Child Behavior Problems and Family Functioning as Predictors of Adherence and Glycemic Control in Economically Disadvantaged Children with Type 1 Diabetes: A Prospective Study

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Objective This prospective study examined how child behavior problems and family functioning predict adherence behavior and glucose regulation (glycemic control) in a sample of economically disadvantaged children. **Methods** Children with type 1 diabetes ($N = 116$; 58.6% African American) were assessed for externalizing and internalizing behavior problems and family adaptability and cohesion and followed for a mean of 3.8 years. Glycemic control (glycosylated hemoglobin [HbA_{1c}]) was assessed at baseline and follow-up, and adherence was assessed at follow-up. **Results** Analyses controlled for baseline HbA_{1c} and years to follow-up. Multivariate analyses indicated that better adherence was predicted by high family cohesion. Better glycemic control was predicted by high family cohesion, the absence of externalizing behavior problems, and the presence of internalizing behavior problems. In addition, tests of moderation indicated that better follow-up glycemic control occurred among girls from high cohesion families and younger children from low adaptability families. Although better adherence predicted better glycemic control, adherence did not mediate the relationships of behavior problems or family functioning with glycemic control. **Conclusions** A child's behavior problems and family functioning may influence both adherence to the diabetes regimen and glycemic control several years later, suggesting the potential value of interventions that address child behavior and family functioning.

Key words diabetes; child; family; behavior problems; adherence; glycemic control.

Management of type 1 (insulin-dependent) diabetes is complex, requiring insulin injections (often three to four times daily), monitoring and controlling one's diet, and obtaining appropriate amounts of physical activity. Patients need to check their blood glucose multiple times daily to monitor the effectiveness of the diabetes care plan and make informed decisions about insulin dosage and food consumption. They also should check their urine for ketones when blood glucose levels are high or when feeling ill. Adhering to these behaviors optimizes metabolic or glycemic control (i.e., optimal blood glucose levels) and prevents or delays medical complications. This was demonstrated in a landmark study which showed that maintaining blood glucose levels as close to normal as possible through strict adherence to a regimen can help prevent or slow the progression of many diabetes complications (DCCT Research Group, 1994).

Nonadherence to a wide range of therapeutic regimens is common (Chui et al., 2003; Farber et al., 2003; Litt & Cuskey, 1980), and nonadherence among children and adolescents with diabetes is particularly prevalent (Ellis, Naar-King, Frey, Rowland, & Gregor, 2003; Weissberg-Benchell et al., 1995). Researchers have

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turned their attention to factors that affect adherence among children with diabetes and to the links between adherence and clinical status (Hanson & Onikul-Ross, 1990). A popular model is that psychosocial factors affect glycemic control indirectly, via their influence on adherence behavior. Alternatively, psychosocial factors may affect glycemic control directly through various endocrine and autonomic pathways. Finally, it is possible that the order is reversed—poor glycemic control and diabetic complications may lead to impaired psychosocial functioning. There is a small but growing literature examining these links in children with diabetes.

One pathway that has been studied is the effect of life stress on adherence and glycemic control. Goldston, Kovacs, Obrosky, and Iyengar (1995) found that greater life disruption predicted poorer glycemic control, and the relationship between life stress and glycemic control was partially mediated by adherence. On the other hand, Hanson, Henggeler, Harris, Burghen, and Moore (1989) found support for a link between stress and poor glycemic control, but not between stress and nonadherence. Still other studies have found no association between stress and glycemic control (e.g., Hauenstein, Marvin, Snyder, & Clarke, 1989). These inconsistent findings may be due to the fact that "stress" is an overly general construct, and more specific variables need to be studied. Two variables that have begun to receive attention are child behavior problems and family dysfunction.

Child psychopathology and behavior problems have been associated with poorer adherence and glycemic control among children with diabetes. Liss et al. (1998) found that children with a history of poor glycemic control had higher levels of psychopathology than children who had good glycemic control. Fully 88% of the children with poor glycemic control were diagnosed with at least one disorder (e.g., anxiety, depression, and attention/disruptive behavior disorders), versus only 28% of the comparison children. Kovacs, Charron-Prochownik, and Obrosky (1995) identified risk factors for multiple hospitalizations related to diabetes in a sample of newly diagnosed, school-age children. The risk of multiple admissions was predicted by poorer glycemic control, higher levels of externalizing behavior problems, younger age at diabetes diagnosis, and lower socioeconomic status.

Family functioning is also important to study, because the quality of family relationships may influence adherence to a diabetes regimen, family functioning may create emotional stress that directly alters glucose levels, and diabetes, especially if poorly managed or leading to complications, can strain family relationships (Baumer, Hunt, & Shield, 1998; Thompson, Auslander, & White, 2001). In general, longitudinal studies have not found an effect of poor glycemic control on subsequent family problems (e.g., Kovacs, Kass, Schnell, Goldston, & Marsh, 1989). In contrast, family dysfunction has been found to negatively impact a child's glycemic control, and this may be mediated by poorer adherence (Anderson, Miller, Auslander, & Santiago, 1981; Hanson, De Guire, Schinkel, & Kolterman, 1995). Klemp and La Greca (1987) found that family cohesion and organization were correlated with higher levels of diabetes self-care and adherence, whereas family conflict was correlated with poorer adherence. Only family conflict was correlated with poorer glycemic control. Among the few longitudinal studies relevant to family functioning and diabetes, Jacobson et al. (1994) showed that families with higher verbal expressiveness had children who were in better glycemic control 4 years later. Hauser et al. (1990) found that family conflict, cohesion, and organization strongly predicted short-term adherence levels, and this team also found that families that were the least openly expressive of positive emotions were more likely to miss clinical follow-up visits (Jacobson, Hauser, Willett, Wolfsdorf, & Herman, 1997). In general, the literature suggests that children with more structured, cohesive, and supportive family environments are in better control of their diabetes.

