Type 1 Diabetes Self-Management From Emerging Adulthood Through Older Adulthood

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OBJECTIVE

The purpose of this study of adults with type 1 diabetes was to analyze patterns of diabetes self-management behaviors and predictors of glycemic control across the adult life span.

RESEARCH DESIGN AND METHODS

This study was a secondary cross-sectional analysis of data of 7,153 adults enrolled in the T1D Exchange Clinic Registry who were divided into four developmental stages (emerging, young, middle-aged, and older adults). Data were collected by questionnaire and medical record review at enrollment. Statistical analyses compared sociodemographic, clinical, and diabetes-related factors across groups. Logistic regressions were conducted for each group to identify factors associated with hemoglobin A_{1c} ≥7%.

RESULTS

The sample was divided according to adult developmental stage: emerging adults, age 18 to <25 years (*n* = 2,478 [35%]); young adults, age 25 to <45 years (*n* = 2,274 [32%]); middle-aged adults, age 45 to <65 years (*n* = 1,868 [26%]); and older adults, age ≥65 years (*n* = 533 [7%]). Emerging adults had the highest mean hemoglobin A_{1c} level (8.4 ± 1.7% [68 mmol/mol]), whereas older adults had the lowest level (7.3 ± 0.97% [56 mmol/mol]; *P* < 0.0001). Emerging adults were less likely to use an insulin pump (56%) or a continuous glucose monitor (7%) but were more likely to miss at least one insulin dose per day (3%) and to have had an episode of diabetic ketoacidosis in the past year (7%) (all *P* < 0.0001). Different factors were associated with hemoglobin A_{1c} ≥7% in each age-group, but two factors were noted across several groups: the frequency of blood glucose checks and missed insulin doses.

CONCLUSIONS

When discussing diabetes self-management, providers may consider a patient's developmental stage, with its competing demands (such as work and family), psychosocial adjustments, and the potential burden of comorbidities.

Type 1 diabetes is a chronic illness that needs to be managed over a lifetime. Diabetes self-management is necessary to prevent common diabetes-related complications and includes eating a healthy diet, engaging in exercise, taking appropriate amounts of insulin, and self-monitoring blood glucose (1). Adults with type 1 diabetes are at higher risk for cardiovascular disease (CVD), but that risk can be significantly reduced through control of traditional CVD risk factors (e.g., blood pressure, lipids, smoking) (2).

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Adults transition through several developmental stages, and diabetes self-management may vary with these stages. Emerging adulthood, a distinct period in the adult life span between 18 and 25 years old, is a time when change and exploration are common for many individuals (3) and when young adults experience separation from parents (4). During this period, emerging adults with type 1 diabetes may have good overall quality of life but greater diabetes distress and poorer self-management compared with older adults (age >30 years) with type 1 diabetes (5). However, in a large national cohort from the T1D Exchange Clinic Registry, hemoglobin A_{1c} levels increased from ages 8 to 16 years, remained steady between the ages of 16 and 18, and then gradually declined during the emerging adult years (ages 18–26) (6). Still other researchers have found that glycemic control worsens during the time period immediately after high school, with better problem-solving ability protecting against this trend (7). More research is needed on how emerging adults actively regulate the social relationships (with parents, friends, partners) that may help or hinder their diabetes self-management (8).

Young adults who work have challenges related to establishing a working life and perhaps starting a family, and thus they may have less time to devote to self-management. They may find managing diabetes to be difficult in the workplace, particularly as a result of time pressures and work environments that lack a routine schedule (9). Diabetes distress may affect this population and can be triggered by stigma, worry about pregnancy, and concerns for the future (10).

Middle-aged adults may seek to maintain their careers but may be affected by lower health-related quality of life, the need to take more sick leave, and greater unemployment than adults without type 1 diabetes (11). Older adults may deal with multiple comorbidities and cognitive decline that can interfere with diabetes management (12,13), and these may result in more frequent hypoglycemia (14). Poor glycemic control and longer diabetes duration are associated with cognitive decline in older adults who are also dealing with diabetes-related complications (1).

