Model of Associations Between Psychosocial Variables and Health-Outcome Measures of Adolescents with IDDM

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The purpose of this study was to develop a model that describes the contributions of key psychosocial variables to the health outcome of adolescents with insulin-dependent diabetes mellitus (IDDM). Subjects were 93 adolescents with IDDM and their parents. Health-outcome measures included adherence and metabolic control (HbA_{1c}). Psychosocial variables included adolescent age, chronic life stress, social competence, family relations, and family knowledge about IDDM. Multiple regression analyses showed that adherence ($P < .029$) and stress ($P < .052$) were directly related to metabolic control and that knowledge about IDDM ($P < .029$), family relations ($P < .099$), and adolescent age ($P < .086$) had direct effects on adherence. Combined, the independent variables accounted for 14.5% of the variance in predicting HbA_{1c} and 18.5% of the variance in predicting adherence. In general, these findings are consistent with extant theory. The direct link between stress and metabolic control, however, contrasts with the current view that psychosocial variables affect metabolic control indirectly through their influence on adherence behavior. The methodological limitations of the findings are noted, directions for future research are suggested, and the implications for clinical interventions are described. *Diabetes Care* 10:752–58, 1987

In recent years, investigators have devoted considerable attention to the role that psychosocial variables play in mediating health outcomes in adolescents with insulin-dependent diabetes mellitus (IDDM). In general, these investigators have hypothesized that psychosocial variables have an indirect effect on metabolic control through their impact on regimen-adherence behaviors (1–3). This hypothesized relationship is based on two assumptions: adherence directly influences metabolic control, and psychosocial variables have a direct effect on adherence. The purpose of this study was to test these assumptions and develop a model that describes the unique contributions of key psychosocial variables to adolescent adherence and metabolic control.

Reviewers have noted that many different psychosocial variables correlate significantly with adherence and/or metabolic control (4–6). It is not clear, however, whether these variables have a direct or indirect effect on adherence and metabolic control. For example, do positive family relations directly enhance the physical health of adolescents, or do such relations improve adherence, which then promotes good metabolic control? A related concern is the association among the psychosocial variables themselves. For example, perhaps family functioning has a positive effect on health outcome because it is associated with low stress and/or positive social competence in the child. When the influences of stress and social competence are controlled, perhaps the linkage between family functioning and health status is minimal. Therefore, when the association between a psychosocial measure and health outcome is examined, it is important to control for variables that may mediate this association.

To clarify the linkages between psychosocial variables and health-outcome variables, we used multiple regression analysis (MRA) to evaluate the relative contributions of pertinent psychosocial variables to the health of adolescents with IDDM. Five psychosocial variables were chosen to represent major conceptual domains that have been related to either adherence or metabolic control in previous research: life stress, social competence, family relations, family knowledge about IDDM, and adolescent age. We do not propose to test the impact of all conceptually relevant areas that have been reported in the literature but rather to identify a select num-

ber of important conceptual domains from which to develop a preliminary model.

Investigators have shown that life stress is associated with poor metabolic control (7–9). Although few researchers of IDDM have evaluated the issue, there is considerable evidence in the social sciences that social competence, which includes the availability of positive social relations, is a significant determinant of health status (10–12). Family functioning also plays an important role in IDDM management. Family cohesion, rigidity, and conflict have been associated with low adherence and/or poor metabolic control in adolescents (13–15). It is widely assumed that knowledge about IDDM is an important domain, because it is a major component of IDDM treatment and a frequent topic of research. Findings regarding the association between knowledge and health status, however, have been inconsistent (16–19). Finally, because adolescent age has been related to metabolic control and self-management skills (16,17), it is also included in the model.

