Strengths, Risk Factors, and Resilient Outcomes in Adolescents With Type 1 Diabetes: Results From Diabetes MILES Youth–Australia

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Diabetes Care 2017;40:849–855 | https://doi.org/10.2337/dc16-2688

OBJECTIVE

Despite the challenges of living with type 1 diabetes, many adolescents achieve "resilient outcomes": high engagement in self-management behaviors such as self-monitoring of blood glucose (SMBG), good quality of life (QOL), and within-target glycemic outcomes (HbA_{1c}). Adaptive diabetes-related behaviors (i.e., "strengths") are associated with resilient outcomes, yet the combination of risks and strengths in relation to resilient outcomes is unclear. The aim of this study was to investigate relations among diabetes strengths and resilient outcomes in the context of psychological and family risk factors.

RESEARCH DESIGN AND METHODS

A total of 471 Australian adolescents with type 1 diabetes (mean age 15.7 ± 1.9 years; diabetes duration 6.9 ± 4.2 years; 62% female; 53% using insulin pumps) completed a national cross-sectional survey about their diabetes-related strengths, risk factors (depressive/anxiety symptoms, family conflict), and resilient outcomes (SMBG frequency, general QOL, HbA_{1c}).

RESULTS

Greater diabetes strengths were significantly related to resilient outcomes: more frequent SMBG ($r = 0.39$), lower HbA_{1c} ($r = -0.31$), and higher general QOL ($r = 0.50$), as well as to lower risks: fewer depressive ($r = -0.45$) and anxiety ($r = -0.40$) symptoms and less conflict ($r = 0.28$). In multivariate regressions, diabetes strengths consistently related to all resilient outcomes beyond significant risk factors.

CONCLUSIONS

In a large sample of Australian adolescents, diabetes strengths were strongly related to key resilient outcomes, even in the presence of well-documented psychological and family risk factors. More research is needed to determine whether strengths reduce or buffer other risks. Given the associations with self-management, HbA_{1c}, and general QOL, monitoring and enhancing diabetes strengths may support resilience promotion during a vulnerable developmental period.

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Received 16 December 2016 and accepted 26 March 2017.

Management of type 1 diabetes is particularly challenging during adolescence, a period of elevated risk for deterioration in diabetes self-management and glycemic outcomes compounded by developmental, physiological, and hormonal changes (1,2). Psychosocial concerns and poor diabetes-related quality of life (QOL) play a role in suboptimal diabetes outcomes during adolescence (3,4).

Despite these challenges, resilient outcomes are relatively common: diabetes resilience is defined as achievement of one or more positive diabetes outcomes (i.e., high engagement in diabetes self-management behaviors, self-perception of having good QOL, within-target glycemic outcomes) despite the challenges of living with type 1 diabetes (5). Positive outcomes in all three areas are ideal, yet outcomes may vary across domains (6), and diabetes resilience may be represented by achieving one or more optimal outcomes in the face of exposure to adversity (5). For example, in a longitudinal trajectory analysis of 150 adolescents (aged 14–18 years) with type 1 diabetes, 40% were classified as "meeting treatment targets," defined as maintaining a trajectory of frequent self-monitoring of blood glucose (SMBG) mean 4.8 $\pm$ 0.3 checks per day) and within-target HbA_{1c} (mean 7.4 $\pm$ 1.2%) (7). Compared with the other 60% of the sample with two to three SMBG checks per day and mean HbA_{1c} above target, the outcomes in this group represent resilience in the domains of self-management behavior and glycemic outcomes (QOL not assessed).

Risks and strengths are both associated with diabetes outcomes. Risk factors, including family conflict about diabetes, parental monitoring of youth self-management that does not match the youth's needs or abilities, depressive symptoms, diabetes distress, and limited socioeconomic resources in the family, have all been linked with suboptimal self-management and glycemic outcomes (3,7–10). There is also a growing body of evidence about protective skills and behaviors (i.e., strengths) that promote resilient outcomes, including confidence or self-efficacy to manage the demands of type 1 diabetes, adaptability to handle unpredictable diabetes-related challenges (e.g., problem-solving, effective coping), and seeking and receiving developmentally appropriate help and support from family and other supporters (2,5,11–15).

The mounting empirical attention to positive processes and outcomes in type 1 diabetes is encouraging, and this initial wave of research has tended to focus on identifying and characterizing strengths and protective processes. Less is known about how risks and strengths function in combination in relation to resilient outcomes. A better understanding of whether diabetes-related strengths serve a protective function in the context of risk factors can inform the focus of future resilience-promotion interventions to enhance diabetes outcomes. Thus, the aim of this study was to investigate relations among diabetes-related strengths and resilient outcomes across adolescents with type 1 diabetes with varying levels of psychological and family risk. We hypothesized that strengths would be associated with resilient outcomes (i.e., high engagement in self-management behaviors, high general QOL, within-target HbA_{1c}) beyond the associations of risk factors (i.e., elevated depressive symptoms, anxiety symptoms, and diabetes-related family conflict).

