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Age Differences in Reactivity to Daily General and Type 1 Diabetes Stressors

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Older adults often report less exposure to and less affective reactions to daily stressors. However, older adults with a chronic illness such as Type 1 diabetes may experience more daily stressors due to the complications of diabetes and may be more affected by those stressors. The study examined (a) age differences in reported exposure to general and diabetes stressors, (b) whether daily general and diabetes stressors relate to daily positive and negative affect, self-care, and blood glucose, and (c) whether these daily associations are moderated by age and comorbidity. Individuals with Type 1 diabetes (n = 199; 52.3% female, average age 46.81 years) completed a checklist for 14 days reporting general and diabetes stressors. General diabetes distress was assessed with the Diabetes Distress Scale. Daily positive and negative affect and daily self-care behaviors were rated each day. Blood glucose was assessed via glucometers. Older adults reported fewer daily general and diabetes stressors and less diabetes distress compared to younger adults. Multilevel models indicated that both daily general and diabetes stressors (between- and within-person) were associated with lower positive and higher negative affect. Fewer diabetes stressors were associated with better self-care and lower (better) mean blood glucose. Neither age nor comorbidity interacted with general or diabetes stressors to predict any outcome (except one effect for comorbidity), indicating that older adults and those experiencing more comorbid conditions were similarly affected by stressors. Results suggest that older adults experience fewer stressors than younger adults but are similarly affected when stressors do occur.

Keywords: stress, aging, negative affect, daily diary, Type 1 diabetes

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Adults across the life span experience stressful events frequently in their daily lives (Zawadzki et al., 2019), with daily stress associated with poorer well-being and mental (Charles & Luong, 2013) and physical health (Chiang, Turiano, Mroczek, & Miller, 2018; Stone, Reed, & Neale, 1987). Common everyday sources of stress during adulthood include problems at work, at home, and interpersonal tensions (Birditt, Fingerman, & Almeida, 2005). Adults with a chronic illness frequently experience stressors associated with managing the chronic illness, in addition to the general stressors of daily life. Little is known, however, about how the stressors of daily life as well as those associated with managing a chronic illness affect daily well-being and illness management, despite the fact that nearly 60% of adults in the United States have at least one chronic disease (National Center for Chronic Disease Prevention and Health Promotion, 2019). Further, older adults are often found to be less reactive to daily stress than their younger counterparts, although this work has largely been conducted in the context of general life stressors (Stawski et al., 2019). The purpose of the present study was to examine the association of daily general and illness-specific stressors to affect and illness management and to determine whether age influenced these associations.

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We examine general and illness-specific stressors in the context of Type 1 diabetes. Type 1 diabetes affects some 3 million Americans, the vast majority of whom are adults (Chiang, Kirkman, Laffel, Peters, & the Type 1 Diabetes Sourcebook Authors, 2014). The incidence of Type 1 diabetes is growing at an annual rate of 3% (McKenna, 2012), placing increased numbers of adults at risk for serious complications from diabetes such as hypertension, kidney disease, and retinopathy. Type 1 diabetes is an illness that requires a rigorous daily self-care regimen to mimic a well-functioning pancreas. Individuals must engage in a number of behaviors, such as multiple daily blood glucose checks or bolusing, adjusting the amount and timing of insulin, as well as managing food intake and exercise to minimize problems (Chiang et al., 2014). Daily diabetes stressors may occur in response to this difficult management regimen (Lansing, Berg, Butner, & Wiebe, 2016). However, little is known about the daily diabetes stressors that individuals with Type 1 diabetes experience across the adult life span and how those diabetes stressors may occur in the context of other general stressful events.

Diabetes stressors (such as taking the wrong amount of insulin, skipping blood glucose checks) may disrupt affect and be associated with highs or lows in blood glucose control (Lansing et al., 2016). Broad examinations of diabetes stress using the Diabetes Distress Scale (Polonsky et al., 2005) indicate that the diabetes regimen itself can be associated with emotional distress and that diabetes distress is associated with higher HbA1c, a measure of how well diabetes has been controlled in the past 3–4 months (Chiang et al., 2018). Our work with adolescents (Lansing et al., 2016) examining daily diabetes stressors indicates that on days when adolescents experienced greater numbers of diabetes stressors, they experienced greater negative affect and higher (worse) blood glucose. The role of daily general stressors in diabetes management, however, is not well understood. Current data from the present study suggest that daily general stressors (arguments, stressors at home) may spillover to affect diabetes stressors (Tracy et al., 2019). Research with adolescents with Type 1 diabetes indicates that survey measures of both general and diabetes stressors are associated with poorer HbA1c, self-care, and quality of life (Rechenberg, Whittemore, Holland, & Grey, 2017). During adulthood, the multiple demands of managing diabetes in the context of work environments and parenting responsibilities may create challenges for the management of diabetes. Maintaining good affect, self-care, and blood glucose control may be especially challenging when adults experience both diabetes and general stressors on a given day.

Age differences may occur in how both general and diabetes stressors are experienced and relate to daily affect and diabetes management. A growing literature indicates that older adults frequently report less exposure to stressors (Birditt et al., 2005; Koffer, Ram, Conroy, Pincus, & Almeida, 2016; Stawski, Sliwinski, Almeida, & Smyth, 2008) than younger adults. The literature is more mixed with respect to whether older adults are more or less affected by daily stressors (see Stawski et al., 2019 for a review). Stress reactivity is most frequently examined through a statistical association between the presence of daily stressors and daily affect (Stawski et al., 2019), with age differences in reactivity assessed through age moderating this daily association. Studies have revealed age-related decreases in stress reactivity (Birditt, 2014; Scott, Ram, Smyth, Almeida, & Sliwinski, 2017), no age-related differences in stress reactivity (Stawski et al., 2008), and age-related increases in stress reactivity (Sliwinski, Almeida, Smyth, & Stawski, 2009). Multiple life span theories of emotional aging (e.g., Socioemotional Selectivity Theory, Strength and Vulnerability Integration Theory) have offered explanations for why older adults may be less reactive to stressful events. Older adults may experience greater well-being and positive affect than young individuals (Carstensen, Isaacowitz, & Charles, 1999) through reappraisal processes that make stressful events less distressing (Charles, 2010) and/or the use of proactive strategies that allow them to avoid the occurrence of stressful events in the first place (Charles, Piazza, Luong, & Almeida, 2009).

