</td>
<td>0.230</td>
<td>0.200–0.260</td>
<td>0.194</td>
<td>0.162–0.227</td>
</tr>
<tr>
<td>Diabetes</td>
<td>0.031</td>
<td>0.004–0.058</td>
<td>0.062</td>
<td>0.033–0.092</td>
</tr>
<tr>
<td>Diabetes × year</td>
<td>0.033</td>
<td>0.013–0.054</td>
<td>0.030</td>
<td>0.003–0.056</td>
</tr>
</tbody>
</table>

Log transformation was taken for the outcome variables ADL and IADL.

### Diabetes-related factors: analysis using longitudinal data

Diabetic subjects with diabetic complications were more likely to be impaired in ADL and IADL than those without complications. For instance, diabetic subjects with amputation were 1.6 times more likely to report ADL limitations than diabetic subjects without amputation, when adjusted for age, sex, household income, BMI, waist-to-hip ratio, CES-D score, and duration of diabetes. Diabetic subjects with amputation had the most substantial compromise of functional status (amputation: ADL, OR 1.57, 95% CI 1.35–1.83; IADL, 1.43, 1.23–1.67; nephropathy: ADL, 1.10, 1.02–1.17; IADL, 1.09, 1.04–1.15; retinopathy: ADL, 1.05, 1.01–1.12; IADL, 1.08, 1.02–1.13; all models were adjusted for the same confounders stated above).

In addition, diabetic subjects with a longer duration of diabetes were more likely to report functional limitations than those with a shorter duration of the disease. For instance, diabetic subjects with diabetes duration of >30 years were 1.10 times more likely to report IADL limitations than those with duration ≤10 years, when controlled for age, sex, household income, BMI, waist-to-hip ratio, CES-D score, and a number of diabetes-related complications (11–20 years: IADL, OR 1.03, 95% CI 0.98–1.07; 21–30 years:

![Figure 1](image-url)—Baseline ADL and IADL scores by age in SALSA.
IADL, 1.08, 1.01–1.15; >30 years: IADL, 1.10, 1.02–1.18).

**CONCLUSIONS** — We found that the prevalence of diabetes among Mexican Americans aged 60 and above was 32.7% (men 34.5%, women 31.4%), which is close to the prevalence found among Mexican Americans with the same age range in the Starr County (Texas) Study (men 31.6%, women 25.8%) (6). The prevalence of diabetes is also similar to that estimated in the Third National Health and Nutrition Examination Survey (NHANES III) conducted in 1988–1994 for Mexican Americans (10). We found that older Mexican Americans with diabetes had a higher risk for hypertension, stroke, myocardial infarction, kidney disease, and amputation. Presence of diabetes and associated complications may lead to a significant decline in functional status among these patients.

The prevalence of functional limitations among diabetic subjects was found to be nearly two times higher than that among nondiabetic subjects in our study. Our results are comparable with other studies conducted among various ethnic groups, although the criteria used to define functional limitations are slightly different across studies. For instance, in the 1982–1984 NHANES, activity limitations (as measured by job performance, ability to perform housework, and ADL) were nearly two times more common in Mexican Americans with diabetes than in those without diabetes (28). In a study by Tucker et al. (11), it was found that diabetes was more often associated with disability (as measured in 12-item ADL and 6-item IADL) among Puerto Ricans aged >55 years. In another study of inner-city blacks, those with diabetes aged 70 years and older had higher scores in four assessments related to functional status (as measured by general health, IADL, modified versions of the Rosow-Breslau scale, and the Sanford Health Assessment Questionnaire) than nondiabetic control subjects (18). In a study among older (age ≥65 years) French people living in the community, diabetic subjects more often lacked autonomy according to the Katz ADL Scale and the Lawton IADL Scale (16,29).

We found similar patterns of functional limitations between and within sex subgroups as reported in a previous study of Spanish-speaking Hispanic subjects aged ≥60 years (19). Women reported more limitations than men, and limitations also increased with age in both diabetic and nondiabetic subjects.

The current study provides the first longitudinal analysis with repeated measurements to examine the effect of diabetes on the decline in functional status among older Mexican Americans. Our results support the hypothesis that older Mexican Americans with diabetes had a significantly higher decline rate in their functional status than their nondiabetic counterparts. There is another 2-year cohort study in older Mexican Americans (30). Although their scope and study design were slightly different from ours, our data also showed that the higher CES-D score was associated with higher ADL and ADL scores (P < 0.0001).

Our results also indicated that both diabetes-related complications and a longer duration of diabetes contribute to the increase in functional decline among these subjects. Our results are consistent with the finding from the 1989 National Health Interview Survey, in which diabetic subjects with complications were more likely to be impaired in their normal activities than those without the chronic complications of diabetes. In addition, 66–81% of type 2 diabetic subjects with amputation, sensory neuropathy, kidney disease or proteinuria, angina or any heart trouble, or retinopathy reported limitation in activities (15).

Furthermore, the current research supports the causal relationship of diabetes with functional impairment. This study using a prospective cohort study design confirmed the time relationship that exposure (diabetes) precedes outcome (decline in ADL and IADL) in time. Diabetic subjects with worse glycemic control are more likely to develop complications, leading to functional impairments. The results suggest that duration of diabetes is related to diminished functional status in a dose-response manner when controlled for age, sex, household income, BMI, and diabetes-related complications. Diabetic patients with a longer duration of the disease were more likely to report functional limitations than those with a shorter duration. Finally, results obtained from the current research were in line with prior studies conducted in different populations and settings that diabetic subjects had more functional limitations than nondiabetic subjects (11,16,19).

The findings of this research have important implications for the Mexican American society. The limitations in ADL and IADL, which are commonly used to assess disability in basic life activities among the population >65 years of age, can be observed as evidence of disability. Disability is a major social, economic, and public health issue. Disability is associated with a greater increase in physician visits, utilization of health care services, hospitalization, institutionalization, dependency in basic life activities, and loss of economic self-sufficiency (13,14). These circumstances greatly diminish the quality of life of those affected as well as increase the economic burden for individuals and society.

Attenuation of diabetes progression into chronic complications could result in reduced economic, social, and public health burden for individuals and society. Promoting proper patient education/awareness, increasing access to regular medical care, and providing good quality of care might help to circumvent some of the problems, especially in communities with lower socioeconomic status. In addition, functional status perhaps should be considered a potential long-term outcome of diabetes when clinicians are caring for their older adult patients with diabetes.

This study has several strengths. First, a population-based sample of older Mexican Americans was used, which could result in generalizability to other older Mexican-American communities in other geographic localities in the U.S. Second, unlike most of the previous studies, which have substantial underreporting rates using self-reported physician-diagnosed diabetes, the current study used three diagnostic criteria to decrease the underreporting rate. Third, a repeated-measure design provides more precise estimates for the outcomes of interest than previous cross-sectional studies. Fourth, a longitudinal study is the best design to assess functional status change over time with regard to diabetes status and allow for establishing relative temporality of exposure and outcome.
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