It is unlikely, then, that one approach to promoting diabetes self-management would be appropriate for all stages of adulthood. Rather, there is a need to understand how diabetes self-management changes throughout adulthood in order to develop targeted and appropriate interventions. Therefore, the aims of this study of adults with type 1 diabetes were to:

1. Analyze patterns of diabetes self-management behaviors and glycemic control across different developmental stages of the life span (emerging, young, middle-aged, and older adults)
2. Identify the independent predictors of hemoglobin $A_{1c} \geq 7\%$ (≥ 53 mmol/mol) in each developmental stage

Previous research on emerging adults has indicated that this age-group has greater diabetes distress and poor self-management (5) and may (7) or may not (6) have higher hemoglobin A_{1c} than other age-groups. They are also managing social relationships that affect self-management (8). Further, this time of increased freedom and decreased monitoring by parents may increase risky behavior (15). Therefore, we hypothesized that the emerging adult group in this study may exhibit less than optimal diabetes self-management and will consequently have the highest hemoglobin A_{1c} levels of the four age-groups.

RESEARCH DESIGN AND METHODS

We conducted a secondary cross-sectional analysis using data from the T1D Exchange Clinic Registry that included participants from 67 U.S.-based pediatric and adult endocrinology practices (16). All adults ≥18 years old who were enrolled in the registry and who had completed the self-report exercise questionnaire (n = 7,153) were included in these analyses. This sample was enrolled between September 2010 and August 2012. Participants were categorized into four age-groups to represent different developmental stages: emerging adulthood (18 to <25 years), young adulthood (25 to <45 years), middle age (45 to <65 years), and older adulthood (≥65 years). These categories were based on the age categories defined in the MEDLINE database (17). However, given our interest in the emerging adult age-group, we divided the adult category (defined in MEDLINE as ages 19 to <45 years) to include two distinct age-groups: emerging adult (18 to <25 years) and young adult (25 to <45 years).

Data were collected by questionnaire and medical record review at the time of enrollment in the registry. These include sociodemographics (sex, education, employment); clinical data taken from the medical record (height, weight, lipids, blood pressure); depressive symptoms as measured by the self-report Patient Health Quesionnaire-8 (PHQ-8), with a score ≥10 indicating an elevated risk of depression (18,19); and self-reported general health as measured by a single question asking in general how participants would describe their health, with potential answers including "excellent," "very good," "good," "fair," and "poor." This variable was dichotomized to "good to excellent" and "fair to poor" for these analyses. Health insurance coverage data were collected by self-report (yes or no) and included various options: private, Medicare, Medigap, Medicaid, Children's Health Insurance Program, military, Indian, or none. Diabetes-related data were obtained from the medical record (hemoglobin A_{1c}, diabetes complications), through a combination of medical record and self-report (diabetes duration, use of continuous glucose monitor or insulin pump), or through self-report (number of blood glucose checks per day, the presence of severe hypoglycemia or diabetic ketoacidosis in the past 3 months [yes/no]). Adjustments to diet and insulin before, during, and after exercise were assessed by self-report: "Before (or during) exercise, how often to you eat or drink carbs to prevent low blood sugar?," with potential responses including "never," "rarely," "sometimes," "most of the time," and "always"; "Do you make any changes in insulin either before or during exercise?" and "If yes, what changes do you make?," with potential responses including "lower dose of rapid-acting insulin before exercise," "lower dose of long-acting insulin before exercise," and "suspend or lower basal rate on pump before or during exercise"; and "Do you make any changes in insulin after exercise?" and "If yes, what changes do you make?," with potential responses of "lower dose of rapid-acting insulin after exercise," "lower dose of long-acting insulin before exercise," "suspend or lower basal rate on pump after exercise," or "suspend or lower basal rate on pump overnight after exercise."

Three additional factors that may influence glycemic control were obtained by self-report: annual household income, health insurance type, and number of

test strips covered by insurance per day. Smoking was assessed with the question, "Do you currently smoke at least one cigarette a week?" Self-reported exercise was assessed using a single question: "In a typical week, how many days do you spend at least 30 min doing any physical activities or exercises such as running, working out, yoga or Pilates, aerobics, sports, gardening, physical education in school, or walking for exercise?" Ideal cardiovascular health factors were assessed using definitions for exercise, blood pressure, total cholesterol, smoking, and BMI from the American Heart Association (20).

Statistical Analysis

Analyses were conducted with SAS version 9.3 (SAS Institute, Cary, NC). Descriptive statistics were calculated for each developmental stage group. The χ^2 test and ANOVA were used to compare the sociodemographic, clinical, and diabetes-related factors across each group. These factors were chosen based on previous evidence of their association with hemoglobin A_{1c} level. Bivariate analyses and logistic regression were conducted for each developmental stage group to identify factors that are independently associated with poor glycemic control, defined in this study by hemoglobin $A_{1c} \geq 7\%$, as recommended for nonpregnant adults by the American Diabetes Association (1). Factors significantly associated ($P < 0.10$) at the bivariate level were included in the logistic regression. The significance level for the logistic regression was set at $P < 0.05$.