RESEARCH DESIGN AND METHODS

Participants and Procedures

The data for this study were drawn from the Diabetes Management and Impact for Long-term Empowerment and Success (MILES) Youth Survey–Australia (MILES Youth), a large-scale, national survey of youth with type 1 diabetes and parents/carers in Australia, described in detail elsewhere (16). The overall goals of MILES Youth were to explore *1*) the extent to which young people with diabetes engage in self-care behaviors, *2*) the perceived effect of living with diabetes (including its management and acute complications) on QOL and emotional well-being, and *3*) youth perceptions about their ability to manage their condition and about the supportiveness of parents, peers, and health care professionals. The study was intended to generate results that would raise awareness of psychosocial well-being and the needs of youth with type 1 diabetes and their parents and that could be used to inform resources, services, and interventions to benefit this population. The initial MILES Youth Study survey was piloted, and cognitive debriefing interviews were conducted with eight youth aged 11–18 years. Their feedback and that of an expert advisory group suggested that the survey was too long to feasibly recruit and obtain complete data from a large sample. The battery of questionnaires was therefore shortened to reduce burden and increase response rates. To achieve this, some measures were retained in their entirety, and others were abbreviated by using validated short forms or by selecting a subset of representative items (16).

Youth eligibility criteria for the MILES Youth Study included age 10–19 years and a diagnosis of type 1 diabetes. The study team invited 5,928 eligible National Diabetes Service Scheme (NDSS) registrants whose parents had previously agreed to being contacted for research purposes to participate and also advertised the survey via flyers in diabetes clinics, social media postings, at diabetes events, and in diabetes publications. Participants were entered into a prize drawing to win a tablet computer as an incentive for participation. A total of 781 youth participated in MILES Youth. To focus on adolescent experiences for this analysis, only respondents aged 13–19 years, whose type 1 diabetes was diagnosed for at least 1 year, and who completed the measure of diabetes-related strengths were included, with a final sample size of 471. Data were collected via secure web survey (open for 6 weeks in late 2014), and the questionnaire battery was administered according to participant age.

Measures

The Diabetes Strengths and Resilience Measure for Adolescents (DSTAR-Teen) was used to assess diabetes-related strengths. The DSTAR-Teen is a 12-item, self-report measure of adaptive attitudes and behaviors related to living with type 1 diabetes, with strong reliability and validity (11). Internal consistency in this sample was good (α = 0.88).

Individual and family risk factors were assessed with three self-report questionnaires. To assess depressive symptoms, youth completed the eight-item version of the Patient Health Questionnaire for Adolescents (PHQ-A) (17), with the ninth item regarding suicidal ideation and self-harm omitted because of the problematic nature of that item (18). Internal consistency in this sample was excellent

(α = 0.91). To assess anxiety symptoms, youth completed the seven-item Generalized Anxiety Disorder Scale, (GAD-7) (19). Internal consistency in this sample was excellent (α = 0.91). A cutoff of 10 or above was used for both the PHQ-A (20) and GAD-7 (19) as an indicator of clinically significant symptoms. Family conflict related to diabetes management was assessed with two items derived from the Diabetes Family Conflict Scale Revised (DFCS-R) (21), measuring the frequency of arguments about *1*) remembering to inject insulin or check blood glucose and *2*) meals and snacks. These two items represent two major components of diabetes management about which conflict is common (22) and were averaged together to create a summary conflict score in all analyses, with higher scores indicating less conflict.

Three outcomes were assessed, aligned with the Diabetes Resilience Model (5). Youth self-reported their average frequency of SMBG on a scale from fewer than one to seven or more checks per day as a proxy measure of engagement in key self-management behaviors of the type 1 diabetes regimen, and self-reported their most recent HbA_{1c} value. Responses were categorized with resilient outcomes defined as four or more SMBG checks per day and HbA_{1c} $\leq$58 mmol/mol (7.5%). General QOL was assessed using a single item from the Monitoring Individual Needs in Diabetes (MIND) Youth Questionnaire (MY-Q), asking respondents to rate their life in general on a 0–10 scale ranging from "worst possible life" to "best possible life" (23). This single-item measure of general QOL is correlated with diabetes-specific health-related QOL as measured by the MY-Q (r = 0.55, $P < 0.001$) and with general emotional well-being as measured by the World Health Organization-Five (WHO-5) Well-being Index (r = 0.58, $P < 0.01$) (24). General QOL was considered both as a continuous outcome with higher scores indicating better QOL and as a dichotomized outcome using the cutoff of $\geq$7, based on the median score in this sample and on empirical evidence from a similar 1–10 rating scale that uses 7 as the cutoff (23).

Demographic variables (age, sex, language, country of birth) and clinical variables (diabetes duration, insulin therapy via pump or injections) were also self-reported. The Index of Relative Socio-Economic Advantage/Disadvantage (IRSAD) (25) was used to index socioeconomic status. An IRSAD decile code was computed using the respondent's postcode. Full details of the study methods are reported elsewhere (16).

