

Research article

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## Educational disparities in health behaviors among patients with diabetes: the *Translating Research Into Action for Diabetes (TRIAD) Study*

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### Abstract

**Background:** Our understanding of social disparities in diabetes-related health behaviors is incomplete. The purpose of this study was to determine if having less education is associated with poorer diabetes-related health behaviors.

**Methods:** This observational study was based on a cohort of 8,763 survey respondents drawn from ~180,000 patients with diabetes receiving care from 68 provider groups in ten managed care health plans across the United States. Self-reported survey data included individual educational attainment ("education") and five diabetes self-care behaviors among individuals for whom the behavior would clearly be indicated: foot exams (among those with symptoms of peripheral neuropathy or a history of foot ulcers); self-monitoring of blood glucose (SMBG; among insulin users only); smoking; exercise; and certain diabetes-related health seeking behaviors (use of diabetes health education, website, or support group in last 12 months). Predicted probabilities were modeled at each level of self-reported educational attainment using hierarchical logistic regression models with random effects for clustering within health plans.

**Results:** Patients with less education had significantly lower predicted probabilities of being a non-smoker and engaging in regular exercise and health-seeking behaviors, while SMBG and foot self-

examination did not vary by education. Extensive adjustment for patient factors revealed no discernable confounding effect on the estimates or their significance, and most education-behavior relationships were similar across sex, race and other patient characteristics. The relationship between education and smoking varied significantly across age, with a strong inverse relationship in those aged 25–44, modest for those ages 45–64, but non-evident for those over 65. Intensity of disease management by the health plan and provider communication did not alter the examined education-behavior relationships. Other measures of socioeconomic position yielded similar findings.

**Conclusion:** The relationship between educational attainment and health behaviors was modest in strength for most behaviors. Over the life course, the cumulative effect of reduced practice of multiple self-care behaviors among less educated patients may play an important part in shaping the social health gradient.

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## Background

Social disparities in health are well recognized, although the mechanisms that link lower socioeconomic status (SES) with poorer health outcomes are not fully understood [1,2]. Poorly educated, impoverished and minority patients often have poorer access to and lower quality of medical care [3,4]. However, social disparities in health have been reported even in populations with uniform access to care [5,6], and thus alternative pathways should be considered. Educational attainment is the one aspect of SES which is usually established in early adulthood and stable over the life course, and is relatively easily ascertained. This paper focuses on educational disparities in diabetes-related health behaviors.

Unhealthy behaviors and psychological states (e.g., depression, hopelessness, anxiety) have been associated with poor childhood conditions, inadequate education, blue-collar employment and financial barriers [7]. Social epidemiologists Mirowsky and Ross have used the theory of human capital [8] to propose that education endows people with the means to become "effective" individuals, who gain control of their health by developing a healthy lifestyle, thus mediating the association between education and health. Moreover, effectiveness yields benefits that include prosperity (e.g., higher income among well educated) as well as social support, but also provides benefits that transcend both. The authors pose three ancillary hypotheses about how education promotes health [8]. The first hypothesis, the human capital theory of learned effectiveness, posits that education enables people to better merge otherwise unrelated behaviors into a unified healthy lifestyle [8]. Refutation of this theory requires that income fully mediates the education effect on health. The second hypothesis, the theory of personal control, posits that education facilitates a sense of control over one's life, and those who feel in control seek and act on information that may improve health [8]. The third hypothesis suggests that education-related family human capital is trans-

mitted, i.e., educated parents inspire a healthy lifestyle in their offspring [8].

The associations between educational attainment and health behaviors are particularly important in diabetes, given the critical role of health behaviors, including diabetes self-management and health-related lifestyle [9-15]. Studies in diabetic populations with uniform access to and quality of care (receiving managed care or socialized medicine) have reported persistent social disparities in glycemic control [16,17], diabetes-related comorbidities [18-20], and diabetes-related mortality [21], suggesting that factors other than health care access likely mediate the SES-diabetes health relationship. Using a sample of managed care patients with diabetes, we studied the cross-sectional relationship between educational attainment (our primary measure of SES) and smoking, physical activity, self-monitoring of blood glucose (SMBG), foot self-exam, and diabetes-related health-seeking behaviors. We have previously shown that these managed care settings provide uniform access to and quality of diabetes care across levels of SES [6], providing less confounded data on the relationship between SES and health behaviors.