RESULTS

The mean ± SD age of all participants was 37.14 ± 17.00 years; 54% were female and 89% were white. The total sample of participants was divided according to developmental stage: emerging adult, age 18 to <25 years (n = 2,478 [35%]); young adult, age 25 to <45 years (n = 2,274 [32%]); middle age, age 45 to <65 years (n = 1,868 [26%]); and older adult, age ≥65 years (n = 533 [7%]). The majority of the emerging adults were students (62%), whereas the majority of older adults were retired (74%). Older adults had the highest rate of self-reported poor or fair health (19%) and the highest rates of peripheral (36%) and autonomic (15%) neuropathy. Middle-aged adults had the highest number of PHQ-8 scores ≥10 (12%), indicating a risk for depression (Table 1).

Diabetes Self-Management Behaviors and Glycemic Control Across Adult Developmental Stages

As shown in Table 1, emerging adults had the highest mean ± SD hemoglobin A_{1c} (8.4 ± 1.7% [68 mmol/mol]), whereas older adults had the lowest level (7.3 ± 0.97% [56 mmol/mol]; $P < 0.0001$). Consequently, emerging adults had the lowest percentage (16%) achieving the recommendation for hemoglobin A_{1c} <7% (<53 mmol/mol), whereas the older adults had the highest percentage (38%) ($P < 0.0001$). Emerging adults were less likely to use an insulin pump (56%) or a continuous glucose monitor (7%) and reported the fewest blood glucose checks per day (all $P < 0.0001$). Emerging adults were more likely to report missing at least one insulin dose per day (3%) and to report having an episode of diabetic ketoacidosis in the past year (7%) (both $P < 0.0001$). Older adults were least likely to report adjusting their insulin before or during exercise (32%), and they were similar to young and middle-aged adults in that they rarely ate a carbohydrate before they exercised (6%) (both $P <$ 0.0001). Significant differences also existed in how the different age-groups managed cardiovascular risk factors, except for cholesterol: most had total cholesterol <200 mg/dL. The middle-aged and older adult groups had the fewest participants (34%) achieving ideal BMI <25 kg/m^2, and older adults had the fewest (27%) achieving ideal blood pressure (<120/80 mmHg). Emerging and young adults had the lowest level of nonsmoking (92%), whereas few young adults (27%) reported they engaged in exercise for 150 min/week.

Factors Associated With Poor Glycemic Control by Developmental Stage

Different factors were associated with higher odds of hemoglobin $A_{1c} \geq 7\%$ in each developmental stage group (Table 2). In emerging adults (ages 18 to <25 years), no factors were associated with lower odds of hemoglobin $A_{1c} \geq 7\%$, but reporting missing insulin doses one to five or more times a week (compared with almost never) was associated with higher odds of having hemoglobin $A_{1c} \geq 7\%$.

In young adults (age 25 to <45 years), two factors were associated with lower odds of hemoglobin $A_{1c} \geq 7\%$: reported episodes of severe hypoglycemia (resulting in a seizure or coma) in the past 3 months and more reported daily blood glucose meter checks. The remaining factors were associated with higher odds of hemoglobin $A_{1c} \geq 7\%$: being single or separated/divorced/widowed compared with being married; higher diastolic blood pressure, depression score, and diabetes duration; reporting missing insulin doses more frequently; and the presence of peripheral neuropathy.

In middle-aged adults (age 45 to <65 years), six factors were associated with glycemic control. Using a continuous glucose monitor, performing more daily blood glucose checks, and exercising 30 min/day on more days per week were associated with lower odds of hemoglobin $A_{1c} \geq 7\%$. Self-reported poor to fair health, missing insulin doses, and having peripheral neuropathy were associated with higher odds of hemoglobin $A_{1c} \geq 7\%$.

In the older adults group (age ≥65 years), two factors were associated with lower odds of hemoglobin $A_{1c} \geq 7\%$: having military insurance and reporting more days of exercise per week. Three factors were associated with increased odds of hemoglobin $A_{1c} \geq 7\%$: having a high school diploma or an associate degree (compared with less than a high school diploma), working full or part-time (compared with being retired), and smoking.

CONCLUSIONS

In this study we divided a large national sample of adults with type 1 diabetes into four distinct developmental stages to explore differences in diabetes self-management and glycemic control across the adult life span. This approach differs from other analyses of type 1 diabetes self-management that have often focused on children (21–23) or emerging adults (7,24) and not later stages of adulthood.