Statistical Analysis

All data were cleaned and evaluated for normality and outliers. First, bivariate associations were assessed between the DSTAR-Teen scores and each measure of risk and each outcome to determine which should be included in subsequent multivariate analyses. Pearson correlations were conducted for all variables with continuous scores (i.e., DFCS-R, SMBG, HbA_{1c}, QOL, PHQ-A, GAD-7). Next, multivariate regressions were conducted to evaluate whether strengths were associated with resilient outcomes, controlling for relevant demographic/clinical covariates (i.e., those with significant bivariate associations) and beyond psychological and family risk factors. Separate logistic regression models were run with each of the three resilient outcomes as dependent variables: SMBG frequency of four or more checks per day, HbA_{1c} $\leq$58 mmol/mol or 7.5%, and general QOL ratings $\geq$7. Finally, a logistic regression model was run with a dichotomous dependent variable representing achievement of all three resilient outcomes, comprising SMBG frequency of four or more checks per day, HbA_{1c} $\leq$58 mmol/mol or 7.5%, and general QOL rating $\geq$7. The following independent variables were entered simultaneously in each model: demographic variables (age, sex), clinical variables (diabetes duration, insulin regimen), risk factors (family conflict, depressive symptoms, and anxiety symptoms), and the diabetes strengths score (DSTAR-Teen). Odds ratios and 95% CIs are reported for all independent variables in the multivariate logistic regressions. Analyses were conducted using SPSS Statistics for Windows 22.0 software (IBM Corp., Armonk, NY) and Stata 14 software (StataCorp LP, College Station, TX). Respondents with missing data were excluded from our multivariate analyses (n = 50 excluded in the HbA_{1c} analyses because of missing values).

RESULTS

Participant Characteristics

The sample (N = 471) was 62% female with a mean age of 16 $\pm$ 2 years (range 13–19). They had type 1 diabetes for a mean of 7 $\pm$ 4 years (range 1–18), and 53% reported using an insulin pump. Their mean self-reported most recent HbA_{1c} was 66 $\pm$ 17 mmol/mol or 8.2 $\pm$ 1.6% (range 33–173 mmol/mol, 5.2–18.0%), and 38.7% had within-target HbA_{1c}. The mean daily SMBG was 4.7 $\pm$ 2.1 checks per day, and 75.7% reported a mean of four or more checks per day. The mean general QOL rating was 6.8 $\pm$ 2.0, and 65.0% had scores $\geq$7. In addition, 112 participants (26.7%) achieved all three resilient outcomes: SMBG frequency of four or more checks per day, HbA_{1c} $\leq$58 mmol/mol or 7.5%, and general QOL ratings $\geq$7. Participant characteristics and descriptive information for all self-reported demographic, clinical, and behavioral measures are summarized in Table 1.

Bivariate Associations

Lower risks were significantly associated with greater diabetes strengths (Table 2): DSTAR-Teen scores were correlated with fewer depressive symptoms, fewer anxiety symptoms, and less diabetes family conflict. Greater strengths were also associated with more resilient outcomes (continuous): more frequent SBMG, lower HbA_{1c}, and higher general QOL. Strengths also differed across categories of the resilient outcomes: DSTAR-Teen scores were significantly higher among youth who reported four or more blood glucose checks per day (35.2 $\pm$ 7.7) compared with those with less frequent SMBG (27.8 $\pm$ 8.7) (t_{468} = 8.7, $P < 0.001$); among those with HbA_{1c} within target (36.3 $\pm$ 7.5) compared with above target (31.7 $\pm$ 8.6) (t_{419} = 5.6, $P < 0.001$); and among those with general QOL scores $\geq$7 (36.2 $\pm$ 7.8) compared with $<$7 (28.3 $\pm$ 7.5) (t_{469} = 10.6, $P < 0.001$).

Multivariate Regressions

Complete results for the four logistic regression models with SMBG, HbA_{1c}, general QOL, and all three resilient outcomes together as dependent variables are presented in Table 3.

In the model evaluating greater engagement in self-management (four or more SMBG checks per day versus fewer than four checks per day) as the dependent variable, diabetes strengths were significantly associated with greater SMBG (four or more checks per day) beyond significant associations with

Table 1—Participant demographic, clinical, and behavioral characteristics (*N* = 471)