We hypothesized an educational gradient in health behaviors and that better quality of care and provider communication would attenuate the gradient. To elucidate possible mechanisms through which education may influence health behaviors, we structured analyses to evaluate (directly or indirectly) Mirowsky and Ross' hypotheses.

## Methods

### Study Setting

This research is part of the Translating Research Into Action for Diabetes (TRIAD) study, a multi-center cohort study examining individual, provider and health plan (i.e., structural) factors associated with diabetes care and outcomes. The TRIAD study was developed by and coor-

minated through six Translational Research Centers (TRCs) and the Centers for Disease Control and Prevention (CDC). The TRIAD TRCs collaborated with 68 provider groups in ten health plans that served approximately 180,000 patients with diabetes across seven states. We restricted the study to patients who spoke either English or Spanish. Patients from provider groups with fewer than 50 patients with diabetes were excluded. Participating health plans included staff model health maintenance organizations (HMOs), network/independent practice associations, point-of-service plans, and preferred provider organizations with commercial, Medicare, and Medicaid products. Thus the sample includes a diverse mix of patients including those enrolled through their employment, poor and elderly enrolled via federal programs, and individually enrolled patients. The Institutional Review Boards at each TRC and the CDC reviewed and approved the study protocol. TRCs initially enrolled randomly selected subjects between July 2000 and August 2001. The CDC and the National Institute for Health (NIH) funded the study. The design has been described in more detail previously [22].

#### **Study Design and Data Collection**

A standard algorithm was applied to automated pharmacy, laboratory, inpatient, and outpatient diagnostic data obtained from the participating health plans [23] to identify all community-dwelling diabetes patients 18 years and older who had been continuously enrolled for at least 18 months and could speak English or Spanish. The TRIAD study cohort was randomly selected from this population. Nursing home residents, pregnant women, and persons unable to provide informed consent were excluded. Of 13,086 contacted eligible people, 11,927 (91% cooperation rate) responded to a first survey conducted in 2000–2001 (57% of respondents by computer assisted telephone interview and 44% by written survey). A certified, back-translation of the survey was created for Spanish-speaking subjects and for these individuals, Spanish-speaking interviewers administered the interview over the phone. Using an algorithm endorsed by the Council of American Survey Research Organizations (CASRO), if persons unable to be contacted had the same rate of eligibility as those contacted, and were counted in the denominator, the survey response rate would have been 69%. Following up on the 11,927 respondents to the first survey, we conducted a second survey in 2002–2003 and obtained 8,794 (74%) responses via computer-assisted telephone interview or mailed survey. After accounting for those lost to follow-up or no longer eligible for the study, the CASRO rate for the second cohort was 83%. We used only this second cohort for the present study given many of our variables of interest were not included in the first survey. We further excluded 31 respondents age < 25 years, as well as any respondents

missing any exposures, outcomes or modeled covariates specific to this study to obtain our final study cohort of 8,763 patients.

#### **Exposures and outcomes**

Our primary exposure of interest was educational attainment (hereafter "education"), stratified into 4 levels: i) not a high school graduate, ii) high school graduate, but not college, iii) some college, or iv) 4-year college graduate or more. However, we also compared models specifying other measures of SES including annual family income, social class, and parental educational attainment. Social class was based on autonomy over one's labor in the workplace and was categorized through a modified Olin Wright classification [24]: 1) working class, 2) supervisory and 3) managerial (decision-making). The Olin Wright social classification is based on employment status and is widely used in European social research. Homemakers were considered "working class" unless they indicated otherwise. Respondents who were students, unemployed or retired, had never worked or who did not classify their past work were excluded from analysis of social class. Parental educational attainment was categorized by the educational level of the parent with the highest level of education.