There are several statistical and methodological concerns that must be addressed when MRA is used to isolate the psychosocial determinants of adherence and metabolic control. First, relatively reliable and valid indices of each of the psychosocial variables and health-outcome measures are necessary. Second, it is important to recognize the complex and systemic nature of human behavior and, whenever possible, to employ multiple respondents and/or multiple indices of a particular domain. For example, the parents' knowledge about IDDM might be as important in the health of the adolescent as the adolescent's knowledge of appropriate care. Likewise, an adolescent's perception of other family members' stressors probably relates to the adolescent's stress, even though these stressors might not have directly influenced the adolescent. Third, although MRA is robust, it is important not to violate the assumptions regarding multicolinearity and the normal distribution of residuals. Fourth, the ratio of sample size to independent variables must be large enough to provide a reasonable level of statistical power.

MATERIALS AND METHODS

Subjects

Subjects included 93 adolescents with IDDM. All adolescents were from intact families, and both parents participated in the study. The mean (±SD) ages were 40.2 ± 5.55 yr for the mothers, 41.9 ± 6.52 yr for the fathers, and 14.4 ± 2.45 yr for the adolescents. The mean age at onset of IDDM was 8.9 ± 3.68 yr, and 51% of the adolescents were female. The mean number of children in the families was 2.7. The sample was predominately middle class according to A. B. Hollingshead's (Department of Sociology, Yale University, New Haven, CT) four-factor index of socioeconomic status (SES), where I = 1.1%, II = 12.8%, III = 22.3%, IV = 40.4%, and V = 23.4%. Approximately 12% of the families were Black, and the rest were White.

Procedures

The parents of all adolescents who attended their regularly scheduled IDDM clinic appointment at a large children's hospital during a 7-mo period were contacted. The adolescents are regularly seen at this clinic every 2–4 mo. This treatment facility serves most of the adolescents who have IDDM and live in and around the metropolitan area. The families received a letter from C.L.H. and their physician asking them to participate in a study that explores how adolescents and their families learn to live with diabetes. After the letter, the families were contacted by phone to invite them into the study and to schedule an interview. Families were interviewed either in their homes or at the clinic on the day of their regularly scheduled clinic visit. All out-of-town families were interviewed at the clinic in private rooms. Only 8% of the families refused to participate. An additional 5% of the families were excluded because of mental retardation in the adolescent or temporary remission of the disease due to recent onset or because the diabetes was non–insulin dependent.

At the beginning of the session, the interviewer obtained written consent from the families participating in the study and assured family members of the confidentiality of all information. The families were informed of their privilege to discontinue participation in the study at any time. The consent form and all procedures were approved by the Institutional Review Board of Le Bonheur Children's Hospital. The interviews were conducted to accommodate the adolescents' treatment regimen. Each adolescent's blood glucose was tested at the outset of the session to ensure that he/she was not hypoglycemic. All questionnaires were administered in a counterbalanced order and were explained by the interviewer before their administration.

Interviewers included three graduate and two advanced undergraduate students who were not informed about the metabolic control of the adolescents. They received extensive training (100–120 h) regarding IDDM, testing and observational measures, and interviewing techniques before any family contact. In addition, each interviewer participated in 15 h of role play and accompanied an experienced interviewer on his/her initial family visit.

Measures

The variables were chosen to provide a single global index of each conceptual domain: adherence, metabolic control, family knowledge about IDDM, family relations, chronic stress, social competence, and adolescent age. Most of these domains consist of multiple measures and include information from multiple perspectives.

Metabolic control. Metabolic control was determined by averaging the adolescent's hemoglobin A_{1c} (HbA_{1c}) taken at the time of the clinic visit and during the year before the evaluation. All blood samples were analyzed with the Bio-Rad column-assay method and were performed in the same laboratory. HbA_{1c} is the best available indicator of overall metabolic control in the 6–8 wk before the blood test (21–23). The range of average HbA_{1c} levels in our sample was

4.6–14.4%, with a mean of 9.3%. Normal HbA_{1c} values in children without diabetes range from 3.0 to 7.4%, with a mean of 5.2%.