Very little is known about adult age differences in daily stress reactivity within the context of a chronic illness like Type 1 diabetes. Consistent with the idea that older age might be associated with less exposure and less reactivity to stress, Hessler, Fisher, Mullan, Glasgow, and Masharani (2011) revealed that older adults with Type 2 diabetes reported less diabetes distress than younger adults. Further, stress was less strongly associated with older adults' HbA1c than young adults, suggesting that older adults may be less affected by stress. Global measures of diabetes distress likely reflect not only general diabetes stress exposure (stressors related to the treatment regimen), but also the distress associated with those stressors. Similarly, Helgeson, Van Vleet, and Zajdel (2019) found that older adults with Type 2 diabetes reported less global distress, but not fewer daily stressors. The relation between overall diabetes stressors and mood was attenuated for older adults. However, most adults with Type 1 diabetes are diagnosed prior to the age of 18 (75% of all cases, Haller, Atkinson, & Schatz, 2005; more recent estimates around 60% before the age of 30, Thomas et al., 2018), which means that they have lived with the stressors of daily management for a long period of time. Although older adults with Type 1 diabetes may have gained lifelong experience and knowledge about its management that might reduce exposure to stressful events, they are also more likely to be dealing with the long-term complications of the disease including cardiovascular, kidney, and eye disease as well as neuropathy (Dhaliwal & Weinstock, 2014). Research among adults with multiple chronic illness conditions (Piazza, Charles, & Almeida, 2007) indicates that older individuals with many chronic illness conditions (4 or more) show greater reactivity to stressors than those with fewer chronic illness conditions. Such physiological vulnerabilities may make it difficult to utilize the reappraisal processes that are associated with lower stress reactivity. Thus, older adults with diabetes and multiple chronic illness conditions may be especially reactive to daily stressors, which may disrupt not only affect, but the self-care behaviors that are important for maintaining blood glucose values within a more normal range.

In the present study we examined the relation of daily general and diabetes-specific stressors to daily affect, self-care, and blood glucose among individuals with Type 1 diabetes who ranged in age from young adulthood through late adulthood. The present study had three aims: 1) to examine between-person age differences in reported exposure to general and diabetes stressors as well as general diabetes distress, 2) to examine on a daily basis whether both general and diabetes stressors are associated with positive and negative affect, self-care behaviors, and blood glucose, and 3) to test whether these latter associations are moderated by age, comorbidity, and the interaction of age and comorbidity. Onehundred and 99 individuals diagnosed with Type 1 diabetes completed a daily diary reporting on their daily diabetes and general stressors, positive and negative affect, and self-care. They also completed a survey measure of diabetes distress. Blood glucose data were gathered from glucometers. We predicted that both more general and diabetes stressors would independently be associated with poorer affect, self-care, and blood glucose. We also examined whether the combined effect of both general and diabetes stressors on a given day (interaction between general and diabetes stressors) would be especially challenging. We hypothesized that older adults would report fewer general stressors consistent with the existing literature. We did not specifically hypothesize whether older adults would be more or less reactive to daily diabetes or general stressors, as older adults could be either more adept at the kind of cognitive appraisals processes that have been associated with lower reactivity or more physiologically vulnerable to the effects of having lived with Type 1 diabetes for decades. We expected that older adults with greater comorbidities would be more reactive, consistent with Piazza et al. (2007).

Method

Participants

Participants were recruited from university-affiliated endocrinology clinics across two sites. Study procedures were approved by the Institutional Review Boards at both sites. All participants provided informed consent. Participants were eligible to participate if patients were 25 years of age or older, had a diagnosis of Type 1 diabetes for at least one year and were taking insulin within 1 year of diagnosis, spoke English as their primary language (necessary for cognitive testing as part of the larger study), and were married or in a cohabiting relationship for at least one year. 199 eligible couples (398 individuals, 199 patients) were enrolled and completed study measures (see Table 1 for demographics). Patients were on average 46.81 (SD = 13.95, range 25.9–74.9) years old, 52.3% were women, and the majority were well-educated and working full- or part-time. Patients were largely Non-Hispanic White. Patients reported having lived with diabetes for an average of 26.98 years, 68.7% reported using a pump for insulin delivery, 43.4% utilized a continuous blood glucose monitor, and average HbA1c was above current ADA guidelines of an HbA1c level $<$7.0% (M = 7.57, SD = 1.06). Participants were mostly married (91.5%) and the average length of romantic relationship was 19.36 years (SD = 14.56).

Procedure

Participants were recruited from two university-affiliated endocrinology clinics in Utah and Pennsylvania. At the Pennsylvania site, patients were approached in the clinic by their diabetes care provider who obtained permission to release their name to the project director. If patients agreed, the project director called to explain the study in detail. After patients agreed to participate, partner contact information was obtained. If partners agreed to participate, couples were enrolled in the study. Of the 206 patients approached in the clinic, 4 declined to have their contact information forwarded to the project director. Of the 202 contacted by the project director, 47 were ineligible (including 2 who were found to be ineligible after they had started study procedures), 57 declined participation, and 6 could not be reached to determine eligibility. Thus, 92 couples were scheduled and included in the study.

At the Utah site, a trained research assistant approached the patient in the clinic and provided information about the study. If

Table 1
Demographic Information

Variable	M (SD)	Range
Age	46.81 (13.95)	25.85–74.89
Gender (% Women)	52.3%	—
Race (%White)	92.5%	—
Ethnicity (% Hispanic)	6%	—
Presence of children in the household (%)	49.7%	
Educational status		
GED	2.0%	
High school graduate	10.1%	
Some college (did not graduate with degree/certificate)	16.1%	
Associate/vocational degree	12.1%	
Bachelor's degree	32.2%	
Master's degree	16.6%	
MD/PhD/JD	11.1%	
Work status		
Working full-time	53.8%	
Working part-time	14.1%	
Unemployed, looking for work	3.0%	
Unemployed, not looking for work	8.5%	
Retired	15.6%	
On disability	5.0%	
Length of diagnosis	26.98 (13.88)	3.10–60.63
Pump use (%)	68.7%	—
CGM use (%)	43.4%	—

Note. CGM = continuous glucose monitor; GED = General Education Diploma.

patients agreed to participate, contact information was obtained from partners, and partners were contacted by a research assistant about the study. Of the 319 patients approached and screened for eligibility, 66 were deemed ineligible and 118 declined participation. Of the remaining 135 couples, 107 were scheduled and included in the study.