Our outcomes of interest included dichotomized self-reported health behaviors among individuals for whom the behavior would be considered to have clear benefit, would be consistently recommended by their health care providers, and answered the relevant survey item. These outcomes included 1) daily self-monitoring of blood glucose among insulin-treated patients only ("SMBG"); 2) daily self-examination of feet among patients who reported any symptoms of peripheral neuropathy including decreased sensation of hot or cold, numbness, tingling or burning, a history of foot ulcers or previous amputation (if one foot); 3) current smoking; 4) regular exercise (= 10 minutes of walking daily and/or moderate leisure time physical activity on a regular basis); and 5) diabetes-related health-seeking behavior including reported use of non-clinical services in past 12 months (diabetes website, support group, or health education) ("health-seeking"). Analysis of SMBG, foot exam, smoking, exercise and health-seeking was based, respectively, on the 1,912, 2,542, 6,538, 6,318 and 6,290 eligible patients.

#### **Statistical analysis**

We used hierarchical logistic regression models (SAS GLIMMIX Macro with penalized quasi-likelihood estimation method), with random intercepts for health plan, to account for the clustered study design (health plan, provider group, and patient levels) and dependency of patient characteristics within health plans and provider groups. When outcomes are common, logistic regression

odds ratios poorly approximate relative risk [25]; therefore we modeled predicted probabilities for each level of education, with observed margins for case-mix adjusters, rather than relying on odds ratios.

We present model estimates of the effect of each level of education adjusted for observed marginal distributions of characteristics that might confound the relationship between education and behavior: demographics (sex, age, race or ethnicity), severity measures (diabetes treatment, comorbidity score, duration of diabetes), depressive symptoms and employment status. For SMBG, we also adjusted of coverage for the costs of the test strips given the potential that this may confound the relationship with the social exposure and utilization. Refutation of Mirowsky and Ross's human capital theory of learned effectiveness [8] required that income fully mediate the education effect on health. Therefore we specified an additional set of models (one for each health behavior) that simultaneously adjusted for education and income. We also present results from models using alternative measures of SES (annual income, social class and parental education).

We summarized health behaviors using a count of the number of the studied beneficial behaviors each subject reported. For non-insulin treated patients, there were 4 possible self-care behaviors: 1) not smoking; 2) regular exercise; 3) daily foot exam; 4) health seeking behavior; and a fifth for insulin-treated patients only, 5) daily SMBG. Counts by level of education were estimated from hierarchical regression models accounting for clustering within health plans as a random effect, and using least square means with observed margins for case-mix adjusters listed above.

We also tested interactions between education and five hypothesized effect modifiers: age, sex, race/ethnicity, provider's communication skills (based on patient reports of their provider's ability to listen, explain, respect and spend time with patient), and disease management intensity. Provider communication and disease management intensity were scored and dichotomized (above/below the median based on factor analyses conducted in TRIAD [26]). We assessed whether any of these five potential effect modifiers interacted with education or any other SES measures (i.e., twenty cross-products) in separate models for each of the five behaviors (e.g., did the relationship between education and smoking differ for younger versus older patients).

## Results

### Population Characteristics

The study population of 8,763 diabetic patients was racially diverse (56% non-white) and 90% of participants

were older than 45 years of age (Table 1). About one quarter of the patients had annual household income under \$15,000 and 21% had not graduated high school. Only two percent of patients conducted the interview in Spanish. Most patients were treated with oral agents, insulin monotherapy or insulin combination therapy; only 7% controlled their diabetes with diet and exercise alone. At least one quarter of our subjects had a history of myocardial infarct (MI), coronary artery bypass graft (CABG), percutaneous transluminal coronary angioplasty (PTCA), stroke, or amputation.

### Association of education with health behaviors

Predicted probabilities (95% CI) of being a non-smoker or engaging in regular exercise and health-seeking behavior were significantly ( $p < 0.001$ ) lower among those with less education (Table 2). However, SMBG and foot exam were not significantly associated with educational attainment. Further, these relationships were not substantively altered by adjustment for demographics (sex, age, race or ethnicity), severity measures (diabetes treatment, comorbidity score, duration of diabetes), depressive symptoms, and employment status. In models adjusted for both income and education, educational gradients remained significant for smoking and health seeking behavior, while exercise became non-significant ( $p = 0.08$ ) (Table 3).

### Alternative measures of SES

With few exceptions, the other SES indicators were similarly associated with behaviors. Similar to lower educational attainment, lower income was also significantly associated with higher rates of smoking, and lower rates of regular exercise and health-seeking behavior. The Olin Wright social class indicator suggested that being a worker (as opposed to supervisor or manager) was weakly associated with less exercise and health-seeking behavior, but was not associated with smoking, SMBG or foot exam. Lower parental educational attainment was also significantly associated less exercise and health-seeking behavior.