Aims of This Research

Although there are many specific child disorders and maladaptive traits, there appear to be two broad dimensions of child psychopathology: internalizing behavior problems, characterized by anxiety, depression, and social withdrawal; and externalizing behavior problems, characterized by aggression and antisocial behavior (Achenbach, 1991). In addition, although one could assess numerous specific family variables, two dimensions appear to capture the majority of the variance in family functioning: adaptability, or the family's ability to flexibly respond to various situations; and cohesion, or the family's degree of closeness (Olson, Portner, & Lavee, 1985). There have been almost no prospective studies examining the links between child psychopathology/family functioning and subsequent adherence/glycemic control.

In this study of children and adolescents with type 1 diabetes, we examined how baseline levels of two

psychosocial factors—children's internalizing and externalizing behavior problems and families' adaptability and cohesion—predicted the children's glycemic control (assessed via levels of glycosylated hemoglobin [HbA_{1c}]) several years later. We also assessed the child's adherence as recorded in the medical record (the frequency of blood glucose checks, attendance at clinic visits, and proportion of clinic visits to which the child brought a blood glucose meter) prior to the final glycemic control assessment. Thus, we were able to investigate whether child behavior problems and family functioning predicted subsequent adherence, whether adherence predicted glycemic control, and whether adherence mediated the relationships between child behavior problems/family functioning and later glycemic control. It was hypothesized that children without behavior problems and those with high family cohesion and adaptability at baseline would have better adherence and better glycemic control at follow-up and that adherence would mediate the relationship between behavior problems or family functioning and glycemic control. We also tested whether behavioral problems and family functioning measures were redundant or independent predictors of adherence and glycemic control.

Previous studies of children and adolescents with diabetes have suggested that being older, being female, having black ethnicity, or having a longer duration of diabetes may place a person at increased risk for poor glycemic control (Davis et al., 2001; Fishbein, Faich, & Ellis, 1982; Hamman et al., 1985). We conducted moderator analyses to examine whether the relationships of behavior problems and family functioning to adherence and glycemic control were stronger for, or limited to, subsets of children based on their age, gender, ethnicity, or duration of diabetes. In all analyses, we controlled for the duration between baseline and follow-up as well as the baseline level of glycemic control. Controlling for the latter allowed us to predict follow-up glycemic control independent of initial health status, and also reduced the potential confound between baseline behavioral and family variables and health status.

Most prospective studies in pediatric diabetes have used small samples that were primarily middle- or upper-class white populations, even though adherence difficulties and poor glycemic control are thought to be more common in low-socioeconomic-status and minority populations. The current research employed a relatively large sample of children and families who were participating in a special program for the economically disadvantaged, and the majority of the children were African American.

Method

Participants

Study participants were children and adolescents with type 1 diabetes who were evaluated at an outpatient diabetes clinic at a large, urban, university-affiliated pediatric hospital. All participants were receiving assistance from Children's Special Health Care Services, a publicly funded, state-based insurance program. Eligibility for this program is based primarily upon the presence of a childhood chronic illness and low income. All school-aged children who participated in a standard, multidisciplinary, comprehensive clinical evaluation between 1992 and 1996 composed the group from which the present sample was drawn. Therefore, this research sample is highly representative of the population of chronically ill, economically disadvantaged children treated at an inner-city medical center. Furthermore, because we used available data from standard clinical evaluations, participation was not limited to families who were willing to participate solely for research purposes.

A total of 257 children were initially seen in the clinic and potentially available for inclusion. We excluded children who had other medical conditions that we anticipated might alter their adherence or glycemic control, as well as children with intellectual deficits that might interfere with their psychosocial functioning. Thus, we excluded 9 children (3.5%) who had an endocrine disorder other than type 1 diabetes, 4 children (1.6%) who had a severe chronic medical condition in addition to type 1 diabetes, and 3 children (1.2%) who had mental retardation. Next, because this was a prospective study, we excluded children who were not seen again in the clinic at least 1.5 years after baseline; of the 241 remaining children, 95 (39%) were excluded for this reason. (Most of these children did not return after the baseline visit, and 15 of these 95 also did not complete at least one of the two psychosocial questionnaires.) Finally, 30 additional children (12%) were excluded because they were missing one or both of the psychosocial questionnaires, even though they were followed for at least 1.5 years.