The final sample included 199 couples across both sites. Participants at the Pennsylvania site were older ($p < .01$) and had diabetes for a longer period of time ($p < .05$) than participants at the Utah site, but differed on no other demographic variable. More detail is provided on recruitment elsewhere (Helgeson, Berg, et al., 2019). Once patients and partners were recruited for the study, they were emailed online surveys (that included consent) to complete at home prior to the in-lab visit. Couple members were asked to complete these separately. During the laboratory visit, couple members provided written consent for all study procedures and were placed in separate rooms to complete an additional online questionnaire (which included the Diabetes Distress measure) and a brief interview.

In the lab assessment, individuals were trained in how to complete a daily online diary assessment that included questions regarding their most stressful event of the day and a checklist about stressful general and diabetes events that may have occurred. The present study uses measures from the daily diary portion of the study for patients alone. Participants received an automated e-mail with the survey link each night at 6 p.m. with instructions to complete the diary before going to bed that night. They were sent reminders via text, phone call or e-mail (depending on their preference) at 9 p.m. if they had not yet completed their survey. Daily blood glucose was measured each day using a study-provided glucometer. On average, patients completed 13.82 days of the diary out of a possible 14 ($SD = .56$).

Patients were compensated up to $225 for completing all of the parts of the study ($100 for the initial survey and lab-assessment, $7.14 per diary completed up to $100, and $25 for returning a study-owned glucometer in a prepaid/preaddressed envelope).

Measures

Daily diabetes-specific stressors. Individuals completed a brief checklist (1 = *yes*, 0 = *no*) where they indicated the presence of six or seven common daily diabetes-specific stressors: problem with high blood sugar, low blood sugar, forget or skip a blood glucose test, take the wrong amount of insulin, feel bad (upset, angry, sad) because of your diabetes, difficulties with your diet, plus one additional item if they were using a pump or continuous blood glucose monitor (i.e., problem with your equipment used to monitor diabetes). This measure has been used previously in adolescents and emerging adult samples with T1D (Berg et al., 2013; Butner et al., 2018) and is based on empirically derived coding of patients' descriptions of diabetes-specific stressors (Beveridge, Berg, Wiebe, & Palmer, 2006). Because individuals utilizing pumps or CGMs were presented with an additional stressor, the daily measure of diabetes-specific stressors reflected a proportional count of daily stressors endorsed per day (out of 6 or 7, depending on whether they used equipment).

Daily general stressors. Individuals indicated the presence of four of the most common general daily stressors (1 = *yes*, 0 = *no*; e.g., argument or disagreement with someone, stressful or bothersome event at work[1], stressful or bothersome event at home, have something bad happen to a relative or close friend) from the Daily Inventory of Stressful Events (Almeida, Wethington, & Kessler, 2002). To maintain consistency with the measure of diabetes stressors, this daily measure of general stressors reflected the proportional count of stressors endorsed.

Daily affect. Individuals rated 18 items on a 1 (not at all) to 5 (extremely) scale each day. Negative affect was assessed with nine items: depressed mood (sad, discouraged, hopeless), anxious mood (anxious, on edge, uneasy), and anger (annoyed, angry, resentful). These items were developed by Cranford et al. (2006) for use with daily diaries. These scales have demonstrated reliability to detect within-person negative mood changes in the context of daily diaries (Cranford et al., 2006). Given Cranford et al.'s (2006) findings that three-item measures reveal acceptable reliability to detect within person changes in mood across days, we also developed three-item measures of three positive affect domains. These included happiness (joyful, happy, amused), interest (curious, excited, interested), and contentment (content, tranquil, at peace). The reliability of the 9-items reflecting negative affect was excellent (within person reliability $\lambda = .91$), with these items averaged such that higher scores indicated greater negative affect. The reliability of the 9-items reflecting positive affect was also excellent (within-person reliability $\lambda = .94$), with these items averaged such that higher scores indicated greater positive affect.[2]

Daily self-care behaviors. Daily self-care was measured using five (or six if the person was on a pump or continuous blood glucose monitor-CGM) items from a shortened version of the Self-Care Inventory created for use in daily diaries (Berg et al., 2014). Participants rated how well they followed recommendations from their health care provider to engage in self-care behaviors ("Checking blood glucose with monitor," "Administering insulin as recommended," "Adjusting insulin based on blood glucose," "Having quick-acting sugar available to treat reactions," "Eating the proper foods or counting all carbohydrates," and "Using my pump (programming the pump, making sure there is enough insulin) or continuous monitor (wearing the sensor correctly") for those using a pump or continuous blood glucose monitor) in the past 24 hr from 1 (did not do it) to 5 (did it exactly as recommended). An average score was computed of the items with higher scores reflecting better self-care. Within-person reliability was $\lambda_{00} = .97$.

Daily mean blood glucose. Daily blood glucose (BG) was measured using OneTouch Verio IQ glucometers across participants. Participants were instructed in the in-lab session to use this

[1] As older adults were more likely to be retired, we conducted analyses of the general stressors eliminating work. As there was also overlap between diabetes stressful events dealing with affect and the affect measures and highs and lows in blood glucose at BG mean, we also conducted analyses deleting these three variables from the compilation of diabetes stressors. The results for age moderation were identical to the results without these stressors (see Table S1 in the online supplemental materials). To be consistent with the operationalization of general stressors used in the literature, we kept work-related stressors in the analyses and kept all diabetes stressors as highs and lows in blood sugar are the most frequent stressors reported.

[2] Analyses were also conducted for the six specific affects with the results for age moderation identical and for general and diabetes stressors nearly identical (see Table S2 in the online supplemental materials).

meter as they would their regular glucometer across the 14-day diary portion of the study and values were uploaded by study staff after completion of the diary. A daily mean was computed to estimate average BG level for each 1-day (24 hr) period.[3]

Diabetes distress. As a more global measure of diabetes distress, individuals completed the 17-item Diabetes Distress Scale (DDS; Polonsky et al., 2005), a measure of disease-specific emotional distress in individuals with diabetes. The DDS includes four empirically derived subscales (emotional burden, regimen-related distress, physician-related distress, diabetes-related interpersonal distress), with items rated on a scale from 1 (*not a problem*) to 6 (*a very serious problem*). In addition to good construct validity of the measure and subscales, the DDS items demonstrated high internal consistency for the total score ($\alpha = .93$) as well as subscales (αs = .88 to .90) in a mixed sample of individuals with either Type 1 or Type 2 diabetes (Polonsky et al., 2005). The total score was used with higher numbers reflecting higher diabetes distress. In our sample, reliability of the total scale was excellent ($\alpha = .90$).