Adherence. The adolescents' adherence behaviors were measured across five areas that are identified as important by the American Diabetes Association (24) and researchers of adherence behaviors (25): diet, insulin adjustment, hypoglycemia, glucose testing, and foot care. Self-report and observational items developed by Cerkoney and Hart (26) and Schlenk and Hart (27) were used to assess adherence in each of these areas. The items were summed across the five areas to yield a total of 49 possible points. Examples of diet items include eating foods that are restricted from the diet, delaying and skipping meals, and the frequency of eating more or less than the prescribed diet. Insulin adjustment items assessed knowledge and use of appropriate types and amounts of insulin and syringes. Examples of hypoglycemia items include knowledge of symptoms, ready availability of a sugar source at all times, and carrying IDDM identification. Glucose testing items related to techniques and frequency of testing for glucose and acetone. Foot-care items assessed the appropriate care of the feet (e.g., proper shoes and socks, toenail care, and bathing).

Family knowledge about IDDM. The parents' and adolescents' knowledge about IDDM was assessed with a shortened version (odd items only) of the Tests of Diabetes Knowledge (TDK; 18,28). The multiple-choice test included 20 items measuring general information and 13 items measuring problem-solving skills. Estimates of split-half reliability are .90 ($P < .0001$) for general information and .84 ($P < .0001$) for problem solving, indicating that it is acceptable to use only the even or odd items if a shortened version of the test is desired. Because of the number of measures assessed in this study, we used only the odd items of the TDK to reduce the response burden on the subjects. A principle-components factor analysis was completed on the parents' and adolescents' TDK scores to derive a global index of family knowledge about IDDM. One factor was derived that had an eigenvalue of 2.01 and accounted for 67% of the variance. Adolescent, maternal, and paternal scores loaded .87, .81, and .77, respectively, on this factor. Factor scores, representing the global index of family knowledge about IDDM, were generated and used in subsequent analyses. The use of factor scores reduces the number of comparisons required in testing the model and also increases the reliability and validity of the construct (29).

Family relations. Several well-standardized measures of family functioning were obtained from multiple perspectives (i.e., adolescent, mother, and father) and were combined by factor-analytic techniques to provide a global index of family relations. First, the parents' marital satisfaction was assessed with the 15-item Locke-Wallace Marital Adjustment Scale (MAS; 30). The MAS is one of the most widely used and well-validated measures of marital relations (31). Mothers' and fathers' MAS scores were summed to provide an aggregate measure of marital adjustment. The second instrument used to measure family relations was the 30-item Family Adaptability and Cohesion Evaluation Scales II (FACES-II; 32). FACES-II assessed adolescents' and parents' perceptions of family cohesion and adaptability. Cohesion reflects the degree of emotional bonding that family members have toward one another; and adaptability is the family's ability to change its power structure, role relationships, and relationship rules in response to situational and developmental stress. The validity of the FACES scales has been supported by recent studies of families with adolescents (33–35). The adolescents', mothers', and fathers' scores on cohesion and adaptability were converted to z scores and summed to yield aggregate family scores for each scale. The third instrument used to measure family relations was the supportive subscale of the Diabetes Family Behavior Checklist (DFBC; 2,36). This subscale includes nine items that assess the adolescents' perceptions of parental support specific to the IDDM-treatment regimen. The adolescents' perceptions of maternal and paternal support were summed to provide an aggregate measure of parental support.

The four measures (marital adjustment, cohesion, adaptability, and parental support) derived from these instruments were submitted to a principle-components factor analysis. One factor was generated with an eigenvalue of 2.28, which accounted for 57% of the variance. Factor loadings were .78 for marital adjustment, .88 for cohesion, .84 for adaptability, and .41 for parental support. Factor scores reflecting overall family functioning were used in subsequent analyses.