Thus, the final sample consisted of 116 participants: 55 boys (47.4%) and 61 girls (52.6%), with a mean age of 11.7 years at baseline (range, 6 to 17 years). The sample included 68 African Americans (58.6%), 46 whites

(39.7%), one Hispanic (0.8%), and one Asian (0.8%). Over half of the children ($n = 63$; 54.3%) had mothers who were single, divorced, or widowed; 48 children (41.4%) had mothers who were married or cohabiting; and 5 children (4.3%) had other guardian situations. The duration of time from diabetes diagnosis to the date of baseline assessment ranged from less than 1 month to 13.1 years, with a mean duration of 3.0 years. Duration of time from baseline assessment to final, follow-up visit ranged from 1.5 years to 5.2 years, with a mean duration of 3.8 years.

Procedure

At the baseline visit, the parent or guardian who accompanied the child to the clinic was asked to complete a standard set of questionnaires as part of the team psychologist's assessment, and several of these measures served as the psychosocial predictors in this study. Children also had their glycemic control status (HbA_{1c}) assessed at baseline. Children then were offered continuing care in this clinic, planned for every 3 months, over the ensuing years.

In 2001, the investigator obtained approval from the university institutional review board to review medical records and to record and publish the psychosocial and medical data as research data. A systematic medical chart review was conducted on all the children. This review revealed that the children were followed at the clinic for variable amounts of time after the baseline visit and that attendance was sporadic during follow-up. Thus, we could not identify one constant follow-up interval that applied to all children. Rather we set a maximum window for follow-up of just over 5 years from baseline, which was the longest possible follow-up duration (through 2001) for children who were enrolled last into the study (in 1996), and we identified each child's final visit to the clinic within that window. From the final visit, we obtained glycemic control data from the record, and we also obtained adherence data for the prior weeks and year, as described below. Note that the period leading up to the final visit was used for the adherence assessment because this interval was the only one available that was consistent across all children, given the sporadic attendance throughout the follow-up period and the variable length of follow-up.

Measures

The measures were four child and family psychosocial predictors (two types of behavior problems and two types of family functioning) as well as measures of adherence, glycemic control, and potential covariates or moderators.

Internalizing and Externalizing Behavior Problems

Parents completed the Child Behavior Checklist (CBCL) for ages 4–18 (Achenbach, 1991) to assess their child's behavioral and emotional functioning. Age- and gender-appropriate *T*-scores were calculated for the externalizing and internalizing dimensions and were used in analyses to allow comparisons across children. Because items assessing physical/somatic complaints may confound measures of psychopathology among children with chronic physical illness, we excluded the somatic complaints scale from the internalizing scale, and the internalizing *T*-score was calculated by averaging the *T*-scores for the other two internalizing subscales (*withdrawn* and *anxious/depressed*). Because the distributions for the externalizing and internalizing *T*-scores were positively skewed, and also to facilitate interpretation, we dichotomized scores on these two scales. Thus, *T*-scores for both dimensions were dichotomized using the scale creators' suggested cut point for the "borderline clinical range" of $T = 60$ (1.0 *SD* above the mean). *T*-scores less than 60 were coded as "0," indicating the absence of a behavior problem, whereas *T*-scores at or above 60 were coded as "1," indicating the possible presence of a behavior problem. Using *T*-scores of 60 identifies children with even mild or moderate levels of behavioral problems, and the prevalence of children in this sample meeting a more conservative criterion of $T = 70$ was too low to be useful. (There were only 7 children with externalizing problems and 4 children with internalizing problems above $T = 70$.)

Family Adaptability and Cohesion

Parents completed the Family Adaptability and Cohesion Evaluation Scales–III (FACES-III) (Olson et al., 1985), which is a 20-item questionnaire that assesses two domains: adaptability, or the family's ability to be flexible in response to various situations, and cohesion, or the family's degree of closeness. The FACES-III has adequate psychometric properties, with internal consistency reliabilities of .62 for cohesion and .77 for adaptability (Olson et al., 1985). The authors originally conceptualized the adaptability and cohesion scales as measuring two continuous variables, with optimal family functioning in the middle of the range of each scale. However,

studies have indicated that the instrument captures a linear rather than curvilinear construct (Henggeler & Burr-Harris, 1991; Volker & Ozechowski, 2000); therefore, we treated adaptability and cohesion as linear scales.[1] Because the distributions of these two variables were negatively skewed (and to maintain consistency with our approach to the CBCL), we dichotomized adaptability and cohesion by splitting the distributions at the mean of the normative sample's distribution. For this study, we used the norms for the "families with adolescents," as published in the test manual, and assigned scores of 0 = low and 1 = high, which refers to below or above the normative mean with respect to family adaptability and cohesion. Thus, a family that is low in adaptability (scoring 24 or less) is in the range that the scale authors have labeled *rigid* to *structured*, whereas high adaptability families are in the range from *flexible* to *chaotic*. Low cohesion families (scoring 37 or less) are in the range that the authors have labeled *disengaged* to *separated*, whereas high cohesion families are in the *connected* to *enmeshed* range.