Comorbidity. Comorbid illnesses and conditions were assessed using the Self-Administered Comorbidity Questionnaire. The SCQ is a short, self-report measure that assesses the presence ("Do you have the problem?") of 12 common health problems (e.g., heart disease, diabetes, and hypertension) and allows for participants to list (up to 3) additional health problems not otherwise listed. The SCQ is sum scored with the presence of each health problem. This measure had good test–retest reliability (intraclass correlation coefficient = 0.94) in a sample of inpatient participants (Sangha, Stucki, Liang, Fossel, & Katz, 2003).

Analysis Plan

Missing data in the diary was generally around 1.5%, with BG mean, the exception at 5.9%. We had no missing data for the survey measures. As missing data was so minimal and the multilevel models use Maximum Likelihood based estimation procedures, we did not estimate missing data. In order to examine age differences in reported exposure to stress, we examined the relation of age to diabetes distress, average diabetes stressors across the 14 days, and average general stressors across the 14 days, and then used multiple regressions to examine the association between age of the person with diabetes and metrics of diabetes and general stress controlling for length of diagnosis and comorbidity. Analyses oriented toward the question of age differences in reactivity to stressors utilized multilevel models (Raudenbush, Bryk, Cheong, & Congdon, 2000) performed in HLM (Version 7.02; Raudenbush, Bryk, Cheong, Congdon, & du Toit, 2011) to address the daily diary structure that days were nested within individuals. All models included both within-person and between-person (average across 14 days) effects (Hoffman & Stawski, 2009). Within-person effects were person-centered (individuals' own average across the 14-days) and between-person effects were grand mean centered (average of the sample). Site differences were examined for all dependent measures. Because all effects were not significant (p ranging from .17 to .98), site was not included in models. Gender was also included in multilevel models and was not significant in any model (with the exception of a main effect on self-care, reported in Table 2). Thus, gender was not included in the final multilevel models. Educational level was considered as an additional covariate post hoc. However, inclusion of educational level only produced one significant main effect on negative affect (reported in Table 2), thus was not included in the final multilevel models. Day was included in all models with age, number of comorbidities, and length of diagnosis predicting the intercept. For analyses with BG mean, pump and CGM status were included as covariates, but were not significant ($p > .10$) and thus were not included in the final models reported. Random effects were allowed on all effects. Primary independent variables were the proportion of daily diabetes stressors and general stressors (both within and between), age, length of diagnosis, and comorbid conditions (on the intercept) and the cross-level interactions of Age × Daily Diabetes Stressors, Age × Daily General Stressors, Comorbidity × Daily Diabetes Stressors, Comorbidity × Daily General Stressors, and Age × Comorbidity × Diabetes Stressors, and Age × Comorbidity × General Stressors. Significant interactions were plotted, and simple slopes were tested. Separate models were tested for patients' reports of positive and negative affect, self-care, and BG mean. Pseudo R^2 was calculated for each multilevel model (Cohen, Cohen, West, & Aiken, 2003).

Results

Preliminary Analyses

Means and standard deviations as well as intercorrelations among all study measures are shown in Table 2. Individuals reported .25 stressors per day of the 6–7 diabetes events (total count of 1.71 stressors each day, $SD = .94$). The number of general stressors was .15 (total count of .61 stressors each day, $SD = .40$). A paired samples t test revealed that on average individuals reported more diabetes stressors than general stressors, $t = 12.13$, $p < .001$. In general, individuals were reporting relatively low levels of general and diabetes stressors on a daily basis. In addition, individuals reported relatively low levels of diabetes distress, consistent with large-scale studies of diabetes distress in individuals with Type 2 diabetes (Lipscombe, Burns, & Schmitz, 2015). Individuals reported low levels of negative affect and levels of positive affect at the midpoint of the scale (reflecting moderately).

As shown in Table 2, on average across the 14 days the between-person number of diabetes stressors was correlated with the average number of between-person general stressors. Global diabetes distress was associated with both greater numbers of between-person diabetes and general stressors. Older adults reported having diabetes for a longer time, better self-care, and also reported more comorbidities.

[3] We also conducted analyses using the average daily risk range (ADRR), which was calculated using McCall and Kovatchev's (2009) average risk for high and low BG Index. The reason we included ADRR is that the scaling of BG is neither linear nor equivalent at the low and high ends of the scale with a greater range of high BG values [180–600+ mg/dl] than low [~20–70 mg/dl]). The ADRR is calculated using at least 14 days within a month of self-monitoring blood glucose (SMBG) (at least 3 readings /day) and is designed to be equally sensitive to hypoglycemic and hyperglycemic BG deviations to optimize to predict glycemic extremes. The results were identical to those using BG mean as the dv.

Table 2
Means and Correlations of Primary Study Variables

Variable	*M* (*SD*)	Range	1	2	3	4	5	6	7	8	9	10	11	12
1. Diabetes stressors	0.25 (0.14)	.00–.65	—	.57**	.43**	−.29**	.44**	−.20**	−.44**	.23**	−.20**	−.05	.05	.12
2. General stressors	0.15 (0.10)	.00–.50		—	.28**	−.21**	.48**	−.21**	−.28**	.10	−.09	−.02	.05	.14*
3. Diabetes distress	1.98 (0.74)	1.00–4.71			—	−.21**	.38**	−.29**	−.32**	.17*	−.17*	.07	−.03	.11
4. Age	46.81 (13.95)	25.85–74.89				—	−.07	−.01	.28**	−.03	.62**	.43**	.00	−.08
5. Negative affect	1.57 (0.35)	1.03–3.43					—	−.20**	−.26**	.07	−.08	.04	.20**	.10
6. Positive affect	2.86 (0.62)	1.13–4.41						—	.15*	−.14	.06	−.17*	.01	.04
7. Self-care behaviors	4.42 (0.56)	2.26–5.00							—	−.36**	.30**	.09	.08	.23**
8. BG mean	175.52 (35.30)	99.05–306.67								—	−.08	.05	−.11	−.03
9. Length of diagnosis	26.98 (13.95)	3.10–60.63									—	.34**	−.01	.00
10. Comorbidity	2.34 (1.44)	1.00–8.00										—	−.13	.00
11. Education	16.01 (2.94)	11.00–22.00											—	−.03
12. Gender[a]	52.3%	—												—

Note. BG = blood glucose.
[a] 1 = Female; 0 = Male.
* $p < .05$. ** $p < .01$.