### Potential effect modifiers

Contrary to our expectations, quality of care and provider communication did not significantly alter the observed education-behavior relationship, nor the relationships between the other SES measures and health behaviors. Also, these relationships were similar across sex, race and other patient characteristics. The notable exception was the relationship between education and smoking which varied significantly ( $p = 0.003$ ) across age, with a strong, inverse relationship in those aged 25–44, modest for those ages 45–64, and non-evident for those over 65 [27].

**Table 1: Subject characteristics, quality of care, provider communications, and out-of-pocket charges for the TRIAD study respondents (n = 8,763)\***

Subject characteristics		N (%)
Sex	Women	4687 (53.5)
	Men	4076 (46.5)
Age	25–44	816 (9.3)
	45–64	4252 (48.6)
	65 or older	3684 (42.1)
Race or Ethnicity	Latino	1291 (15.8)
	Black, non-Latino	1260 (15.4)
	White, non-Latino	3594 (44.0)
	Asian/Pacific Islander	1304 (16.0)
	Other	720 (8.8)
Annual Household Income	< \$15,000	2017 (24.3)
	\$15,001 – 40,000	2783 (33.6)
	\$40,001 – 75,000	2066 (24.9)
	> \$75,000	1424 (17.1)
Education	Less than high school graduate	1773 (20.8)
	High school graduate	2530 (29.7)
	Some college	2496 (29.3)
	College graduate	1720 (20.2)
Diabetes treatment	Diet and exercise only	604 (7.0)
	Oral agents only	5215 (60.0)
	Insulin alone or in combination	2868 (33.0)
Comorbidity Score**	No history of serious events	6017 (73.5)
	History of one or more serious events	2166 (26.5)
Health plan location	California	1771 (20.2)
	Hawaii	2023 (23.1)
	Indiana	904 (10.3)
	Michigan	1268 (14.5)
	New Jersey	1259 (14.4)
	Texas	1538 (17.6)

\*Complete data only

\*\*Summary score based on whether or not there is a history of myocardial infarct, CABG, PTCA, stroke, or amputation

**Summary measure of healthy behaviors**

The summary estimate of the total number of healthy behaviors reported by level of education is shown separately for insulin and non-insulin treated patients (Figure 1). In both cases, there was a significant relationship between education and the number of healthy behaviors (both  $p < 0.001$ ).

**Discussion**

This is the first large study of the relationship between educational attainment and multiple health behaviors among fully insured patients enrolled in a managed care setting. We found that even in managed care settings with uniform access to and quality of diabetes care across levels of SES [6], less education was associated with poorer health care behaviors among particularly high risk patients for whom these behaviors would be unquestionably indicated and recommended by their health care providers.

Alternative SES indicators yielded similar, although not always significant, findings. In general, education and income more strongly predicted health behaviors than social class or parental education. Each indicator has characteristics which influence its association with each outcome. Income varies over time and is likely to be influenced by adult health status, since progressing disease severity may reduce income. Educational attainment, on the other hand, is generally more stable over the life course, and less likely to be influenced by diabetes health status, since diabetes related complications typically occur later in the life course. Moreover, since education is a strong predictor of subsequent income, income may be considered as on the causal pathway between education and behaviors. Parental education may be less predictive of adult behavior given that childhood social exposures may be overshadowed by later life experiences and opportunities for social advancement. The Olin Wright social classification was only weakly associated with health behaviors in this study. This measure of social stratification is questionable among homemakers and the unem-

**Table 2: Model-based\* predicted probability estimates (95% confidence intervals) for self-reported health behaviors across levels of educational attainment, income, social class and parental educational attainment. Translating Research Into Action (TRIAD) Study.**