Adherence

Information regarding adherence to the diabetes regimen was obtained from the medical chart for the 10 days as well as the full year prior to the child's final visit. Three adherence measures were obtained: (a) the number of routine clinic visits in the prior year (four visits per year were recommended for all children), (b) the proportion of the clinic visits that each child attended in which he/she brought the blood glucose meter (ranging from 0 to 1.0), and (c) the number of blood glucose checks in the 10 days prior to the final visit (at least four blood checks per day were recommended for all children). These three measures tapped different windows of time because the first two behaviors could be assessed only over longer durations, whereas the frequency of blood glucose checks was obtained from the information downloaded from the blood glucose meter, which had a 10-day memory capacity. For those children (43% of the final sample) who did not bring their meter to the final visit, the family's self-reported frequency of glucose checks was used, which appeared to be a reliable estimate of the value that would have been obtained from the meter.[2] To obtain one measure of adherence behavior, we created a single composite of the three behaviors by transforming each into a *z*-score and averaging the *z*-scores. Higher values of this adherence composite indicate better adherence.

Glycemic Control

This was assessed by quantitating total glycosylated hemoglobin (TGHb) and then calculating levels of HbA_{1c}. Boronate affinity high pressure liquid chromatography was used, which is an optimal assay because it is less sensitive than other assays to hemoglobin variants (e.g., sickle cell hemoglobin) that are more likely to be found in minority populations (Fluckiger, Woodtli, & Berger, 1984). The TGHb value obtained from this assay is converted to HbA_{1c} using the formula: $HbA_{1c} = (TGHb \times 0.588) + 1.706$. HbA_{1c} provides an integrated blood glucose level over the prior 2 to 3 months. It is a valid and reliable indicator of glycemic control and is widely used for research and clinical purposes. Higher percentage values of HbA_{1c} indicate higher blood glucose levels in recent months and, therefore, poorer glycemic control; the normative range in our laboratory is 4% to 8% of hemoglobin. We analyzed HbA_{1c} values from both baseline and follow-up visits for all children.

Potential Covariates and Moderators

Age at baseline, gender, ethnicity, duration of diabetes (from diagnosis until baseline assessment for this study), and time to follow-up (from baseline assessment) were obtained from the medical charts.

Results

Analyses of Participant Attrition

Analyses were conducted to compare the retained sample of children ($n = 116$) with those 125 children who were not included due to not being followed for at least 1.5 years or missing baseline data. Children in the retained sample were significantly younger than those not included, $M = 11.7$ years, $SD = 3.0$, versus $M = 13.0$ years, $SD = 3.2$; $t(239) = 3.39$; $p < .001$. However, the two groups did not differ significantly on the frequency of baseline behavioral problems, type of family functioning, or baseline HbA_{1c}.

Relationships of the Child and Family Psychosocial Predictors to Adherence and HbA_{1c}

Table I presents the sample descriptive data on the four psychosocial predictors and measures of adherence and glycemic control. These children had somewhat elevated levels of externalizing behavior problems, but only slightly elevated levels of internalizing problems. Their

Table I. Descriptive Data for the Sample Demographics, Psychosocial Predictors, Adherence, and Glycemic Control Measures

Measure	Mean	*SD*	Range	*n*	%
Externalizing					
problems (present)				35	30.2
Internalizing					
problems (present)				23	19.8
Family adaptability (low)				68	58.6
Family cohesion (low)				55	47.4
Adherence (*z*)	0.00	0.70	−0.84–1.62		
Clinic visits last year	2.9	(1.1)	1–5		
Visits brought meter (%)	56.1	(37.5)	0–100		
Glucose checks last 10 days	21.5	(10.3)	0–40		
Glycemic control (HbA_{1c} %)					
Baseline	9.3	(2.5)	4.8–17.9		
Follow-up	11.1	(2.6)	5.0–17.9		

HbA_{1c} = glycosylated hemoglobin.

family's adaptability and cohesion were close to normative levels. Importantly, most of the children had poor glycemic control, with baseline and follow-up values above the normative range for most children.

Table II presents the adherence and glycemic control follow-up data as a function of the four psychosocial predictors. The table also presents the *p*-value from analyses of covariance (ANCOVAs) that were conducted to determine how the presence or absence of behavior problems and low or high family functioning at baseline predicted adherence and HbA_{1c}. Analyses covaried the duration until follow-up because it varied widely and was related to follow-up HbA_{1c} ($r = -.19$, $p = .04$). Analyses also controlled for baseline HbA_{1c}, which correlated significantly with follow-up HbA_{1c} ($r = .28$, $p = .002$). Age, gender, ethnicity, and duration of diabetes at baseline were tested as moderators, as reported below.

As shown in Table II, better adherence at follow-up was significantly predicted by low internalizing behavior problems and high family cohesion at baseline, but externalizing problems and high family adaptability did not reach significance in predicting adherence. Better glycemic control (lower HbA_{1c}) at follow-up was significantly predicted only by high family cohesion.