We found that adults with type 1 diabetes across different developmental stages differ in their diabetes self-management behaviors and glycemic control. Several developmental stage groups had similar predictors of poor glycemic control, specifically, the frequency of blood glucose checks, missed insulin doses, and exercise. In this sample, the majority of each age-group used an insulin pump and few (range 7–26%) used a continuous glucose monitor. The remaining predictors of poor glycemic control were distinct for each group, indicating

Table 1—Characteristics of type 1 diabetes across the developmental stages

Factor	Emerging adult, 18 to <25 years (n = 2,478)	Young adult, 25 to <45 years (n = 2,274)	Middle-aged adult, 45 to <65 years (n = 1,868)	Older adult, ≥65 years (n = 533)	P value
Female	1,243 (50)	1,334 (59)	994 (53)	269 (50)	<0.0001
Age (years)	20 ± 1.8	34 ± 5.8	54 ± 5.6	71 ± 5	<0.0001
Race					<0.0001
White	2,051 (83)	2,037 (90)	1,758 (94)	517 (97)	
Black, non-Hispanic	101 (4)	68 (3)	49 (3)	7 (1)	
Education less than a high school diploma	227 (9)	34 (2)	41 (2)	17 (3)	<0.0001
Employment					<0.0001
Student	1,525 (62)	112 (5)	7 (0.4)	0 (0)	
Full- or part-time	743 (30)	1,763 (78)	1,235 (67)	111 (21)	
Homemaker, unemployed, disabled	180 (7)	377 (17)	388 (21)	29 (5)	
Retired	0 (0)	0 (0)	210 (11)	393 (74)	
Health insurance					
Private	1,684 (79)	1,895 (85)	1,508 (82)	302 (58)	<0.0001
Medicare	105 (5)	96 (4)	221 (12)	464 (88)	<0.0001
Medicaid	196 (9)	141 (6)	77 (4)	7 (1)	<0.0001
Military	40 (2)	24 (1)	35 (2)	35 (7)	<0.0001
No coverage	36 (2)	41 (2)	46 (3)	0 (0)	0.002
Self-reported poor or fair health	268 (12)	249 (12)	270 (16)	89 (19)	<0.0001
Depression (PHQ-8 score ≥10)	193 (9)	206 (10)	207 (12)	29 (6)	0.0003
Cardiovascular health–related factors					
BMI <25 kg/m^2	1,153 (52)	582 (36)	435 (34)	125 (34)	<0.0001
SBP <120 mmHg and DBP <80 mmHg	1,085 (46)	949 (45)	599 (34)	139 (27)	<0.0001
Total cholesterol <200 mg/dL	766 (81)	575 (82)	531 (81)	170 (88)	0.12
No smoking	2,245 (92)	2,062 (92)	1,725 (93)	519 (98)	<0.0001
PA for 30 min, 5 days/week	930 (38)	623 (27)	614 (33)	210 (39)	<0.0001
Always eat CHO before PA	214 (9)	126 (6)	97 (6)	27 (6)	<0.0001
Adjust insulin dose before/during PA	993 (44)	1,111 (56)	747 (47)	144 (32)	<0.0001
Diabetes duration (years)	9.7 ± 5.0	18.6 ± 9.5	29.2 ± 13.8	34.5 ± 16.7	<0.0001
HbA_{1c} (%)	8.4 ± 1.7	7.54 ± 1.3	7.6 ± 1.5	7.3 ± 0.97	<0.0001
HbA_{1c} <7%	397 (16)	739 (34)	491 (28)	193 (38)	<0.0001
CGM use	165 (7)	525 (23)	480 (26)	80 (15)	<0.0001
Insulin					<0.0001
By pump	1,373 (56)	1,454 (65)	1,169 (63)	302 (57)	
By injections	1,080 (44)	789 (35)	675 (37)	227 (43)	
Blood glucose checks/day (n)	4.4 ± 2.4	5.2 ± 2.7	5.5 ± 2.7	5.8 ± 2.4	<0.0001
Miss at least one insulin dose/day	76 (3)	35 (2)	23 (1)	3 (0.6)	<0.0001
Episode of DKA in past 3 months	190 (7)	80 (4)	41 (2)	7 (1)	<0.0001
Severe hypoglycemia (seizure/coma) in past 3 months	203 (8)	220 (10)	226 (12)	64 (12)	0.0001
Peripheral neuropathy	12 (0.5)	150 (7)	427 (23)	192 (36)	<0.0001
Autonomic neuropathy	3 (0.1)	61 (3)	217 (12)	78 (15)	<0.0001

Data are mean ± SD or n (%) unless otherwise indicated. CGM, continuous glucose monitor; CHO, carbohydrate; DBP, diastolic blood pressure; DKA, diabetic ketoacidosis; HbA_{1c}, hemoglobin A_{1c}; PA, physical activity; SBP, systolic blood pressure.

a need to account for a patient's developmental stage when tailoring diabetes self-management education.