Stress. Chronic life-events stress was measured by the adolescents' responses on the 50-item Adolescent-Family Inventory of Life Events and Changes (A-FILE; 37). The A-FILE was developed through factor-analytic techniques with a national sample of 2740 adolescents. It was designed to assess the adolescents' perceptions of individual and family life changes during the past year, because stress experienced by each member of the family is thought to affect the family

TABLE 1
Means, standard deviations, and ranges of all psychosocial variables

	Mean	SD	Range
Adherence to treatment	34.62	4.57	21–46
Perceived competence	11.98	1.83	8–16
Social competence	25.34	4.84	10–34
Adolescent knowledge about IDDM	25.06	5.96	5–33
Mother knowledge about IDDM	28.35	3.94	11–33
Father knowledge about IDDM	25.25	5.32	7–33
Adolescent cohesion	57.06	10.56	32–75
Mother cohesion	63.47	8.29	28–77
Father cohesion	62.33	9.40	30–79
Adolescent adaptability	43.16	7.59	21–58
Mother adaptability	46.49	6.19	31–61
Father adaptability	46.07	6.12	33–63
Mother marital	109.43	26.81	33–153
Father marital	109.81	25.14	40–158
Parental support of treatment	47.51	11.07	23–72
Chronic stress	5.04	3.89	0–22

TABLE 2
Correlation matrix of psychosocial and outcome variables

	HbA_{1c}	Stress	Competence	Family	Knowledge	Age
Adherence	−.30*	−.11	.25*	.32†	.28*	−.21‡
HbA_{1c}		.24*	−.06	−.22‡	−.02	.13
Chronic stress			.00	−.33†	.12	.08
Social competence				.31†	.26*	−.06
Family relations					.13	−.36†
Knowledge about IDDM						.03

*$P < .01$; †$P < .001$; ‡$P < .05$.

system. The A-FILE includes items from the Coddington scales (38) and has strong internal consistency, test-retest reliability, and convergent validity (37).

Social competence. A global index of the adolescents' social competence was determined by combining both the adolescents' and mothers' viewpoints. The adolescents completed the 28-item Perceived Competence Scale for Children (PCS; 39–41), which assesses their perceived competence across four domains: social, cognitive, physical, and general self-esteem. The internal consistency of the PCS is high, and several studies have supported its convergent, construct, and discriminant validity. The mothers completed the well-validated Social Competence Scale of the Child Behavior Checklist (SCS-CBCL; 42). The SCS-CBCL was completed only by the mothers, because interparent reliability is extremely high for the scale. The SCS-CBCL assesses the adolescents' competence in school, peer activities, and family relations. Scores from the PCS and SCS-CBCL were converted to z scores and summed to provide an overall index of social competence.

RESULTS

The statistical analyses served two purposes. First, the intercorrelations among the psychosocial variables (family knowledge about IDDM, family relations, chronic stress, social competence, and adolescent age) and the health-outcome measures (adherence and metabolic control) were examined. Second, MRA was used to isolate the direct associations between the independent and dependent variables. The means ± SD for all measures are listed in Table 1.

Correlations

The zero-order correlation matrix for the seven variables is presented in Table 2. HbA_{1c} was significantly correlated with adherence ($r = -.30$, $P < .002$), stress ($r = .24$, $P < .010$), and family relations ($r = -.22$, $P < .017$). High adherence, positive family relations, and low life stress were associated with good metabolic control. Three psychosocial variables were significantly and positively associated with adherence: social competence ($r = .25$, $P < .008$), family relations ($r = .31$, $P < .001$), and family knowledge about IDDM ($r = .26$, $P < .007$). Adolescent age was negatively correlated with adherence ($r = -.21$, $P < .022$). Thus, good adherence was associated with social competence, positive family relations, the family's acquisition of knowledge about IDDM, and a younger adolescent age. Moreover, several of the correlations among the psychosocial variables were also significant. These included correlations between family relations and social competence ($r = .31$, $P < .001$), family relations and chronic stress ($r = -.33$, $P < .001$), family relations and adolescent age ($r = -.36$, $P < .001$), and family knowledge about IDDM and social competence ($r = .26$, $P < .007$).