Age Differences in Stress Exposure

As can be seen in Table 2, older adults reported fewer diabetes and general stressors across the 14 days of the diary and less diabetes distress. As show in Table 3, controlling for length of diagnosis and comorbidity, age continued to be associated with lower diabetes distress, fewer diabetes stressors and fewer general stressors. Greater comorbid conditions were also associated with higher diabetes distress.

To further understand age differences in general and diabetes stressors, multilevel ordinal analyses were conducted predicting each type of event on the checklist with age, length of diagnosis, and comorbidity on the intercept (see Table 4). Older adults reported fewer diabetes stressors across the majority of stressors, with the exception of three (taking the wrong amount of insulin, feeling bad about their diabetes, and problems with equipment). Older adults also reported fewer general stressors with two exceptions. Older adults reported general stressors that occurred at home or with a friend or family member with similar frequency as younger adults.

Age Differences in Reactivity to Stress

We first ran unconditional models to calculate intraclass correlation coefficients (ICCs), finding both variability between- and within-person for all variables. Between-person variability was 56.62% for positive affect, 44.67% for negative affect, 68.13% for self-care behaviors, and 30.61% for blood glucose.

Positive affect. Multilevel models predicting positive affect (see Table 5) revealed that both daily general and diabetes stressors (within-person effects) significantly predicted lower positive affect. This means that on days when individuals reported greater general and diabetes stressors than their own average, they reported lower positive affect. In addition to these daily within-person effects, significant between-person effects were found for general stressors, indicating that individuals who reported greater general stressors across the 14-day diary reported less positive affect than individuals who reported fewer general stressors. No age main effects or interactions of age with general or diabetes stressors were found, indicating no evidence for age differences in reactivity for positive affect. Greater comorbid conditions were associated with lower positive affect. However, comorbidity did not interact with general or diabetes stressors, and the three-way Age × Comorbidity × Stressor interactions were not significant. Neither the within nor the between General × Diabetes Stressor interactions were significant.

Negative affect. Both within-person and between-person effects of general and diabetes stressors were found on negative affect. That is, on days when individuals reporter greater general and diabetes stressors than their average, they reported higher negative affect. Further, individuals who reported greater diabetes and general stressors across the 14-day diary reported greater negative affect. No age main effects or interactions of age by general or diabetes stressors were found, indicating no evidence for age differences in reactivity for negative affect. The main effect

Table 3
Multiple Regressions Predicting Diabetes Distress, Average Diabetes, and General Stressors

	Diabetes distress		Diabetes stressors		General stressors	
Predictors	*B* (*SE*)	*t*	*B* (*SE*)	*t*	*B* (*SE*)	*t*
Intercept	2.465 (.178)	13.83**	.381 (.033)	11.56**	.223 (.024)	9.16**
Length of diagnosis	−.005 (.005)	−1.01	.000 (.001)	−.51	.000 (.001)	.70
Comorbidity	.105 (.039)	2.68**	.009 (.007)	1.30	.005 (.005)	.97
Age	−.013 (.005)	−2.62*	−.003 (.001)	−3.30**	−.002 (.001)	−3.02**
Percent variance explained	7.9% **		9%**		5.2%**	

* $p < .05$. ** $p < .01$.

Table 4
Odds Ratios of Multilevel Ordinal Analysis Predicting Reported Exposure to Each Type of Stressor by Age, Length of Diagnosis, and Comorbidity

Dependent measure	Age odds ratio [95% CI]	Length of diagnosis odds ratio [95% CI]	Comorbidity odds ratio [95% CI]
Diabetes stressors did you. . . .			
have a problem with high blood sugar?	.982** [.968, .995]	.996 [.982, 1.009]	1.027 [.917, 1.150]
have a problem with low blood sugar?	.976** [.962, .990]	1.010 [.996, 1.024]	1.111 [.992, 1.244]
forget or skip a blood glucose test?	.969** [.947, .990]	1.000 [.978, 1.021]	1.152* [1.004, 1.322]
take wrong amount of insulin?	.991 [.971, 1.012]	1.006 [.987, 1.026]	.843* [.716, .993]
feel bad (upset, angry, sad) because of your diabetes?	.984 [.967, 1.001]	.989 [.972, 1.005]	1.191* [1.034, 1.372]
have difficulties with your diet today?	.982* [.966, .998]	.995 [.978, 1.012]	1.056 [.937, 1.192]
have a problem with your equipment used to monitor diabetes (pump or continuous blood-glucose monitor)?	.984 [.968, 1.001]	1.012 [.993, 1.032]	1.034 [.993, 1.032]
General stressors did you. . . .			
have an argument or disagreement with someone?	.975** [.960, .989]	1.006 [.992, 1.020]	1.144* [1.027, 1.274]
have a stressful or bothersome event at work?	.960** [.944, .975]	1.004 [.987, 1.022]	.973 [.849, 1.115]
have a stressful or bothersome event happen at home?	.989 [.976, 1.002]	1.005 [.993, 1.018]	1.092 [.975, 1.223]
have something bad happen to a relative or close friend?	.999 [.978, 1.020]	1.009 [.991, 1.028]	.945 [.818, 1.093]

* $p < .05$. ** $p < .01$.

of comorbidity, the Comorbidity × Stressor interactions, and the three-way Comorbidity × Stressor × Age were all not significant. The general stressor by diabetes stressor interaction (between) was significant. Plotting the interaction one standard deviation above and below the mean for general stressors (see Figure 1) indicated that diabetes stressors on average were associated with greater negative affect, only for those experiencing higher general stressors (simple slopes test for those with higher general stressors slope =. 81, t = 3.51, p = .0006, for those with lower general stressors slope = .23, t = 1.03, p = .30). The within-person interaction was not significant.