The association between more blood glucose checks per day and lower hemoglobin A_{1c} was previously established in a larger sample (n = 20,555) from the T1D Exchange Clinic Registry that included both adults (n = 8,914) and children (n = 11,641) (25). Further, those who reported a higher number of blood glucose checks were more likely to report using an insulin pump. Current American Diabetes Association guidelines for both insulin pump users and those using multiple daily injections recommend that patients self-monitor blood glucose before each meal and snack, at bedtime, after meals if they suspect low blood glucose, after treating low blood glucose until they achieve normal levels, before physical activity, and for tasks such as driving (26). Certain patients may be unable to achieve this frequency

Table 2—Logistic regression of hemoglobin A_{1c} ≥7% for all developmental stages

Parameter	Emerging adults (18 to <25 years)	Young adults (25 to <45 years)	Middle-aged adults (45 to <65 years)	Older adults (≥65 years)
Marital status	NS		NS	NS
Married		Reference		
Single		1.6 (1.2–2.2)		
Separated, divorced, widow, other		1.8 (1.04–3.1)		
Education	NS	NS	NS	
Less than HS diploma				Reference
HS diploma/GED				3.2 (1.01–10.1)
Associate degree				5.4 (1.2–24.0)
Bachelor degree				
Master degree				
Work	NS	NS	NS	
Retired				Reference
Full- or part-time				2.6 (1.5–4.4)
Military insurance	NS	NS	NS	
No				Reference
Yes				0.3 (0.1–0.6)
Health	NS	NS		NS
Good to excellent			Reference	
Poor to fair			1.9 (1.1–3.1)	
Diastolic blood pressure (each 1-unit increase)	NS	1.03 (1.01–1.04)	NS	NS
PHQ-8 (each 1-unit increase)	NS	1.06 (1.02–1.1)	NS	NS
Diabetes duration (each 1-year increase)	NS	1.03 (1.02–1.04)	NS	NS
Use of continuous glucose monitor	NS	NS		NS
No			Reference	
Yes			0.57 (0.42–0.77)	
Meter checks/day (each 1-check increase)	NS	0.9 (0.8–0.93)	0.90 (0.86–0.95)	NS
Missing insulin doses				NS
Almost never	Reference	Reference	Reference	
<1 time/week to <1 time/month	NS	2.1 (1.6–2.8)	2.0 (1.4–2.9)	
1 to ≥5 times/week	6.6 (2.7–15.8)	3.8 (2.5–5.8)	3.5 (2.0–6.2)	
At least daily	NS	10.5 (1.3–83.0)	NS	
Severe hypoglycemia (seizure/coma) in the past 3 months	NS			
No		Reference		
Yes		0.6 (0.4–0.9)	NS	NS
Peripheral neuropathy	NS			NS
No		Reference	Reference	
Yes		2.2 (1.1–4.3)	1.8 (1.2–2.7)	
≥30 min of exercise/day (each 1-day increase)	NS	NS	0.9 (0.84–0.97)	0.87 (0.80–0.95)
Smoking	NS	NS	NS	
No				Reference
Yes				12.0 (1.4–101.6)

Data are odds ratio (95% CI). All models were adjusted for participant sex. GED, General Equivalency Diploma; HS, high school; NS, not significant.

of blood glucose checks, and some adults may be better suited to continuous glucose monitoring, which is currently recommended for those aged ≥25 years (26).