	% (*n*) or mean ± SD (range)
Demographics	
Female sex	62 (294)
Age, years	15.7 ± 1.9
Country of birth, Australia	93 (436)
Clinical characteristics	
Diabetes duration, years	6.9 ± 4.2
Insulin regimen, pump	53 (249)
HbA_{1c}, self-reported, mmol/mol[a]	66 ± 17
HbA_{1c}, self-reported, %[a]	8.2 ± 1.6
HbA_{1c} ≤58.0 mmol/mol (7.5%)[a]	38.7 (163)
SMBG checks per day	4.7 ± 2.1
≥4 checks per day	75.4 (356)
Behavioral constructs	
Strengths (DSTAR-Teen)	33.4 ± 8.5 (10–48)
Depressive symptoms (PHQ-A total)	6.8 ± 6.0 (0–24)
<10 in PHQ-A	75.2 (354)
Anxiety symptoms (GAD-7 total)	5.9 ± 5.3 (0–21)
<10 in GAD-7	76.9 (362)
Family conflict (DFCS-R items)	3.4 ± 1.0 (1–5)
General QOL (MY-Q item)	6.8 ± 2.0 (0–10)
≥7 in MY-Q	65.0 (306)

[a]*n* = 421.

demographic, clinical, and risk factors. The model was significant (χ^2 = 97.72, *df* = 8, $P < 0.0001$), had adequate fit (Hosmer-Lemeshow goodness of fit; χ^2 = 4.97, *df* = 8, *P* = 0.76), and an overall accuracy of 79.7%. Controlling for all clinical, demographic, and risk factor variables, only younger age, female sex, and higher DSTAR-Teen scores were significantly associated with SMBG of four or more checks per day.

The model with HbA_{1c} (≤58 mmol/mol vs. >58 mmol/mol) as the dependent variable also demonstrated that diabetes strengths were significantly related to HbA_{1c}, beyond significant associations with clinical, demographic, and risk factors. The model was significant (χ^2 = 74.74, *df* = 8, $P < 0.0001$), with adequate fit (Hosmer-Lemeshow goodness of fit; χ^2 = 5.17, *df* = 8, *P* = 0.739) and an overall accuracy of 71.0%. Controlling for all demographic, clinical, and risk factor variables, male sex, shorter duration of diabetes, less diabetes-related family conflict, and higher DSTAR-Teen scores were significantly associated with HbA_{1c} in the target range.

Diabetes strengths were significantly associated with general QOL scores ≥7, beyond significant associations with demographic, clinical, and risk factors. The model was significant (χ^2 = 216.52, *df* = 8, $P < 0.0001$), had adequate fit (Hosmer-Lemeshow goodness of fit; χ^2 = 14.41, *df* = 8, *P* = 0.07), and an overall accuracy of 79.4%. Controlling for all clinical, demographic, and risk factor variables, older age, male sex, insulin pump use, less diabetes-related family conflict, lower anxiety symptoms, lower depressive symptoms, and higher DSTAR-Teen scores were significantly associated with general QOL ratings ≥7.

In the model with the combined dependent variable, diabetes strengths were significantly associated with achievement of all three resilient outcomes, beyond significant associations with demographic, clinical, and risk factors. The model was significant (χ^2 = 120.37, *df* = 8, $P < 0.0001$), had adequate fit (Hosmer-Lemeshow goodness of fit; χ^2 = 4.34, *df* = 8, *P* = 0.83), and an overall accuracy of 77.6%. Controlling for all clinical, demographic, and risk factor variables, shorter diabetes duration, insulin pump use, lower depressive symptoms, and higher DSTAR-Teen scores were significantly associated with SMBG of four or more checks per day, HbA_{1c} within-target (≤58 mmol/mol vs. >58 mmol/mol), and general QOL ≥7.

CONCLUSIONS

In this large, national sample of Australian adolescents, diabetes strengths were associated consistently with optimal health outcomes above and beyond powerful risk factors. Strengths in this Australian sample (mean DSTAR-Teen = 33.4 ± 8.5) were similar to those seen in the validation sample in the U.S. (mean = 36.9 ± 7.9) (11) These data are the first to provide evidence of resilience in the face of challenges related to living with and managing type 1 diabetes. Positive youth attitudes and behaviors surrounding life with diabetes were linked with all three key resilient outcomes—high engagement in self-management behaviors,

Table 2—Correlations among resilient outcomes, clinical, demographic, and behavioral characteristics, and DSTAR-Teen scores (diabetes strengths) (*N* = 471)

	2	3	4	5	6	7	8	9
1. HbA_{1c}	−0.337**	−0.260**	0.103*	0.153**	−0.182**	0.222**	0.282**	−0.306**
2. SMBG checks per day		0.236**	−0.242**	0.033	0.140**	−0.170**	−0.251**	0.393**
3. General quality of life			−0.114*	−0.068	0.294**	−0.625**	−0.672**	0.501**
4. Age				0.178**	0.138**	0.210**	0.257**	−0.172**
5. Diabetes duration					0.029	0.057	0.012	−0.044
6. Family conflict						−0.187**	−0.219**	0.280**
7. Anxiety symptoms							0.831**	−0.395**
8. Depressive symptoms								−0.454**
9. Diabetes strengths								

*$P < 0.05$. **$P < 0.01$.