Testing Adherence as a Mediator of the Cohesion/Glycemic Control Relationship

We next sought to test whether adherence mediated the relationship between the psychosocial variables and follow-up glycemic control. According to Baron and Kenny (1986) and Holmbeck (1997), mediation occurs when three conditions are met. First, there must be significant relationships between the predictor (e.g., behavior problems, family functioning) and outcome (HbA_{1c}), between the predictor and potential mediator (adherence), and between the potential mediator and outcome. Second, the potential mediator must remain related to the outcome while controlling for the pre-

Table II. Adherence and Glycemic Control (HbA_{1c}) as a Function of the Presence or Absence of Externalizing and Internalizing Behavior Problems, and Low or High Family Adaptability and Cohesion

	Externalizing			Internalizing			Adaptability			Cohesion		
Outcome Measure	Yes (*n* = 35)	No (*n* = 81)	*p*	Yes (*n* = 23)	No (*n* = 93)	*p*	Low (*n* = 68)	High (*n* = 48)	*p*	Low (*n* = 55)	High (*n* = 61)	*p*
Adherence, *M*	−0.17	0.06	.11	−0.36	0.08	.006	0.12	−0.12	.08	−0.24	0.20	.001
(*SEM*)	(0.12)	(0.08)		(0.14)	(0.07)		(0.09)	(0.09)		(0.09)	(0.09)	
HbA_{1c} (%), *M*	11.61	10.92	.18	10.60	11.26	.25	11.10	11.17	.90	11.70	10.62	.02
(*SEM*)	(0.42)	(0.28)		(0.52)	(0.26)		(0.30)	(0.36)		(0.33)	(0.31)	

HbA_{1c} = glycosylated hemoglobin.

Note: Means (and standard errors) are adjusted for time from baseline to follow-up assessment and for baseline HbA_{1c}. *p*-Values are from analyses of covariance comparing the adjusted means of the two groups.

Table III. Multiple Regression Predicting Adherence at Follow-up from Externalizing and Internalizing Behavior Problems and Family Adaptability and Cohesion, Controlling for Time to Follow-up and Baseline HbA_{1c} ($N = 116$)

Predictors	Standard β	*t*-Value	*p*-Value
Time to follow-up	.08	0.88	.38
Baseline HbA_{1c}	−.07	−0.76	.45
Externalizing problems	−.05	−0.48	.63
Internalizing problems	−.17	−1.67	.098
Family adaptability	−.13	−1.48	.14
Family cohesion	.29	3.23	.002
Full model: $F(6, 109) = 3.83$, $p = .002$, $R^2 = .174$			

HbA_{1c} = glycosylated hemoglobin.

Note: Externalizing and internalizing behavior problems coded as 0 = no and 1 = yes; family adaptability and cohesion coded as 0 = low and 1 = high.

Table IV. Multiple Regression Predicting Glycemic Control (HbA_{1c}) at Follow-up from Externalizing and Internalizing Behavior Problems and Family Adaptability and Cohesion, Controlling for Time to Follow-up and Baseline HbA_{1c} ($N = 116$)

Predictors	Standard β	*t*-Value	*p*-Value
Time to follow-up	−.09	−1.04	.30
Baseline HbA_{1c}	.26	2.85	.005
Externalizing problems	.20	2.05	.04
Internalizing problems	−.24	−2.49	.01
Family adaptability	.06	0.69	.49
Family cohesion	−.25	−2.75	.007
Full model: $F(6, 109) = 4.48$, $p < .001$, $R^2 = .198$			

HbA_{1c} = glycosylated hemoglobin.

Note: Externalizing and internalizing behavior problems coded as 0 = no and 1 = yes; family adaptability and cohesion coded as 0 = low and 1 = high.

dictor. Finally, there must be a significant drop in the effect of the predictor once the mediator is included in the full model.

As expected, better adherence (the potential mediator) was related to better outcome (higher HbA_{1c}, controlling for baseline HbA_{1c}), $pr = -.21$, $p = .02$. However, only one of the four psychosocial predictors met the additional relationships required for further mediation testing—only family cohesion was related to both adherence and HbA_{1c}. Thus, the second condition was examined. However, when both family cohesion and adherence were entered simultaneously into a model predicting follow-up HbA_{1c}, adherence was no longer a significant predictor of HbA_{1c}, ($pr = -.14$, $p = .14$), thus eliminating it as a potential mediator of the relationship between family cohesion and glycemic control. Thus, adherence did not mediate any relationships between child behavior and family variables and glycemic control.

Testing the Independence of Predictors of Adherence and Glycemic Control

Our next analyses examined the unique influence of each psychosocial predictor when considering the other three predictors simultaneously. We first examined associations among the four dichotomous psychosocial predictors to determine their independence or redundancy. The presence of externalizing behavior problems was associated with the presence of internalizing behavior problems ($r = .43$, $p < .01$). The presence of externalizing problems, however, was unrelated to the two family variables, and the presence of internalizing problems was significantly but weakly associated with low family cohesion ($r = -.22$, $p < .05$). Low family cohesion and low family adaptability were only minimally related to each other ($r = .17$, $p = .07$).

Two multiple regression analyses were then conducted in which all four predictors were entered simultaneously, after entering time to follow-up and baseline HbA_{1c}. Table III shows the results of the regression model that predicted adherence. The set of four psychosocial predictors explained an additional 15.2% of the variance in adherence, beyond the two covariates. In the full model, high family cohesion remained the sole significant predictor of better adherence. Table IV shows the regression model predicting follow-up glycemic control. The set of four psychosocial variables explained an additional 10.0% of the variance in HbA_{1c} beyond the two covariates. In the full model, high family cohesion remained a significant predictor of lower HbA_{1c} (better glycemic control), and the absence of externalizing behavior problems became a significant predictor of lower HbA_{1c}. Interestingly, the *presence* of internalizing behavior problems also significantly predicted lower HbA_{1c}.