Missing at least one insulin dose on a daily basis was relatively uncommon (<3%), but missing insulin doses with some regular frequency was independently associated with poor glycemic control in all age-groups except the older adults, despite the majority using insulin pumps. For example, those in the young adult age-group who missed a dose were 10 times more likely to have hemoglobin A_{1c} ≥7% than those who almost never missed a dose. These odds were reduced to approximately two times more likely to have hemoglobin A_{1c} ≥7% if they only missed a dose between less than once per week and less than once per month. The emerging adults showed a worrisome pattern of diabetes self-management, with a lower frequency of blood glucose checks, more missed insulin doses, less likelihood of using an insulin pump or continuous glucose monitor, and the highest hemoglobin A_{1c} values. These findings are challenging to understand in the context of previous research showing that emerging adults in the first year after high school report a relatively good diabetes-related quality of life and fair to good health and that diabetes had only a minor impact on their lives (27). In that previous study, emerging adults' scores on a diabetes management scale were higher than the midpoint (mean ± SD score 51.1 ± 12.9; possible range 0–84) and the majority were living independently of their parents. Interestingly, despite what seems to be less than optimal

diabetes self-management behaviors in our emerging adult sample, the majority (88%) also reported good to excellent health. This is understandable given how few diabetes-related complications were reported, yet it is also concerning given their future if these patterns of self-management continue. The role of diabetes self-management education and support, especially needed for emerging adults managing diabetes on their own for perhaps the first time, is to encourage informed decision making in order to improve clinical outcomes (28), particularly long-term outcomes that may seem distant from their current state of apparent good health.

Regular exercise, another self-management strategy, was associated with better glycemic control: more days of exercise per week was associated with lower odds of having hemoglobin $A_{1c} \geq 7\%$ in middle-aged and older adults. Engaging in 150 min of moderate to vigorous exercise each week is recommended as part of diabetes self-management (1). Limited evidence shows that exercise in the presence of type 1 diabetes can affect glycemic control (16,29), but it can affect other cardiovascular risk factors such as BMI, lipids, and diastolic blood pressure (16). More depressive symptoms are associated with less exercise in this population (30), and this should be addressed. The two groups that had the highest rates of exercising at least 5 days/week were the emerging adults (38%) and the older adults (39%). These findings may reflect schedules that allow more time for exercise, as compared with the adults in the young and middle-age groups, who may be busier establishing careers and families. Strategies that use technology may help these young and middle-aged adults. In a sample of adults with type 1 diabetes (mean ± SD age 35.2 ± 10.4 years), the use of a smartphone application (Glucose Buddy) was associated with better glucose control than that in a control group, but it was not associated with improvements in self-care activities, which included exercise, over time (31). A higher fear of hypoglycemia has been associated with less exercise in young adults with type 1 diabetes (32), but fear of hypoglycemia was not measured in our sample, and therefore we do not know how this fear may affect exercise patterns.

Depressive symptoms were not associated with glycemic control across all groups. More depressive symptoms were significantly associated only with higher hemoglobin A_{1c} in the young adult group. This is surprising because the prevalence of depression among adults with diabetes has been found to be much higher than among those without diabetes (33). Further, in a sample of adults with type 1 diabetes (n = 248; mean ± SD age 39.0 ± 13.2 years), suboptimal diabetes self-management mediated the association between depressive symptoms and higher hemoglobin A_{1c} (34). It is difficult to interpret our findings, especially because this age-group did not have the highest prevalence of depression (PHQ-8 score $\geq$10) and given the incomplete information available for data such as diabetes distress, other chronic comorbid conditions, or routine medications in the T1D Exchange data set.

Older adults are not often represented in the type 1 diabetes research. Older adults in our study had the lowest prevalence of depression, despite having the highest prevalence of self-reported poor or fair general health and the highest prevalence of peripheral and autonomic neuropathy. This group also had the highest prevalence of exercising 5 days/week and having hemoglobin $A_{1c} < 7\%$. As control of CVD risk factors improves (2) and mortality rates decrease (35), more adults with type 1 diabetes will enter this older adult developmental stage. Their age-specific health concerns need to be addressed. For example, in a cross-sectional study of adults with type 1 diabetes divided into five age-groups, the older adult group (age $\geq$60 years) had the lowest scores in physical functioning and emotional health, as measured by the 12-Item Short Form Survey, when compared with the general population (11). These disparities highlight the need for additional research in this understudied age-group. Full- or part-time work was associated with higher odds of hemoglobin $A_{1c} \geq 7\%$ in this age-group, which may highlight the need for workplace interventions. Worksite wellness programs have been effective in reducing modifiable CVD risk factors (36) and may be helpful to working older adults who may lack the time or additional resources to seek out programs on their own.

Given the increased incidence of type 1 diabetes among youths during a relatively recent 10-year period (1.8% between 2002 and 2012) (37), in addition to the incidence of adults of all ages being newly diagnosed with type 1 diabetes (time period 2001–2015) (38), unique strategies may be needed as individuals mature and pass through life's developmental stages. Adults should have continued access to a multidisciplinary team that includes diabetes specialists, nutritionists, and clinical psychologists (39). Pediatric patients are viewed in light of their developmental stage, and a similar approach needs to be taken for developmental stages during adulthood. In discussing and promoting diabetes self-management, providers need to consider each patient's developmental stage, with its competing demands (family, work, community), psychosocial adjustments, and potential burden of comorbidities.