Table 3—Odds ratios and 95% CI for associations with SMBG frequency, in-target HbA_{1c}, general QOL, and resilient outcomes

	SMBG frequency (≥4 checks/day) *n* = 469	In-target HbA_{1c} (<58.0 mmol/mol, 7.5%) *n* = 421	General QOL (≥7) *n* = 470	All 3 resilient outcomes *n* = 420
Age	**0.79** (0.69, 0.91)**	1.05 (0.93, 1.19)	**1.18* (1.02, 1.36)**	1.05 (0.91, 1.21)
Sex (male)	**0.57* (0.35, 0.97)**	**1.63* (1.04, 2.56)**	**2.08** (1.21, 3.55)**	1.59 (0.95, 2.67)
Diabetes duration (years)	1.00 (0.95, 1.07)	**0.86** (0.81, 0.91)**	0.96 (0.90, 1.02)	**0.85** (0.79, 0.91)**
Insulin regimen (insulin pump)	1.51 (0.92, 2.48)	1.52 (0.97, 2.39)	**1.74* (1.04, 2.91)**	**2.42** (1.40, 4.19)**
Diabetes-related family conflict[a]	1.07 (0.84, 1.38)	**1.32* (1.05, 1.67)**	**1.55** (1.19, 2.01)**	1.31 (0.99, 1.73)
Anxiety symptoms (GAD-7 ≥10)	0.62 (0.31, 1.24)	0.96 (0.48, 1.95)	**0.33** (0.16, 0.65)**	0.47 (0.17, 1.34)
Depressive symptoms (PHQ-A ≥10)	0.73 (0.37, 1.45)	0.58 (0.28, 1.19)	**0.17** (0.08, 0.33)**	**0.32* (0.12, 0.94)**
DSTAR-Teen scores[a]	**1.10** (1.07, 1.14)**	**1.04** (1.01, 1.08)**	**1.10** (1.06, 1.14)**	**1.10** (1.05, 1.14)**

Data set in bold indicate significant associations with each outcome. SMBG measured as average checks per day, categorized as <4 checks/day (reference category) vs. ≥4 checks/day. Sex reference category = female. Insulin regimen reference category = injections. Anxiety reference category = <10 in GAD-7. Depression reference category = <10 in PHQ-A. *$P < 0.05$. **$P < 0.01$. [a]Higher scores on the measure indicate less family conflict about diabetes.

good general QOL, and in-range HbA_{1c}. Strengths-outcomes associations were retained even when accounting for psychological and family risk factors as well as demographic and clinical covariates. These findings extend the growing body of research on diabetes-related strengths and resilience beyond characterizing positive processes acting alone.

Self-reported resilient outcomes were relatively high for each of the individual outcomes. Although previous research has demonstrated low adherence rates to SMBG recommendations (7), >75% of participants in this study reported a mean of four or more checks per day. In contrast to rates of <20% of participants in the Type 1 Diabetes Exchange in the U.S. achieving HbA_{1c} targets (26), nearly 40% of this national sample of Australian adolescents reported within-target HbA_{1c}. The average rating for general QOL was slightly below the cutoff of 7; however, nearly two-thirds of the sample rated their QOL as ≥7, indicating good general QOL. Moreover, approximately one-quarter of the sample achieved resilient outcomes in all three of the domains assessed. Given the well-documented challenges that make each of these optimal outcomes difficult, these rates suggest that individual resilient outcomes may be achievable by a substantial proportion of Australian adolescents with type 1 diabetes.

Diabetes-related strengths were associated with each of the resilient outcomes individually and combined, even in the context of multiple risk factors. The patterns of strength-outcome associations were similar when accounting for psychological and family risks as well as demographic and clinical covariates. Although the significant covariates and risk factors varied across outcomes, diabetes strengths retained significance with the outcome in every model. The associations among strengths, including diabetes-related self-efficacy and family support, and each outcome, including self-management, general QOL, and glycemic control, are consistent with and support findings from previous research characterizing positive attitudes, behaviors, and processes in this population (2,5,11–15). Similarly, the associations of these outcomes with risk factors, including depressive and anxiety symptoms and diabetes-related family conflict, also mirror previous findings: less diabetes-related family conflict and fewer psychological symptoms were linked with in-range HbA_{1c} and were most strongly and consistently related to better general QOL (3,7–10). The latter finding is not surprising, given the potential overlap of subjective well-being between psychological functioning and general QOL. However, the findings extend the field by demonstrating that these potent risk factors do not outweigh the importance of strengths in relation to behavioral, psychosocial, and biomarker indices of well-being among adolescents with type 1 diabetes. Therefore, diabetes strengths may serve a protective function in the context of risk factors, strengthening support for their role in promoting achievement of resilient outcomes in the face of adversity (5).