Multiple Regression Analyses

Least-squares MRA, with simultaneous entry of the predictor variables, is a conservative statistical approach that was used to evaluate the effects of the independent variables on the health-outcome measures. The advantage of MRA is that it can isolate the effects of a variable by controlling for spurious influences (43,44). For example, although adherence, stress, and family relations were each linked with HbA_{1c}, it is possible that one or more of these variables are not associated with HbA_{1c} when the effects of the others are controlled. This seems especially likely because of the significant variance that is shared between family relations and both adherence and stress. Similarly, four independent variables (social competence, family relations, family knowledge, and adolescent age) were significantly correlated with adherence, which served as the dependent measure in the second MRA. MRA enabled a determination of which psychosocial variables are linked with adherence when the effects of the others

TABLE 3
Summary of multiple regression results for HbA_{1c}

	β	F
Adherence	−.244	4.88*
Chronic stress	.212	3.88*
Social competence	−.089	.67
Family relations	−.048	.15
Knowledge about IDDM	.052	.23
Adolescent age	.007	.01

β, Standardized regression coefficient.
*$P < .052$.

TABLE 4
Summary of multiple regression results for adherence

	β	F
Chronic stress	−.033	.10
Social competence	−.067	.41
Family relations	.194	2.79*
Knowledge about IDDM	.227	4.88†
Adolescent age	−.182	2.99*

β, Standardized regression coefficient.
*$P < .10$; †$P < .05$.

are controlled. In addition, it is possible that independent variables that did not have significant zero-order correlations with HbA_{1c} and adherence might account for a significant amount of the variance when the effects of the other variables are controlled.

HbA_{1c}. As shown in Table 3, the six independent variables (adherence, chronic stress, social competence, family relations, knowledge, and adolescent age) accounted for 14.5% ($R = .38$) of the variance in predicting metabolic control [$F(6,86) = 2.43$, $P < .031$]. Adherence [$F(1,86) = 4.88$, $P < .029$] and chronic stress [$F(1,86) = 3.88$, $P < .052$] were the only variables directly associated with metabolic control. Good metabolic control was predicted by high adherence and low stress.

Adherence. As shown in Table 4, the five independent variables (chronic stress, social competence, family relations, knowledge, and adolescent age) accounted for 18.5% of the variance ($R = .43$) in predicting adherence [$F(5,87) = 3.95$, $P = .003$]. Family knowledge about IDDM was the only variable that was significantly associated with adherence when the effects of the other variables were controlled [$F(1,87) = 4.88$, $P < .029$]. In addition, family relations [$F(1,87) = 2.79$, $P < .099$] and adolescent age [$F(1,87) = 2.99$, $P < .086$] were marginally associated with adherence. Thus, good adherence was predicted directly by high family knowledge about IDDM, positive family relations, and young adolescent age, although the latter two results were of marginal statistical significance.

Finally, we determined whether any of the psychosocial variables had an indirect effect on metabolic control. An indirect effect would be shown if the psychosocial measure *1*) had a significant zero-order correlation with metabolic control but was not directly related to metabolic control and *2*) was directly linked with a variable (adherence) that directly predicted metabolic control. As shown in Tables 2 and 4, family relations met the criteria used to define an indirect relationship with metabolic control. Positive family relations marginally predicted good adherence, which in turn was directly associated with good metabolic control.

The results of the two MRAs were combined to form a path diagram that is presented in Fig. 1. Note, however, that the paths from family functioning and adolescent age to adherence are of marginal statistical significance and that, according to the criteria outlined previously, adolescent age and family knowledge did not evidence indirect effects on metabolic control.

DISCUSSION

Although many investigators have examined the role of psychosocial variables in the health status of adolescents with IDDM, this is the first empirical report to delineate a multidimensional model of the interrelations among these variables. Consistent with extant theory, knowledge about IDDM was directly linked with adherence. This association supports the prevailing view that families of children with IDDM should be well informed regarding the most appropriate management of the disease (16,18). Similarly, the finding that family relations was marginally linked with adherence supports the assumptions of several investigators that family relations play an important role in the maintenance of adherence behaviors (1,2,15). Note that the direct association that was observed between adherence and metabolic control supports the assumptions of most theorists and clinicians.