Exploring Age, Gender, Ethnicity, and Duration of Disease as Potential Moderators

We next tested whether the child's age, gender, ethnicity (dichotomized into the 68 African Americans compared with the 46 whites plus the two Hispanic and Asian children), and duration of diabetes at baseline moderated relationships between any of the four psychosocial predictors and both follow-up adherence and glycemic control. Following the suggestions of Baron and Kenny (1986) and Holmbeck (1997), we used multiple regression analyses in which *time until follow-up* and *baseline HbA_{1c}* were entered first, followed by two main

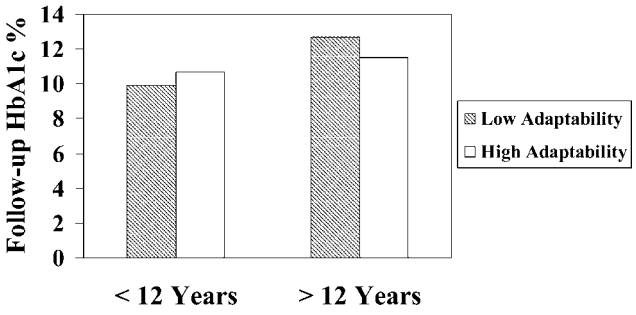

Figure 1. The relationship between family adaptability at baseline and follow-up HbA_{1c} depends on the age of the child at baseline. (Age groups were formed by splitting the sample at the median baseline age of 12.0 years.)

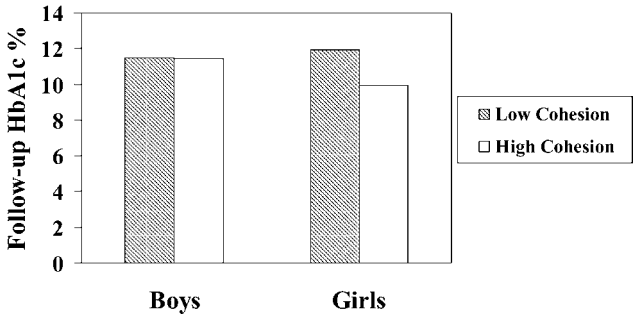

Figure 2. The relationship between family cohesion at baseline and follow-up HbA_{1c} depends on the gender of the child.

effects (one of the potential moderators and one of the child behavior/family psychosocial predictors), followed by the cross-product (interaction term) of the moderator and predictor.

None of four potential moderators (age, gender, ethnicity, and duration of diabetes) moderated the relationship of any of the four predictors with adherence, nor did ethnicity or duration moderate relationships with follow-up HbA_{1c}. However, both age and gender were significant moderators of a predictor of follow-up HbA_{1c}.

First, the child's age at baseline significantly interacted with family adaptability in predicting follow-up HbA_{1c}, $t(110) = -2.39$, $p = .018$. This interaction is displayed in Figure 1, where we have plotted data for younger and older children, using a median split of the sample at the baseline age of 12.0 years to facilitate presentation. Among younger children, low family adaptability predicted better glycemic control (lower follow-up HbA_{1c}; adjusted $M = 9.90$, $SEM = 0.63$) compared with high family adaptability (adjusted $M = 10.71$, $SEM = 0.63$). Among older children, however, low family adaptability predicted significantly worse glycemic control (adjusted HbA_{1c} $M = 12.70$, $SEM = 0.59$) than did high family adaptability (adjusted $M = 11.46$, $SEM = 0.61$).

Second, the child's gender interacted with family cohesion in predicting follow-up HbA_{1c}, $t(110) = -2.29$, $p = .024$. This interaction is depicted in Figure 2. Among the boys, there was no difference in follow-up HbA_{1c} between low and high cohesion families (adjusted $M = 11.61$, $SEM = 0.45$; adjusted $M = 11.66$, $SEM = 0.46$). Among the girls, however, high family cohesion predicted significantly better glycemic control (lower HbA_{1c}; adjusted $M = 9.77$, $SEM = 0.41$) than did low family cohesion (adjusted $M = 11.74$, $SEM = 0.45$), $t(57) = 3.17$, $p = .002$.

Discussion

This prospective study of children with type 1 diabetes found that both child behavior problems and family functioning predicted children's adherence behavior and glycemic control an average of nearly 4 years later. The sample studied is unique in the diabetes literature because it is relatively large and predominantly of ethnic minority and low socioeconomic status and the children's diabetes was poorly controlled. Furthermore, by virtue of using measures that were part of standard clinical practice, this study was not limited to only those families who were willing to participate in research.