These results were obtained from cross-sectional data, which limits our ability to draw conclusions about predicting resilient outcomes over time or about the direction of associations among risks, strengths, and outcomes. It may be that strengths buffer the deleterious effect of risks on outcomes or that youth with better outcomes perceive themselves to have fewer risks and more strengths. Longitudinal data are needed to evaluate change in each construct over time. The outcomes were measured using self-reported single items, which introduces the potential for inaccuracies. Self-report data of SMBG, HbA_{1c}, and behavioral constructs may be limited by response biases, including social desirability. Respondents may report more frequent SMBG or lower HbA_{1c} values for social desirability (27–29). However, recent studies have demonstrated that errors in reported SMBG may be lower than previously thought (28), and the mean HbA_{1c} in this study was only slightly lower than clinic-recorded values in a recent Australian study (8.2% vs. 8.3%) (30). Because this was an anonymous population-based survey, it was not possible to collect objective clinical data, including laboratory values or downloaded data from blood glucose meters or insulin pumps. Furthermore, SMBG frequency is just one aspect of self-management. Objective measures of a range of self-management behaviors, including SMBG and clinic-recorded HbA_{1c} values, will provide more precision about associations of diabetes strengths with these key diabetes outcomes.

Single reporter bias is also a risk when using self-report data. For example, participants who want others to perceive them or who perceive themselves to have more diabetes strengths may also be more likely to report more frequent SMBG, higher QOL, and fewer psychological symptoms, among others. This study

did not collect parental report of their children's emotional functioning because of concerns about participant response burden and critiques of the inaccuracy of parent proxy reports of youth subjective states (e.g., underestimating youth health-related QOL compared with youth reports) (31,32). Collecting additional ratings about the youth's functioning from other reporters, such as parents, may help assess these constructs more comprehensively in future research.

An overarching aim of the MILES Youth Study was to explore a range of topics relevant to the lives of youth with diabetes and their families in order to identify those that might warrant further investigation in more depth. As such, participant burden was a major consideration, and brief measures were used in place of longer instruments when possible (16). Although this introduces limitations, including less detailed assessment and less favorable psychometric properties of individual items compared with longer measures, this approach permitted a broader assessment of numerous constructs. Indeed, previous studies have documented that single-item measures of QOL perform comparably with longer, multi-item measures and may be useful to reduce participant burden (33,34). In the current study, the single-item measure to assess general QOL represented the respondents' perceptions of their general QOL; this did not necessarily reflect the effect of health or diabetes on QOL, both of which may be more directly relevant to resilient diabetes outcomes (5). This single item has been validated against the total score of the MY-Q measure of diabetes-specific health-related QOL (23). The significant correlations of this single-item measure of general QOL with the MY-Q total diabetes-specific health-related QOL score and with the WHO-5 score measuring general emotional well-being (24) strengthen conclusions about its validity despite its brevity. In both samples, the associations with this single-item measure of general QOL were significant and of moderate size, suggesting that associations may be even stronger with diabetes-specific or health-related QOL. Therefore, future research using a validated, multi-item scale of QOL and/or health-related QOL would be valuable.

In addition, instruments measuring risk factors (e.g., PHQ-A, DFCS-R) were adapted for the current study, which may limit their psychometric properties. Specifically, although the psychometric properties of the DFCS-R are established (21), the two items drawn from the DFCS-R have not been validated. Thus, conclusions about diabetes-related family conflict should be drawn with this in consideration, and future research on this topic should consider using the full, validated measure. The PHQ-A was also adapted to remove the item assessing suicidality, given the anonymized, online administration of this survey and inability of investigators to follow-up with participants endorsing that item. This adaptation of the PHQ-A has been used effectively in other studies (18).

This study included a small set of risk factors and strengths, and there may be other diabetes-related adversities (e.g., low health literacy/numeracy [35]) or other protective processes (e.g., optimism [36]). Those analyzed in this study were selected because they have strong empirical support and address adolescents' lives both at the individual and family levels.

As with all clinical research, this study sample may not be representative of the broader population of youth with type 1 diabetes. Participants were recruited primarily from the NDSS, a large national database, and their parents had previously agreed to being contacted for research, which may limit generalizability. To minimize this limitation, recruitment also occurred through advertisements in diabetes clinics, social media postings, at diabetes events, and in diabetes publications. Replication of this study in other countries would be valuable to examine regional or cultural variations and any differences across socioeconomic and racial/ethnic groups.

In conclusion, in a large sample of Australian adolescents, the presence of diabetes-related strengths, even in the face of serious risk factors, appears to be associated with relatively common achievement of three key resilient outcomes: optimal SMBG, within-target HbA_{1c}, and good general QOL. In the context of psychosocial and family risks, strengths appear to play a related but distinct role in self-management, glycemic control, and general QOL. Monitoring and building diabetes strengths may support the development of resilience. Measuring youth strengths and discussing them as part of routine medical or psychosocial care may help providers guide youth and families in building on their existing capacities to overcome challenges (37). For example, for youth who have greater strengths related to family support, providers may involve parents or siblings in targeting adherence challenges, or for those with a more optimistic attitude, a clinician may use cognitive strategies to address diabetes-related stress. Indeed, preliminary and pilot data from strengths-oriented intervention research (38–41) are beginning to emerge. Resilient outcomes—although not easy to attain in the face of diabetes-related challenges—appear to be achievable. Moreover, even in the context of powerful risk factors and both the individual and family levels, diabetes-related strengths hold a great deal of potential to promote these optimal diabetes outcomes during the vulnerable adolescent years.