Self-care. Analyses for self-care indicated that only diabetes stressors (both within- and between-person) were a significant predictor of poorer self-care. A significant effect of length of diagnosis indicated that those who had the illness for a longer time reported better self-care, but there were no inter-

Table 5
Multilevel Models Predicting Affect and Diabetes Outcomes

Fixed effects	Positive affect (*SE*)	Negative affect (*SE*)	Self-care (*SE*)	BG mean (*SE*)
Intercept	2.84 (.05)***	1.56 (.03)***	4.42 (.04)***	176.23 (2.77)
Day	−.02 (.003)***	−.003 (.002)	−.002 (.002)	.49 (.29)
General stress (W)	−.78 (.08)***	.79 (.06)***	−.06 (.05)	2.66 (5.68)
Diabetes stress (W)	−.20 (.06)**	.22 (.05)***	−.68 (.06)***	67.01 (6.28)***
General stress (B)	−1.03 (.49)*	1.36 (.27)***	−.13 (.34)	−26.83 (28.88)
Diabetes stress (B)	−.67 (.35)	.52 (.19)**	−1.18 (.25)***	82.09 (21.64)***
General Stress (W) × Diabetes Stress (W)	.51 (.38)	−.06 (.29)	−.37 (.23)	−29.21 (30.50)
General Stress (B) × Diabetes Stress (B)	1.06 (2.26)	2.88 (1.22)*	.04 (1.62)	−123.15 (132.59)
Length of diagnosis	.005 (.004)	−.0004 (.002)	.01 (.003)*	−.23 (.23)
Age	−.003 (.004)	.002 (.003)	.002 (.003)	.19 (.24)
Comorbidity	−.09 (.03)**	.02 (.02)	.004 (.02)	1.64 (1.89)
Age × General Stress (W)	.01 (.01)	−.001 (.005)	−.001 (.003)	−.26 (.37)
Comorbidity × General Stress (W)	−.08 (.06)	.06 (.06)	−.02 (.04)	10.87 (5.13)*
Age × Comorbidity × General Stress (W)	.01(.004)	−.003 (.003)	−.000003 (.003)	−.24 (.29)
Age × Diabetes Stress (W)	−.01 (.01)	.004 (.004)	.005 (.004)	.43 (.42)
Comorbidity × Diabetes Stress (W)	.01 (.05)	.02 (.04)	.01 (.04)	−2.38 (4.72)
Age × Comorbidity × Diabetes Stress (W)	−.004 (.004)	−.0001 (.003)	−.0003 (.002)	.10 (.23)
Random effects	**Variance**	**Variance**	**Variance**	**Variance**
Intercept	.35***	.09***	.24***	1016.64***
Day slope	.001***	.0003***	.001***	6.40***
General stress slope	.24***	.26***	.08	350.90
Diabetes stress slope	.16**	.16***	.23***	746.82
General Stress × Diabetes Stress Slope	4.31*	3.46**	1.52	14921.97
Level 1 residual	.23	.11	.10	2024.93
Pseudo R^2	5.8%	16.5%	15.1%	2.1%

Note. W = within-person, B = between-person; BG = blood glucose.
* $p < .05$. ** $p < .01$. *** $p < .001$.

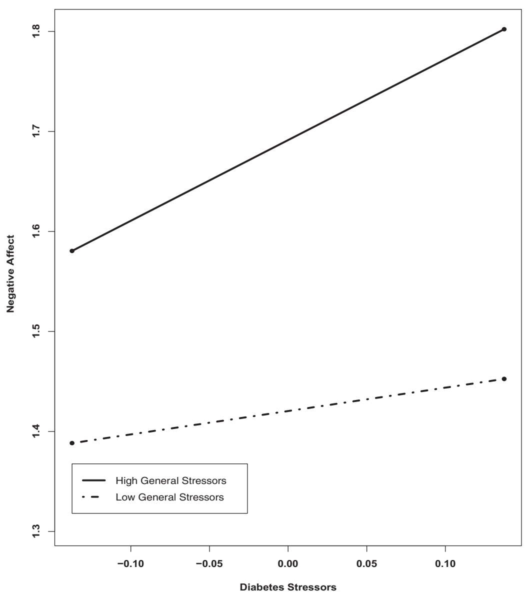

Figure 1. Association between diabetes stressors (between-person) and negative affect moderated by general stressors (between-person).

actions involving age or comorbidity with general or diabetes stressors.

Blood glucose mean. Analyses for daily blood glucose mean indicated that only diabetes stressful events (both within- and between-person) were a significant predictor of higher (worse) blood glucose. No age effects nor interactions with age were significant. A significant cross-level interaction of comorbidity by general stressors (see Figure 2, interaction was plotted at one standard deviation above and below the mean for comorbid conditions) revealed that general stressors were associated with higher BG mean for those with greater comorbid conditions, but with lower BG mean for those with fewer comorbid conditions. However, neither of the simple slopes tests were statistically significant (for those with higher comorbid conditions, slope = 18.35, t = 1.95, p = .052; for those with lower comorbid conditions, slope = 13.02, t = −1.56, p = .12).

Discussion

Age Differences in Exposure to Stress

The results indicate that older adults report less stress both with respect to their chronic illness of Type 1 diabetes and with respect to stressors experienced generally in daily life. The fact that such results were consistent across all metrics of stress (global diabetes distress, daily diabetes stressors, general stressors) is compelling, as these different metrics cross domains (diabetes and general) as well as methodologies (daily diaries and surveys). Although all three metrics of stress were correlated, they were not so highly correlated to indicate that they were tapping into a broader construct of general distress. Age differences in reported exposure to diabetes stressors existed in the context of older adults reporting greater comorbidities, likely due to their having lived with diabetes for a number of years. That is, despite the fact that older adults reported greater comorbidities, they reported fewer diabetes stressors. These findings are consistent with a growing literature that indicates older adults report less exposure to stressors across interpersonal tensions and work contexts (Birditt et al., 2005; Stawski et al., 2008) than younger adults. In fact, the size of the zero-order correlations is quite comparable to those reported in the integrative analysis of Stawski et al. (2019) across multiple data sets including diaries and ecological momentary assessments. The results add significantly to the large literature on diabetes distress, which has typically not examined age differences (Hessler et al., 2011).

Older adults may report less exposure to stress for a number of reasons, some of which we were able to address in the present study. First, older adults have had diabetes for a longer period of time and this greater experience may hone skills to proactively deal with daily challenges that mitigate distress. The analyses controlling for length of diagnosis indicate that age differences in diabetes-specific and general stressors as well as diabetes distress were maintained when length of diagnosis was controlled. Thus, older adults' greater experience with diabetes is not likely to explain their lower reported exposure to diabetes stress. Second, older adults could be experiencing different types of stressors as a result of the course of the illness that are more or less distressing. However, qualitative analyses of open-ended descriptions of the most stressful event of the day in the present sample indicated few age differences in the types of stressors that individuals mentioned on a daily basis (Kelly et al., 2019).