Socioeconomic Indicator	Smoking (%)	Regular exercise (%)	Daily foot self-exam (%)	Health-seeking behavior (%)	Daily SMBG† (%)
<b>Educational attainment</b>					
Less than High School graduate	24.0 (20.8–27.5)	41.9 (37.2–46.7)	70.8 (65.6–75.4)	20.8 (16.9–25.3)	71.6 (62.4–79.3)
High School graduate	17.9 (15.8–20.2)	43.4 (39.2–47.7)	65.7 (61.3–69.9)	23.8 (19.9–28.2)	72.8 (66.3–78.4)
Some college/trade school	17.6 (15.6–19.8)	48.4 (44.1–52.7)	68.7 (64.4–72.6)	30.1 (25.6–35.0)	77.7 (72.2–82.5)
College graduate	10.4 (8.6–12.4)	50.2 (45.6–54.8)	67.3 (61.9–72.3)	33.1 (28.2–38.5)	77.1 (71.0–82.3)
p-value	< 0.0001	0.0001	0.3	< 0.0001	0.4
<b>Income</b>					
< \$15 K	22.8 (19.6–26.4)	36.0 (31.7–40.6)	68.3 (62.2–73.8)	20.8 (17.1–25.1)	75.1 (66.3–82.2)
\$15 K – \$40 K	19.3 (17.0–21.7)	44.4 (40.3–48.6)	66.8 (61.3–71.9)	26.0 (22.1–30.4)	74.9 (69.1–79.8)
\$40 K – \$75 K	15.3 (13.2–17.6)	49.7 (45.4–54.1)	66.7 (60.5–72.3)	27.7 (23.5–32.4)	71.9 (65.5–77.6)
> \$75 K	11.4 (9.4–13.8)	56.0 (51.2–60.8)	63.9 (56.5–70.7)	31.4 (26.5–36.7)	79.2 (72.3–84.7)
p-value	< 0.0001	< 0.0001	0.7	< 0.0001	0.4
<b>Employment-based social class§</b>					
Worker	17.3 (15.2–19.6)	41.6 (38.1–45.2)	66.6 (62.4–70.6)	23.9 (20.0–28.3)	78.2 (73.1–82.6)
Supervisor	17.5 (14.7–20.6)	46.0 (41.7–50.3)	70.3 (64.8–75.2)	25.3 (20.8–30.3)	72.2 (64.4–78.9)
Manager	17.2 (15.2–19.4)	49.4 (45.9–52.8)	67.7 (63.7–71.4)	29.5 (25.1–34.3)	74.9 (70.1–79.0)
p-value	0.99	< 0.0001	0.5	< 0.0001	0.3
<b>Parental educational attainment</b>					
Less than High School graduate	16.8 (14.7–19.1)	43.9 (39.9–48.0)	68.3 (65.1–71.4)	24.9 (20.0–30.5)	73.9 (67.8–79.2)
High School graduate	16.6 (14.5–19.0)	48.5 (44.2–52.7)	67.0 (63.4–70.5)	27.6 (22.3–33.6)	74.6 (68.8–79.6)
Some college/trade school	18.1 (15.3–21.3)	48.8 (44.0–53.7)	65.4 (60.1–70.4)	29.7 (23.8–36.3)	78.2 (71.0–84.1)
College graduate	16.6 (13.5–20.1)	49.7 (44.5–55.0)	72.3 (65.9–77.9)	31.9 (25.5–39.0)	81.8 (74.1–87.5)
p-value	0.8	0.01	0.4	0.003	0.3

\*Each behavior is modeled separately using hierarchical logistic regression models, specifying random intercepts for health plan and adjusting for demographics (sex, age, race or ethnicity), socioeconomic indicators (only the one specified as the table row heading), severity measures (diabetes treatment, comorbidity score, duration of diabetes), comorbidity score, depressive symptoms, and employment status.

†Insulin users only and adjusted for coverage for test strips

§Social class defined by Olin-Wright classification

ployed; furthermore, class may be a less pertinent social determinant of health in the United States than in Europe.

The observed relationships further our understanding of the poorer health outcomes persisting in lower SES patients with diabetes in managed care settings. The strong SES gradients in smoking and physical activity are consistent with other population-based studies including diabetic patients, although the SES indicators varied across studies [28,29]. A population-based US study (Americans' Changing Lives Survey) reported that poor behavioral patterns failed to fully explained the greater all-cause mortality rates in lower SES individuals [30]. Although differences in model specification make the findings difficult to compare, a study of individuals from Finland, a country with socialized medicine, showed that the association between SES and mortality was practically eliminated by adjustment for health behaviors, biologic factors, and psychosocial factors [31]. Subjects with widely varying degrees of health coverage, access and quality are included in population-based studies in the U.S., while, like countries with socialized medicine, subjects in managed care settings such as in TRIAD, have relatively uniform access to care.