Funding. The Diabetes MILES Youth Study 2014 is an activity of, and was funded by, the NDSS Young People with Diabetes National Development Program. The NDSS is an initiative of the Australian Government administered with the assistance of Diabetes Australia. M.E.H. and B.J.A. were supported by funding from the National Institute of Diabetes and Digestive and Kidney Diseases, 1K12-DK-097696 (principle investigator: B.J.A.). C.H. and J.S. are supported by the core funding to The Australian Centre for Behavioural Research in Diabetes derived from the partnership between Diabetes Victoria and Deakin University.

Duality of Interest. No potential conflicts of interest relevant to this article were reported.

Author Contributions. M.E.H. researched data and wrote the manuscript. V.H., C.H., S.T., and J.S. researched data, contributed to the discussion, and reviewed and edited the manuscript. B.J.A., M.M.J., F.P., and T.S. contributed to the discussion and reviewed and edited the manuscript. F.P. and J.S. conceived the Diabetes MILES Study International Collaborative. All authors approved the final version. M.E.H. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

References

1. 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
2. Wiebe DJ, Chow CM, Palmer DL, et al. Developmental processes associated with longitudinal declines in parental responsibility and adherence to type 1 diabetes management across adolescence. J Pediatr Psychol 2014;39:532–541

3. Helgeson VS, Siminerio L, Escobar O, Becker D. Predictors of metabolic control among adolescents with diabetes: a 4-year longitudinal study. J Pediatr Psychol 2009;34:254–270
4. Hilliard ME, Mann KA, Peugh JL, Hood KK. How poorer quality of life in adolescence predicts subsequent type 1 diabetes management and control. Patient Educ Couns 2013;91:120–125
5. Hilliard ME, Harris MA, Weissberg-Benchell J. Diabetes resilience: a model of risk and protection in type 1 diabetes. Curr Diab Rep 2012;12:739–748
6. Luthar SS, Cicchetti D, Becker B. The construct of resilience: a critical evaluation and guidelines for future work. Child Dev 2000;71:543–562
7. Hilliard ME, Wu YP, Rausch J, Dolan LM, Hood KK. Predictors of deteriorations in diabetes management and control in adolescents with type 1 diabetes. J Adolesc Health 2013;52:28–34
8. Anderson BJ, McKay SV. Barriers to glycemic control in youth with type 1 diabetes and type 2 diabetes. Pediatr Diabetes 2011;12:197–205
9. Caccavale LJ, Weaver P, Chen R, Streisand R, Holmes CS. Family density and SES related to diabetes management and glycemic control in adolescents with type 1 diabetes. J Pediatr Psychol 2015;40:500–508
10. Hessler D, Fisher L, Polonsky W, Johnson N. Understanding the areas and correlates of diabetes-related distress in parents of teens with type 1 diabetes. J Pediatr Psychol 2016;41:750–758
11. Hilliard ME, Weissberg-Benchell J, Hood KK. Psychometric properties of a diabetes resilience measure for adolescents. Diabetes 2014;63(Suppl. 1):1244-P.
12. Jaser SS, White LE. Coping and resilience in adolescents with type 1 diabetes. Child Care Health Dev 2011;37:335–342
13. Rohan JM, Huang B, Pendley JS, et al. Predicting health resilience in pediatric type 1 diabetes: a test of the resilience model framework. J Pediatr Psychol 2015;40:956–967
14. Wysocki T, Iannotti R, Weissberg-Benchell J, et al.; Family Management of Childhood Diabetes Steering Committee. Diabetes problem solving by youths with type 1 diabetes and their caregivers: measurement, validation, and longitudinal associations with glycemic control. J Pediatr Psychol 2008;33:875–884
15. Yi-Frazier JP, Yaptangco M, Semana S, et al. The association of personal resilience with stress, coping, and diabetes outcomes in adolescents with type 1 diabetes: variable- and person-focused approaches. J Health Psychol 2015;20:1196–1206
16. Hagger V, Trawley S, Hendrieckx C, et al. Diabetes MILES Youth-Australia: methods and sample characteristics of a national survey of the psychological aspects of living with type 1 diabetes in Australian youth and their parents. BMC Psychol 2016;4:42
17. Johnson JG, Harris ES, Spitzer RL, Williams JB. The patient health questionnaire for adolescents: validation of an instrument for the assessment of mental disorders among adolescent primary care patients. J Adolesc Health 2002;30:196–204
18. Browne JL, Nefs G, Pouwer F, Speight J. Suicidal ideation or non-suicidal self-harm? A mismatch between the DSM-IV criterion and PHQ-9 item nine. Diabetes Res Clin Pract 2015;108:e5–e6