As expected, this study found that better adherence behavior predicted better glycemic control in these children. With respect to child behavior problems, children with internalizing behavior problems had poorer adherence to the diabetes regimen; yet, somewhat surprisingly, these children also had better glycemic control. Externalizing behavior problems did not predict adherence but did predict poorer glycemic control. With respect to the family variables, families with more cohesion had children with better adherence, and higher family cohesion also predicted better glycemic control, but only among girls. The role of the adaptability of the family depended on the age of the child; families low in adaptability had younger children with better glycemic control. We discuss these findings in turn.

Relationship Between Adherence and Glycemic Control

As hypothesized, children with better adherence had better glycemic control. Yet, the magnitude of the relationship was quite modest. This is consistent with the mixed results of prior studies, some of which found a positive relationship between self-care and glycemic control (Kaufman, Halvorson, & Carpenter, 1999) and

some of which did not (Hanson, Henggeler, & Burghen, 1987). There are several possible reasons for this. First, adherence behavior is only one factor that affects glycemic control. The prescribed treatment regimen including insulin dosage and timing needs to be optimal, and a suboptimal regimen—even when closely adhered to—can still lead to poor glycemic control. In addition, psychological factors, particularly emotional stress, have direct hyperglycemic effects, independent of behavior. Further, physiologic and psychosocial changes and the potential to become insulin resistant may influence glycemic control, especially among adolescents going through puberty (Hamilton & Daneman, 2002). Finally, it should be recognized that this study's measure of adherence was not ideal. Although researchers often operationalize adherence via measures such as the frequency of glucose testing or clinic visits, these are actually proxy measures for other behaviors that more directly influence glucose control—injecting insulin as needed, maintaining a correct diet, and obtaining adequate exercise. Although these latter behaviors may be more difficult to assess, they probably have a stronger relationship with glycemic control than the measures of adherence used in this study.

Relationship of Child Behavior Problems to Adherence and Glycemic Control

Children without internalizing behavior problems had better adherence at follow-up, at least in univariate analyses, suggesting that such children experience less difficulty adhering to their medical regimen. This finding is consistent with the literature on depression, which indicates that depressed mood, fatigue, or loss of energy tends to result in diminished interest in activities that are health promoting and to decreased self-care (La Greca & Skyler, 1991). Interestingly, however, in multivariate analyses, the presence of internalizing behavior problems predicted better follow-up glycemic control. This is somewhat surprising, given that several cross-sectional studies found that depression and anxiety are related to poorer glycemic control (Grey, Cameron, & Thurber, 1991; Mazze, Lucido, & Shannon, 1984). It is possible that baseline internalizing problems have a different effect when glycemic control is predicted several years later—perhaps baseline internalizing behavior problems eventually lead to better adherence behavior over time, such as more regular insulin use among those who were initially anxious about their health. It is also likely that internalizing behavior problems encompass various cognitive and affective processes that might have different effects on behavior or glucose metabolism. For example, it is noteworthy that one study found that children with diabetes who made internal attributions for negative events—holding themselves responsible—had better glycemic control (Brown, Kaslow, Sansbury, Meacham, & Culler, 1991), even though this attributional style is typically associated with depression. Thus, it appears that a clearer understanding of both the long-term consequences and the cognitions related to "internalizing behavior problems" is necessary to understand our study's finding.

As expected, children with externalizing behavior problems (aggression, delinquency) had poorer glycemic control at follow-up. Although externalizing behavior problems did not predict poorer adherence (at least as measured in this study), it remains possible that externalizing behavior interferes with other adherence behaviors that are more directly related to glycemic control, such as insulin use and diet. Alternatively, the emotional experiences of children with such behavior, such as anger and interpersonal conflict, could directly increase stress and subsequent glucose levels.

Relationship of Family Functioning to Adherence and Glycemic Control

More cohesive families had children with better adherence, and such families also had daughters (but not sons) with better glycemic control at follow-up. Thus, being in a family whose members are connected and engaged and care about each other appears to protect against poor outcomes in diabetes, which is consistent with findings from studies on other pediatric health problems (Burke, Neigut, Kocoshis, Chandra, & Sauer, 1994; Soliday, Kool, & Lande, 2001). In contrast, a lack of family cohesion may result in a child perceiving less concern and experiencing less monitoring and reminders to engage in appropriate health behaviors. The better glycemic control of daughters from high cohesion families does not appear to be due solely to better adherence, so it is possible that daughters experience family cohesion as particularly stress reducing, which lowers blood glucose. It is noteworthy, however, that sons did not experience the beneficial glycemic consequences of high family cohesion. This gender difference is consistent with research indicating that adolescent girls have more negative outcomes (e.g., depression, risk behaviors, early puberty) than do boys in the context of familial stress or low cohesion (Ellis, McFadyen-Ketchum, Dodge, Pettit, & Bates, 1999; Nolen-Hoeksema & Girgus, 1994; Weist, Freedman,

Paskewitz, Poescher, & Flaherty, 1995). Girls are more likely than boys to disclose feelings and communicate to parents (Stattin & Kerr, 2000), and social support is more protective for girls who are under stress than for boys (Jackson & Warren, 2000).