Analyses examining age differences by each diabetes and general stressor revealed that older adults generally reported less exposure to most types of diabetes stressors with the exception of three (taking the wrong amount of insulin, feeling badly about their diabetes, and problems with equipment). The result that these stressors were experienced equally across the adult life span might indicate that such stressors are ubiquitous in the lives of adults

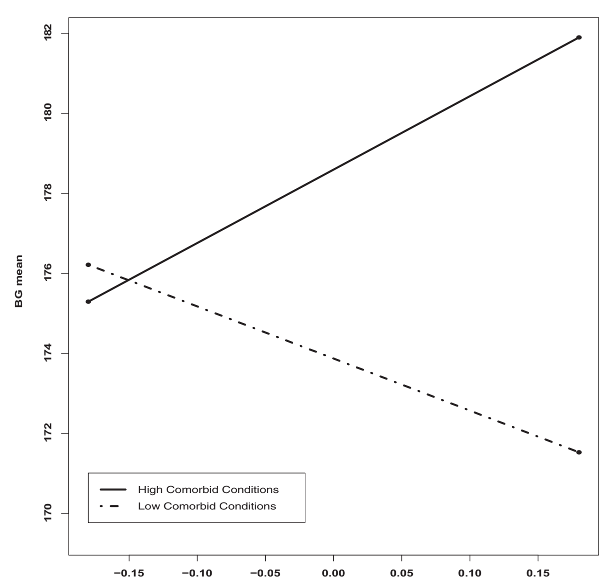

Figure 2. Association between general stressors (within-person) and BG Mean as moderated by comorbid conditions. BG = blood glucose.

across the life span and could be a target for intervention. Routine assessment (are you having trouble accessing insulin? is insulin being drawn up in a syringe correctly? is the insulin pen or pump being used accurately?) and coaching by diabetes educators and health care providers may be needed to assure older adults are indeed taking the correct amount of insulin. Older adults also reported fewer general stressors related to work and arguments, but no differences were found in problems at home and related to family and friends. These results may indicate that such events are less controllable compared to other stressors. Such results provide some nuance to the general finding that older adults may experience fewer stressors overall than young adults. Understanding differential appraisal processes that make some types of stressors less distressing in the first place or proactive coping strategies that prevent problems from occurring (Charles, 2010) is needed. Such research may benefit from methodologies used in the proactive coping literature (Charles et al., 2009) to understand what older adults may be doing to avoid certain diabetes and general stressors and not others. Older adults report using more proactive coping (e.g., "I handle situations before they become stressful," Neubauer, Smyth, & Sliwinski, 2019) than younger adults.

Age Differences in Stress Reactivity

Despite their reduced reported exposure to diabetes and general stressors, on days when stressors occurred, older adults were equally reactive in terms of their positive and negative affect as well as their self-care and BG mean. These results are consistent with the Stress Vulnerability and Integration (SAVI) model proposed by Charles (2010). That is, though older adults may be quite effective at reducing their exposure to stressors, they may experience similar amounts of disruption to affect and diabetes management when they do experience stressful situations (Charles, 2010).

Individuals with greater comorbid conditions, in general, were not more reactive than those with fewer comorbid conditions and age did not interact with comorbid conditions to affect reactivity. Such results are in contrast to Piazza et al. (2007) who found that when older adults had greater numbers of chronic illness conditions (4 or more chronic conditions), they were similar in their reactivity to daily stress as were young adults. Differences in samples may have produced the different results in the present study as many fewer individuals had four or more chronic conditions (8.5% of individuals reported 4 or more comorbid conditions as compared to 21.3% in Piazza et al.'s sample). To be in our study one not only needed to have Type 1 diabetes but also have a partner without diabetes who was able to participate, likely restricting the sample to somewhat healthier couples.

The fact that general and diabetes stressors were similarly disruptive to affect and diabetes stressors disruptive to self-care and blood glucose across the adult life span, suggests that all adults may be in need of dealing with daily stressors that occur with respect to Type 1 diabetes management. Interventions may be needed to reduce the amount of disruption to well-being of these recurrent daily diabetes and general stressors. Interventions that focus on healthy coping techniques and stress reduction have been effective in increasing quality of life and reductions in HbA1c (Fisher, Thorpe, McEvoy Devellis, & Devellis, 2007; Fisher et al., 2018). As diabetes stressors are likely to occur on a daily basis, reducing their effect on affect and self-care and blood glucose could be important for long-term health. Stress reactivity to daily stressors has been associated with long-term health issues including mortality (e.g., Chiang et al., 2018). Thus, preventing and dealing with both general and diabetes stressors can be critical to ensuring patients' daily emotional well-being and long-term health outcomes. In addition, research is needed to understand the physiological as well as psychological mechanisms underlying the association between daily stressors and outcomes, especially blood glucose (Hilliard et al., 2016).

The lack of age differences in our findings for positive and negative affect are somewhat surprising in light of the broad findings in the literature on the positivity effect, where older adults are more likely to report more positive affect and less negative affect than young adults (Carstensen et al., 1999). However, our findings for negative affect are in line with current research that indicates that when one takes into account the differential exposure to daily stressors age differences in negative affect are no longer found (Charles, Mogle, Urban, & Almeida, 2016). However, our results for positive affect are not consistent with Charles et al. (2016) who found that older adults reported greater positive affect compared to younger adults, even when taking into account daily stressors (Charles et al., 2016). The fact that age was not associated with the zero-order correlations of average positive or negative affect has been found in other studies of daily stressors (Koffer et al., 2016). The experience of a chronic illness and its associated daily stressors may make the affective experience more similar across young and older adults. In addition, the fact that adults of all ages were experiencing similar levels of blood glucose may relate to their similarities in affect, given recent work noting that the positivity effect may relate to glucose levels for older adults without diabetes (Mantantzis, Maylor, & Schlaghecken, 2018).