This study had several limitations. First, those enrolled in the T1D Exchange consented voluntarily to be included and therefore may not adequately represent the national population of adults with type 1 diabetes. This resulted in a sample that lacks racial diversity. Second, the data collected were cross-sectional in nature, which limits our ability to make causal assumptions. Last, analyses were limited by the data collected by the T1D Exchange Clinic Registry. Therefore, we were unable to include variables that may have affected diabetes self-management behaviors, such as diabetes distress, fear of hypoglycemia, and social support. However, given the large sample available for analyses, we were able to identify differences in glycemic control and self-management behaviors across different developmental stages, highlighting the need for developmentally appropriate interventions.

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References

1. American Diabetes Association. Introduction. In *Standards of Medical Care in Diabetes—2017*. Diabetes Care 2017;40(Suppl. 1):S1–S2
2. Rawshani A, Rawshani A, Franzén S, et al. Range of risk factor levels: control, mortality, and cardiovascular outcomes in type 1 diabetes mellitus. Circulation 2017;135:1522–1531
3. Arnett JJ. Emerging adulthood. A theory of development from the late teens through the twenties. Am Psychol 2000;55:469–480
4. Levy-Shraga Y, Elisha N, Ben-Ami M, et al. Glycemic control and clinic attendance of emerging adults with type 1 diabetes at a transition care clinic. Acta Diabetol 2016;53:27–33
5. Vallis M, Willaing I, Holt RIG. Emerging adulthood and type 1 diabetes: insights from the DAWN2 Study. Diabet Med 2018;35:203–213
6. Clements MA, Foster NC, Maahs DM, et al.; T1D Exchange Clinic Network. Hemoglobin A1c (HbA1c) changes over time among adolescent and young adult participants in the T1D exchange clinic registry. Pediatr Diabetes 2016; 17:327–336
7. Majumder E, Cogen FR, Monaghan M. Self-management strategies in emerging adults with type 1 diabetes. J Pediatr Health Care 2017;31: 29–36
8. Wiebe DJ, Berg CA, Mello D, Kelly CS. Self- and social-regulation in type 1 diabetes management during late adolescence and emerging adulthood. Curr Diab Rep 2018;18:23
9. Balfe M, Brugha R, Smith D, Sreenan S, Doyle F, Conroy R. Why do young adults with type 1 diabetes find it difficult to manage diabetes in the workplace? Health Place 2014;26:180–187
10. Balfe M, Doyle F, Smith D, et al. What's distressing about having type 1 diabetes? A qualitative study of young adults' perspectives. BMC Endocr Disord 2013;13:25
11. Nielsen HB, Ovesen LL, Mortensen LH, Lau CJ, Joensen LE. Type 1 diabetes, quality of life, occupational status and education level - a comparative population-based study. Diabetes Res Clin Pract 2016;121:62–68
12. Chaytor NS. Cognition in adults and older adults with type 1 diabetes: chicken or egg? Diabetes Spectr 2016;29:219–224
13. Dhaliwal R, Weinstock RS. Management of type 1 diabetes in older adults. Diabetes Spectr 2014;27:9–20
14. DuBose SN, Weinstock RS, Beck RW, et al. Hypoglycemia in older adults with type 1 diabetes. Diabetes Technol Ther 2016;18:765–771
15. Wiebe DJ, Helgeson V, Berg CA. The social context of managing diabetes across the life span. Am Psychol 2016;71:526–538
16. Bohn B, Herbst A, Pfeifer M, et al.; DPV Initiative. Impact of physical activity on glycemic control and prevalence of cardiovascular risk factors in adults with type 1 diabetes: a cross-sectional multicenter study of 18,028 patients. Diabetes Care 2015;38:1536–1543
17. Kastner M, Wilczynski NL, Walker-Dilks C, McKibbon KA, Haynes B. Age-specific search strategies for Medline. J Med Internet Res 2006;8:e25
18. Kroenke K, Strine TW, Spitzer RL, Williams JB, Berry JT, Mokdad AH. The PHQ-8 as a measure of current depression in the general population. J Affect Disord 2009;114:163–173
19. Kroenke K, Spitzer RL, Williams JB. The PHQ-9: validity of a brief depression severity measure. J Gen Intern Med 2001;16:606–613