Mirowsky and Ross's theory of human capital [8] suggests that education improves health by allowing people to develop healthy lifestyles and prosperity (i.e., economic resources to buffer against illness and want). We found evidence that education has an independent effect on health behaviors in models adjusted for income. Moreover, education was predictive of a count of healthy behaviors, giving an indication of the degree of congruence of these health behaviors. Mirowsky and Ross's second hypothesis, the theory of personal control, suggests that education facilitates a sense of control over one's life, encouraging one to seek information that may improve health [8]. We found that education was strongly predictive of health-seeking activities in diabetes, and this was independent of income. The third theory suggests that educated parents practice and transmit a healthy lifestyle to their offspring. We found that parental education was modestly predictive of health-seeking behavior and regular exercise, although less strongly than SES indicators from mid- and later adult life.

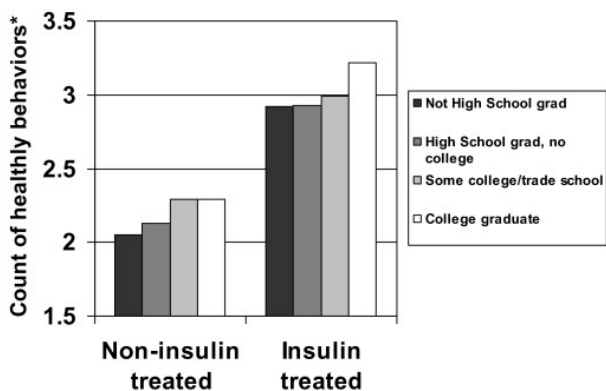
Some study limitations and strengths should be considered. Our study analyses are based on self-reported education and health behaviors, and may be subject to some

**Table 3: Model-based\* predicted probability estimates (95% confidence intervals) for self-reported health behaviors from multivariate models adjusting simultaneously for educational attainment and income. *Translating Research Into Action (TRIAD) Study.***

Socioeconomic Indicator	Smoking (%)	Regular exercise (%)	Daily foot self-exam (%)	Health-seeking behavior (%)	Daily SMBG† (%)
<b>Educational attainment</b>					
Less than High School graduate	22.9 (19.9–26.2)	45.6 (41.5–49.6)	70.4 (65.6–74.8)	22.8 (19.4–26.6)	72.2 (66.4–77.3)
High School graduate	17.3 (15.4–19.3)	44.2 (41.1–47.5)	65.9 (62.2–69.4)	25.0 (22.1–28.1)	76.0 (71.9–79.8)
Some college/trade school	18.2 (16.4–20.2)	48.5 (45.3–51.6)	68.6 (65.1–72.0)	31.1 (28.0–34.4)	75.5 (71.5–79.1)
College graduate	11.0 (9.2–13.1)	48.3 (44.7–52.0)	67.7 (62.7–72.2)	33.3 (29.7–37.1)	76.3 (71.1–80.8)
p-value	< 0.0001	0.08	0.5	< 0.0001	0.7
<b>Income</b>					
< \$15 K	21.1 (18.2–24.3)	37.2 (33.5–41.1)	69.5 (65.1–73.6)	24.5 (21.1–28.3)	74.4 (69.1–79.1)
\$15 K – \$40 K	18.6 (16.7–20.7)	45.2 (42.1–48.3)	68.0 (64.6–71.2)	28.8 (25.8–32.0)	76.6 (72.8–80.1)
\$40 K – \$75 K	15.9 (13.9–18.1)	50.1 (46.7–53.5)	68.0 (63.7–72.1)	29.2 (26.0–32.6)	71.9 (66.8–76.4)
> \$75 K	12.79 (10.7–15.4)	55.9 (51.9–59.9)	64.9 (58.9–70.4)	31.7 (27.9–35.8)	78.4 (72.4–83.4)
p-value	0.0012	< 0.0001	0.7	0.04	0.2

\* Each behavior is modeled separately using hierarchical logistic regression models, specifying random intercepts for health plan and adjusting for demographics (sex, age, race or ethnicity), socioeconomic indicators (only the one specified as the table row heading), severity measures (diabetes treatment, comorbidity score, duration of diabetes), comorbidity score, depressive symptoms, and employment status.