Additive Nature of General and Diabetes Stress

The fact that general and diabetes stressors both contributed to daily positive and negative affect suggests that both types of stressors may independently contribute to daily well-being of adults with a chronic illness. Adults with T1D experience stressors related to diabetes as well as those related to everyday life; however, there are few studies in which general and diabetes-specific stressors are examined simultaneously. Previous studies on daily stressors and daily well-being have largely examined how daily general stressors, such as arguments, work and education, home stressors, and network stressors, are associated with affect and health among the general population (Hill, Sin, Turiano, Burrow, & Almeida, 2018; Sin et al., 2017; Surachman, Wardecker, Chow, & Almeida, 2019). Those who have studied daily stressors in the context of chronic illness either examine how those with chronic illness respond to general stressors compared to those without chronic illness (Costanzo, Stawski, Ryff, Coe, & Almeida, 2012) or how stress more generally affects daily well-being (August, Rook, Franks, & Parris Stephens, 2013). This study, however, focused on both general and diabetes stressors and yielded a more comprehensive understanding of the effects of daily stressors on daily emotional well-being among adults with T1D. Understanding the additive effects of general and diabetes stressors on daily well-being may be particularly important because daily stressors in one domain can spillover to another domain of life (Tracy et al., 2019). Tracy et al. (2019) found with the present sample that daily general stressors were associated with more diabetes stressors. General stressors may impede an individual's ability to spend time on behaviors related to managing diabetes. In addition, diabetes-related stressors such as addressing a high or low blood glucose event may create stressors in interpersonal domains (e.g., generating an argument with one's spouse concerning whether diabetes was managing properly or interfering with responsibilities such as parenting children). Because we found that both general and diabetes stressors independently were associated with emotional well-being, the effects of these two types of stressors appear additive. We did not, in general, find evidence that general and diabetes stressors interacted to produce differential outcomes for affect and self-care. That is, days of higher diabetes and general stressors were not significantly different from days where one was high and the other low. This was somewhat surprising and may have to do with the relatively strong association between general and diabetes stressors.

In contrast to daily affect, diabetes self-care and blood glucose mean were only uniquely associated with diabetes stressors, not general stressors. These results are consistent with work with adolescents that indicates that diabetes-specific stress was only uniquely associated with diabetes-specific outcomes (Rechenberg et al., 2017). The greater link of diabetes stressors to self-care and blood glucose could be due to the overlap in content between diabetes stressors and self-care behaviors. For instance, one of the diabetes stressors was "forgetting or skipping a blood glucose test," similar in content to one of the self-care behaviors of "checking blood glucose with monitor." A similar issue could be operating in the link between diabetes stressors and blood glucose mean in that two of the stressors in the checklist (problem with high blood sugar and problem with low blood sugar) would reflect one's daily blood glucose. Supplemental analyses eliminating overlapping diabetes stressors related to BG mean (highs and lows in blood glucose), however, revealed similar effects. As blood glucose is affected by disruptions in self-care, the types of diabetes stressors we assessed may be directly related to problems in maintaining good glucose control. Future research is needed using a more comprehensive list of diabetes stressors that considers diabetes technologies and diabetes-related complications to rule out whether these issues in assessment are producing the results.

The results of the study should be interpreted in the context of some limitations. First, the sample was limited in diversity, being primarily non-Hispanic white (with Type 1 diabetes most commonly developing among European Americans), highly educated, and experiencing relative good HbA1c levels, although still above ADA recommendations of an HbA1c $< 7.0\%$; (American Diabetes Association, 2019). Although the sample included adults across the life span, the age of older adults was somewhat younger than other samples (e.g., in the National Study of Daily Experiences, the upper age range was up to 84 years of age, Almeida, McGonagle, & King, 2009). Recruiting older adults in the present sample was somewhat challenging as many older adults reported that they were not well enough to participate or had lost their spouse. It is possible that with a sample of older adults of more advanced age, older adults may have used appraisal processes that have been associated with "time left to live" (Carstensen et al., 1999), thereby showing less reactivity to stressors than younger adults. However, differences in life expectancy between those with and without Type 1 diabetes (average life expectancy of 69 years for those with Type 1 diabetes vs. 77 years for males and 81 years for females for those without; see Miller, Secrest, Sharma, Songer, & Orchard, 2012), likely result in these appraisal processes occurring at a younger age than for normative adults. These results should be replicated with a more diverse sample to address generalizability. Relatedly, the individuals in the study were recruited as part of a study of couples coping with Type 1 diabetes and represents only those individuals who have a close romantic partner. Given that married couples are known to have better health and engage in better health care behaviors (Holt-Lunstad, Smith, & Layton, 2010), this also is an important consideration when interpreting our results.

Second, diabetes stressors, general stressors, affect, and diabetes outcomes were assessed at the same time once per day, limiting our ability to make firm statements that affect was in reaction to the stressful event. As noted by Stawski et al. (2019), our results may be more accurately described as stressor-related affect and diabetes management rather than reactivity to a specific stressful event, per se. Use of Ecological Momentary Assessment (EMA) to measure affect and diabetes outcomes subsequent to a diabetes or general stressor would add specificity to the ways in which stressors are tied temporally to reactions to those stressors (see Scott et al., 2017 for details). In addition, although an important contribution of the study was to examine general stressors beyond those of Type 1 diabetes, we did not include a comprehensive assessment of daily general stressors such as the full Daily Inventory of Stressful Events (Almeida et al., 2002). Although daily diary studies are limited in terms of the number of items that can be assessed, expanding both the diabetes and general stressors will be helpful in generalizing the results. Finally, the pseudo R^2s reveal a percentage of variance that is in line with that reported by integrated analyses across several data sets (e.g., Stawski et al., 2019). However, they also reveal that the vast majority of variance in affect, self-care, and BG mean are not explained by daily diabetes or general stressors. Future research is needed as to other aspects of daily experience that may affect these daily outcomes.

The results extend the literature on age differences in reactions to daily stressors by showing similar results across both general and diabetes stressors—in terms of lower reported exposure to stressors with age and no age differences in reactivity to stressors. Individuals with Type 1 diabetes are at risk for developing long-term complications of the disease such as cardiovascular disease, neuropathy, and kidney disease, among others. Those who are more reactive to daily stressors are at higher risk for developing a chronic physical health condition (Piazza, Charles, Stawski, & Almeida, 2013) and of mortality (Chiang et al., 2018). Thus, understanding how to mitigate the effects of daily diabetes and general stressors on well-being and diabetes management will be important in likely slowing chronic disease progression among adults with illnesses like Type 1 diabetes.

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