20. Lloyd-Jones DM, Hong Y, Labarthe D, et al.; American Heart Association Strategic Planning Task Force and Statistics Committee. Defining and setting national goals for cardiovascular health promotion and disease reduction: the American Heart Association's strategic Impact Goal through 2020 and beyond. Circulation 2010; 121:586–613
21. Guo J, Whittemore R, He GP. The relationship between diabetes self-management and metabolic control in youth with type 1 diabetes: an integrative review. J Adv Nurs 2011;67:2294–2310
22. Jaacks LM, Bell RA, Dabelea D, et al.; SEARCH for Diabetes in Youth Study Group. Diabetes self-management education patterns in a US population-based cohort of youth with type 1 diabetes. Diabetes Educ 2014;40:29–39
23. Verchota G, Sawin KJ. Testing components of a self-management theory in adolescents with type 1 diabetes mellitus. Nurs Res 2016; 65:487–495
24. Hendricks M, Monaghan M, Soutor S, Chen R, Holmes CS. A profile of self-care behaviors in emerging adults with type 1 diabetes. Diabetes Educ 2013;39:195–203
25. Miller KM, Beck RW, Bergenstal RM, et al.; T1D Exchange Clinic Network. Evidence of a strong association between frequency of self-monitoring of blood glucose and hemoglobin A_{1c} levels in T1D Exchange clinic registry participants. Diabetes Care 2013;36:2009–2014
26. Chamberlain JJ, Kalyani RR, Leal S, et al. Treatment of type 1 diabetes: synopsis of the 2017 American Diabetes Association Standards of Medical Care in Diabetes. Ann Intern Med 2017;167:493–498
27. Hanna KM, Weaver MT, Slaven JE, Fortenberry JD, DiMeglio LA. Diabetes-related quality of life and the demands and burdens of diabetes care among emerging adults with type 1 diabetes in the year after high school graduation. Res Nurs Health 2014;37:399–408
28. American Diabetes Association. Lifestyle management. Sec. 4. In *Standards of Medical Care in Diabetes—2017*. Diabetes Care 2017; 40(Suppl. 1):S33–S43
29. Röhling M, Herder C, Roden M, Stemper T, Müssig K. Effects of long-term exercise interventions on glycaemic control in type 1 and type 2 diabetes: a systematic review. Exp Clin Endocrinol Diabetes 2016;124:487–494
30. McCarthy MM, Whittemore R, Grey M. Physical activity in adults with type 1 diabetes. Diabetes Educ 2016;42:108–115
31. Kirwan M, Vandelanotte C, Fenning A, Duncan MJ. Diabetes self-management smartphone application for adults with type 1 diabetes: randomized controlled trial. J Med Internet Res 2013;15:e235
32. Martyn-Nemeth P, Quinn L, Penckofer S, Park C, Hofer V, Burke L. Fear of hypoglycemia: influence on glycemic variability and self-management behavior in young adults with type 1 diabetes. J Diabetes Complications 2017; 31:735–741
33. Anderson RJ, Freedland KE, Clouse RE, Lustman PJ. The prevalence of comorbid depression in adults with diabetes: a meta-analysis. Diabetes Care 2001;24:1069–1078
34. Schmitt A, Reimer A, Hermanns N, et al. Depression is linked to hyperglycaemia via suboptimal diabetes self-management: a cross-sectional mediation analysis. J Psychosom Res 2017; 94:17–23
35. Harding JL, Shaw JE, Peeters A, Guiver T, Davidson S, Magliano DJ. Mortality trends among people with type 1 and type 2 diabetes in Australia: 1997-2010. Diabetes Care 2014;37: 2579–2586
36. Arena R, Guazzi M, Briggs PD, et al. Promoting health and wellness in the workplace: a unique opportunity to establish primary and extended secondary cardiovascular risk reduction programs. Mayo Clin Proc 2013;88:605–617
37. Mayer-Davis EJ, Lawrence JM, Dabelea D, et al.; SEARCH for Diabetes in Youth Study. Incidence trends of type 1 and type 2 diabetes among youths, 2002-2012. N Engl J Med 2017; 376:1419–1429
38. Rogers MAM, Kim C, Banerjee T, Lee JM. Fluctuations in the incidence of type 1 diabetes in the United States from 2001 to 2015: a longitudinal study. BMC Med 2017;15:199
39. Reddy M, Rilstone S, Cooper P, Oliver NS. Type 1 diabetes in adults: supporting self management. BMJ 2016;352:i998