†Insulin users only and adjusted for coverage for test strips



**Figure 1**  
**Count of self-reported self-care behaviors\* across levels of educational attainment. *Translating Research Into Action for Diabetes (TRIAD) Study.*** \*Counts by level of education were based on least square means from hierarchical regression models accounting for clustering within health plans and adjusted for sex, age, race or ethnicity, preferred language, health plan location, diabetes treatment, and the presence of comorbidities. For non-insulin treated patients, there were 4 possible self-care behaviors: 1) not smoking; 2) regular exercise ( $\geq 10$  minutes of walking daily and/or moderate leisure time physical activity on a regular basis); 3) daily foot exam; 4) health seeking behavior (use of diabetes website, support group, health education); and a fifth for insulin-treated patients only, 5) daily self-monitoring of blood glucose. In both cases, relationships were significant ( $p < 0.001$ ).

misclassification due to social desirability of some response options. The cross-sectional design precludes causal inferences. Although we found no significant interactions, the nonlinearity of logistic regression models limits our ability to detect significant interactions [32]. The Olin Wright classification applies only to currently employed subjects and led to exclusion of approximately 200 unemployed subjects who likely had lower SES. By creating indicators and proxies for childhood (parental education), mid-life (educational attainment) and late-life (income) socioeconomic status on health outcomes, we were able to consider a "life course approach [33]." While current health behaviors may reflect early SES influences over the life course and may have an accumulated impact [34], we find that health behaviors are more strongly associated with proximate social indicators than those from early life. Unfortunately, disentangling the separate and propagated effects of early-, mid- and late-life SES was not possible [35]. Additionally, we were unable to address potential mediators (particularly health literacy [36–38]) that may explain observed social differences in behavior. Our sample came from the managed care populations participating in the 6-state TRIAD study. Findings may not apply to uninsured subjects given they would not be included in this sample. Thus our sample of subjects was not randomly selected from all people with diabetes in the United States, and our health plans may not represent the larger population of managed care settings. Our sample only included small numbers of subjects whose primary language was Spanish. It is important to note that our findings were observed in samples selected so that each examined health care behavior was unquestionably indicated as a beneficial, preventive

measure (e.g., daily foot examination in diabetic patients with peripheral neuropathy, or a history of ulcers or amputations).

### Conclusion

The need to improve health outcomes associated with diabetes has been a major focus in the United States in recent years. We find evidence of less frequent self care behaviors among particularly high risk, diabetic patients with less education and similar findings using alternative measures of socio-economic status. Our findings were consistent across demographic subgroups, and we did not find that better quality care or better health care provider communication attenuated educational disparities in health behaviors. Although the relationship between education and health behaviors was modest in strength for most behaviors, the cumulative effect of reduced practice of multiple self-care behaviors among less educated patients, over the course of diabetes, may have an important impact in shaping the social health gradient. Given the vulnerability of this population and the persistent social health disparities even in settings offering uniform care [5,6], the effectiveness and benefits of targeted public health interventions that reduce barriers for and promote beneficial diabetes-related health behaviors in patients with less education should be considered. However, because lower educational attainment is associated with poorer health, and poorer health can diminish patients' ability to practice beneficial health behaviors, we can not yet conclude from our findings that interventions aimed at improving health behaviors in disadvantaged patients will be effective in reducing social disparities in health.

### Abbreviations

SES = socioeconomic status

TRIAD = *Translation Research Into Action for Diabetes*

SMBG = self-monitoring of blood glucose

CDC = Centers for Disease Control and Prevention

NIDDK = National Institute for Diabetes, Digestive Disease and Kidney Disease

CASRO = Council of American Survey Research Organizations

CI = confidence intervals

AJPH = American Journal of Public Health

US = United States

### Competing interests

The author(s) declare that they have no competing interests.

### Authors' contributions

AK, SE and AB conceived, designed and coordinated the study. MS performed the statistical analysis. AK interpreted the data and drafted the manuscript. AK, AB, DM, WH and MS obtained funding for this study. All authors were involved in primary data collection for the TRIAD study. All authors read, made critical revisions and approved the final manuscript.

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