19. Spitzer RL, Kroenke K, Williams JB, Löwe B. A brief measure for assessing generalized anxiety disorder: the GAD-7. Arch Intern Med 2006;166:1092–1097
20. 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
21. Hood KK, Butler DA, Anderson BJ, Laffel LMB. Updated and revised diabetes family conflict scale. Diabetes Care 2007;30:1764–1769
22. Dashiff C, Riley BH, Abdullatif H, Moreland E. Parents' experiences supporting self-management of middle adolescents with type 1 diabetes mellitus. Pediatr Nurs 2011;37:304–310
23. de Wit M, Winterdijk P, Aanstoot HJ, et al.; DAWN Youth Advisory Board. Assessing diabetes-related quality of life of youth with type 1 diabetes in routine clinical care: the MIND Youth Questionnaire (MY-Q). Pediatr Diabetes 2012;13:638–646
24. Tomyn AJ, Weinberg MK, Cummins RA. Intervention efficacy among 'at risk' adolescents: a test of subjective wellbeing homeostasis theory. Soc Indic Res 2015;120:883–895
25. Australian Bureau of Statistics. Census of Population and Housing: Socio-Economic Indexes for Areas (SEIFA), Australia, 2011. Australian Bureau of Statistics. Available from http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/2033.0.55.001main+features100042011. Accessed 9 Aug 2016
26. Miller KM, Foster NC, Beck RW, et al.; T1D Exchange Clinic Network. Current state of type 1 diabetes treatment in the U.S.: updated data from the T1D Exchange clinic registry. Diabetes Care 2015;38:971–978
27. Guilfoyle SM, Crimmins NA, Hood KK. Blood glucose monitoring and glycemic control in adolescents with type 1 diabetes: meter downloads versus self-report. Pediatr Diabetes 2011;12:560–566
28. Chae M, Reith DM, Tomlinson PA, Rayns J, Wheeler BJ. Accuracy of verbal self-reported blood glucose in teenagers with type I diabetes at diabetes ski camp. J Diabetes Metab Disord 2014;13:14
29. Blackwell M, Wheeler BJ. Clinical review: the misreporting of logbook, download, and verbal self-measured blood glucose in adults and children with type I diabetes. Acta Diabetol 2017;54:1–8
30. Hackworth NJ, Hamilton VE, Moore SM, Northam EA, Bucalo Z, Cameron FJ. Predictors of diabetes self-care, metabolic control, and mental health in youth with type 1 diabetes. Aust Psychol 2013;48:360–369
31. Upton P, Lawford J, Eiser C. Parent-child agreement across child health-related quality of life instruments: a review of the literature. Qual Life Res 2008;17:895–913
32. Yi-Frazier JP, Hilliard ME, Fino NF, et al. Whose quality of life is it anyway? Discrepancies between youth and parent health-related quality of life ratings in type 1 and type 2 diabetes. Qual Life Res 2016;25:1113–1121
33. Zimmerman M, Ruggero CJ, Chelminski I, et al. Developing brief scales for use in clinical practice: the reliability and validity of single-item self-report measures of depression symptom severity, psychosocial impairment due to depression, and quality of life. J Clin Psychiatry 2006;67:1536–1541
34. de Boer AG, van Lanschot JJ, Stalmeier PF, et al. Is a single-item visual analogue scale as valid, reliable and responsive as multi-item scales in measuring quality of life? Qual Life Res 2004;13:311–320
35. Mulvaney SA, Lilley JS, Cavanaugh KL, Pittel EJ, Rothman RL. Validation of the diabetes numeracy test with adolescents with type 1 diabetes. J Health Commun 2013;18:795–804
36. Santos FR, Sigulem D, Areco KC, Gabbay MA, Dib SA, Bernardo V. Hope matters to the glycemic control of adolescents and young adults with type 1 diabetes. J Health Psychol 2015;20:681–689
37. Hilliard ME. Resilience and protection: achieving good outcomes in pediatric diabetes. Pediatr Diabetes 2014;15(Suppl. 19):INV7
38. Rosenberg AR, Yi-Frazier JP, Eaton L, et al. Promoting resilience in stress management: a pilot study of a novel resilience-promoting intervention for adolescents and young adults with serious illness. J Pediatr Psychol 2015;40:992–999
39. Jaser SS, Patel N, Rothman RL, Choi L, Whittemore R. Check it! A randomized pilot of a positive psychology intervention to improve adherence in adolescents with type 1 diabetes. Diabetes Educ 2014;40:659–667
40. Kichler JC, Kaugars AS. Topical review: applying positive development principles to group interventions for the promotion of family resilience in pediatric psychology. J Pediatr Psychol 2015;40:978–980
41. Weissberg-Benchell J, Rausch J, Iturralde E, Jedraszko A, Hood K. A randomized clinical trial aimed at preventing poor psychosocial and glycemic outcomes in teens with type 1 diabetes (T1D). Contemp Clin Trials 2016;49:78–84