One finding contrasts with prevailing theoretical assumptions and provides a new perspective on the associations between psychosocial measures and health outcome. As noted earlier, several theorists have posited that psychosocial variables affect metabolic control indirectly by influencing adherence behaviors (1,2). Although this assumption may apply for some psychosocial variables, it was not supported by the findings for chronic stress. Chronic stress was not associated with adherence, but it was directly linked to metabolic control and contributed a considerable amount of unique variance.

Another finding reflected the developmental transitions that occur during adolescence. Adolescent age had a marginal direct effect on adherence. Older adolescents were less adherent to their treatment regimen. It seems possible that as

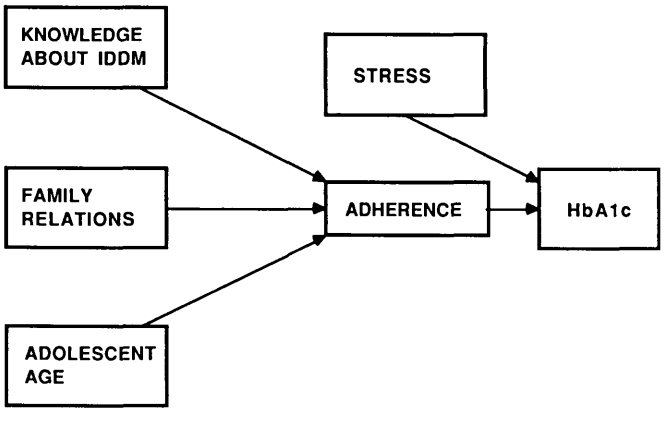

FIG. 1. Model of associations between psychosocial variables and health outcomes.

adolescents mature and take more personal responsibility for their treatment, they may test the extent to which they can deviate from the treatment regimen without serious loss of glucose control. These older adolescents may be evidencing increased rebellion against the demands of the disease, or they may simply be less adherent because they are spending more time with their friends and do not want their friends to perceive them as "different."

Although this study presents the first empirically derived model of the associations between key psychosocial variables and health-outcome variables, the model has several limitations. First, the model accounts for only 18.5% of the variance in predicting adherence and 14.5% of the variance in predicting metabolic control. Although the observed correlations between the psychosocial measures and the health-outcome measures are generally equal to or greater than those observed by other investigators, much of the variance remains unexplained. Second, the validity of the model is linked with the validity of the instruments that were used to measure the different conceptual domains. Although these instruments are reliable and valid, it seems likely that additional refinements in the measurement of domains such as adherence may further increase the explanatory power of the model. Third, the model is limited to the conceptual domains that were assessed in this study. Although we attempted to obtain a relatively broad perspective of the psychosocial correlates of health outcome, some potentially important variables were not considered. For example, adolescent coping strategies and characteristics of the health-care system might contribute significant amounts of variance in predicting health outcomes. As suggested by these limitations, future research should replicate our results and refine the model by considering the effects of other pertinent conceptual domains.

A second priority of future research should involve the design of intervention studies that test the validity of the model. Our findings support a multisystemic view of health and adaptation. Adherence and metabolic control were linked with psychosocial measures that pertained to individual, familial, and extrafamilial variables. We recommend, therefore, that clinicians and researchers take a flexible and multisystemic approach toward evaluating and treating the factors that might contribute to poor metabolic control (45). This multisystemic approach has shown considerable promise in the amelioration of other serious child and adolescent problems (46,47). Briefly, the multisystemic approach entails an evaluation of the adolescent and the systems in which he/she is embedded to determine the variables that may be associated with identified problems. Interventions, which use the strengths of the systems, are then designed to address these variables. For example, poor metabolic control in some adolescents might be associated with high levels of stress that are due to marital conflicts among their parents and low adolescent social competence. Here, the most appropriate interventions might be to refer the parents for marital counseling and engage the adolescent in peer activities that build social competence. In other adolescents, poor adherence might be associated with inadequate knowledge regarding IDDM treatment, and optimal intervention might be educational in nature. The design of intervention studies should take into account the multidimensional and multisystemic nature of the variables associated with adherence and metabolic control.

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