Unlike cohesiveness, family adaptability did not show robust relationships with either adherence or glycemic control. Indeed, higher family adaptability is not a consistent predictor of better health outcomes in pediatric populations (e.g., Daniels, Moos, Billings, & Miller, 1987). We suspect that the role of adaptability depends on the circumstances, and our moderator analyses identified one subgroup of children for whom family adaptability was a predictor. Younger children tended to have better glycemic control when they were in families that were low in adaptability, whereas older children had worse glycemic control in such families. Adaptability is defined as the ability of a family system to change its power structure, roles, and relationship rules in response to situational and developmental demands. Thus, younger children appear to benefit from families that are structured and rule governed, which may provide the needed predictability and control to encourage optimal behavior, minimize stress, and ultimately lead to better glycemic control. This is consistent with research showing that children in optimal diabetic control have more structured and controlling family environments and parents who are highly involved in monitoring and managing their diabetes regimen (Allen, Tennen, McGrade, Affleck, & Ratzan, 1983; Anderson, Ho, Brackett, Finkelstein, & Laffel, 1997; Kyngas & Rissanen, 2001). Yet, older children may have worse glycemic control in such families, suggesting that the developing autonomy needs of adolescents might be frustrated by controlling or rigid families, resulting in poorer behavioral control and perhaps more emotional stress.

Limitations of the Study

In addition to the lack of assessment of important adherent behaviors (e.g., insulin use, diet), as noted above, there are other limitations of this study. First, the variable time window between baseline and follow-up assessment was not ideal; although this variable was controlled statistically, a defined window of time (e.g., 4 years) would have been preferred. Second, our reliance on solely parental report measures of the child's psychopathology and family functioning is a limitation. It would have been better to have a multimodal assessment, such as measures from the children themselves or from teachers. Third, our measures of internalizing and externalizing behavior problems may not have been ideal and may have had limited statistical power to demonstrate relationships. This is due not only to our decision to dichotomize these variables, but also to the fact that there were relatively few children with high levels of behavior problems. Indeed, the rates of behavior problems were only slightly higher than would be expected with a statistically normal distribution, even though this sample was diabetic and economically disadvantaged and over half were from single-parent families—conditions that one might expect would be associated with increased behavior problems. This suggests that the final sample of children included in this study were atypically psychologically healthy, or it raises some questions about the reliability or validity of the CBCL in this setting and sample. A fourth limitation is that a child's age is really a proxy for other measures of biopsychosocial development, and we suspect that more direct measures, such as the child's pubertal status or interpersonal maturity, would have clarified the relationships between the child's age, family adaptability, and glycemic control. Finally, it is important to remember that this sample was unique—largely ethnic-minority, poor children who were in relatively poor glycemic control. Thus, caution should be taken in extending inferences to other groups.

Implications of the Study

This study suggests that child behavior problems and family functioning are important factors to consider in the management of diabetes, in that they predict both adherence and glucose regulation. Yet the relationships between child and family behavior and diabetes outcomes are not straightforward. Although externalizing behavior problems in children predict poorer glycemic control, some aspect(s) of internalizing behavior may even be adaptive for glycemic control, at least several years later. The influence of the degree of family adaptability appears to depend on the child's age; families of younger children may do well to remain structured and rule bound, whereas families of older children may benefit by becoming more adaptable. In general, it appears that families should strive for more cohesion, and this may be particularly protective for daughters. As suggested by La Greca (1998), families of children and adolescents with diabetes should remain actively involved in their youngster's diabetes care but remain

flexible enough to shift the responsibility of management from the parents to the adolescent. This is also consistent with the views expressed by adolescents with diabetes, who report that it is important for their parents to be supportive and involved with their diabetes care, but not overly controlling (Weinger, O'Donnell, & Ritholz, 2001).

Intervention research is vital before concluding that these child and family constructs, which simply predict outcomes, are truly unique risk factors with causal properties. Few studies have examined psychosocial treatments in pediatric diabetes, especially targeting child psychopathology or family functioning. Yet, one large-scale study showed that behavioral family systems therapy led to improved parent-child relationships and adherence, but not improved glycemic control among adolescents with diabetes (Wysocki, Greco, Harris, Bubb, & White, 2001). In addition, at least one small study demonstrated that an intervention encouraging direct parental supervision of the child's diabetes care led to better glycemic control a year later (Bradshaw, 2002). The results of the current study indicate not only the need for intervention research, but also the importance of either targeting the intervention to certain subgroups (e.g., families with low cohesion or families whose adaptability does not match the age of the child) or testing whether the intervention is particularly useful on a subset of the sample.

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Notes

1 We tested for curvilinearity by entering the quadratic term following the linear term into regression models predicting adherence and glycemic control, and no quadratic terms predicted beyond the linear terms (all $p > .32$). Further, we categorized adaptability and cohesion scores into four ordinal groups, as originally suggested by the creators of the measure, and compared group means on adherence and glycemic control; again, no evidence for curvilinearity was found.

2 Analyses suggested that the family's self-report of glucose check frequency was valid and did not overestimate adherence. Among children not bringing their meter to

the clinic, the correlation between the number of family-reported blood checks and the last available objective meter reading within the prior 2 years was quite high ($r = .73$, $p < .01$). Further, compared with children who brought their meter to the clinic, a greater percentage of the families of children who did not bring their meter reported that they conducted glucose checks less than three times a day (47% vs. 60%).