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Developmental Model of Parent-Child Coordination for Self-Regulation Across Childhood and Into Emerging Adulthood: Type 1 Diabetes Management as an Example

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Abstract

Developing individuals and their families benefit from a warm and supportive relationship that fosters the development of good self-regulatory skills in the child needed for a host of positive developmental outcomes. Children and parents face special challenges to self-regulation when faced with a child's chronic illness. A developmental model is presented that traces how positive parental involvement is coordinated with a child's self-regulation skills (regulation of cognition, emotion, and behavior) that are essential for positive health management. This involves different temporal patterns of coordination of child and parent (and other close relationships) that lead to accumulating regulatory developments that afford benefits for managing illness. This process begins early in infancy through attachment and develops into childhood and adolescence to involve the coordination of parental monitoring and child disclosure that serves as a training ground for the expansion of social relationships beyond the family during emerging adulthood. The specific case of families dealing with type 1 diabetes is used to illustrate the transactional and dynamic nature of parent-child coordination across development. We conclude that a developmental model of parent-child coordination holds promise for understanding positive health outcomes and offers new methodological and statistical tools for the examination of development of both child and parent.

Keywords

Self-regulation; parent-child relationships; coordination; diabetes management; adolescence

The ability to effectively regulate one's cognitions, behaviors, and emotions (i.e., self-regulation) is key to competent functioning across a broad array of indicators such as

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academic performance, social competence, psychological adjustment, and health (Eisenberg, Spinrad, & Eggum, 2010; Moffitt et al., 2011; Repetti, Taylor, & Seeman, 2002; Tangney, Baumeister, & Boone, 2004). Parents serve as an important resource for the development and maintenance of effective self-regulation (Belsky & Beaver, 2011), such that those who are warm and sensitive to children's needs and monitor children's activities provide a family context that models effective self-regulation and provides a scaffold for children's developing cognitive and emotional abilities (Lengua, Honorado, & Bush, 2007; Morris, Silk, Steinberg, Myers, & Robinson, 2007). Self-regulatory skills developed in the family context (impulse control, emotion regulation) allow individuals to successfully navigate an expanding set of challenging contexts (e.g., drinking alcohol and driving, risky sexual practices) during late adolescence and early adulthood that increasingly lie outside of the purview of parents.

Developing individuals and their families may face especially difficult challenges to regulation when faced with chronic illness (e.g., diabetes, asthma, cancer; Compas, Jaser, Dunn, & Rodriguez, 2012; Modi et al., 2012). Nonnormative events such as chronic illness can be viewed as "experiments of nature" (Bronfenbrenner, 1977) that afford the opportunity to examine regulation under conditions of paramount adaptive significance and high stress for families. For example, the management of type 1 diabetes requires a complicated and intensive daily regimen of behaviors including repeated glucose testing and insulin injections. These behaviors must be managed in the face of daily negative emotions (Fortenberry et al., 2009) and cognitions such as perceptions of low self-efficacy and control that are offset by greater parental involvement (Berg et al., 2013; Berg et al., 2011; King, Berg, Butner, Butler, & Wiebe, 2014).

Although it is clear that parental involvement is beneficial for chronic illness management, the literature is somewhat fragmented with research focusing on different (albeit related) facets of parental involvement (e.g., support, parental monitoring, criticism) that facilitate or hinder a wide array of child self-regulatory characteristics (adherence behaviors, self-efficacy, self-control, emotion regulation, coping) relevant to health outcomes. Many of these child characteristics can be viewed as reflective of effective self-regulation (see Lansing & Berg, 2014). Further, this literature focuses on a specific direction of effects such that parental involvement presumably leads to enhanced chronic illness management through youth self-regulation skills. However, recent longitudinal research is supportive of the view that facets of parental involvement co-occur (e.g., high parental support co-occurs with low criticism), as do child self-regulation skills (e.g., high self-efficacy co-occurs with high adherence), and that these patterns of parental involvement and child characteristics are coordinated together (Helgeson et al., 2010; King et al., 2012; Luyckx & Seiffge-Krenke, 2009; Wiebe et al., 2014). That is, parents' involvement changes together with youths' self-regulation skills and illness management, mutually influencing each other across time.

In this article we present a developmental model of the coordinative process that exists between parents and children, a coordination that begins early in infancy and extends across the adult life span. Coordination is defined as the emergent temporal patterns between child and parent as they move together throughout time. This model draws on recent developmental theory that highlights the bi-directional nature of relationships between

parents and children, whereby parenting not only affects the developing regulatory skills in the child, but these regulatory skills alter subsequent parenting as well (Hipwell et al., 2008; Pardini, Fite, & Burke, 2008). Our model captures these time-dependent relationships between child and parent as different forms of coordination.

In this paper, we highlight aspects of our model using type 1 diabetes as an example, as it is an illness that has daily regulatory challenges where parental involvement is beneficial. We first review the literature on parental involvement and illness management to demonstrate that there is existing evidence for the connection between positive facets of parental involvement (accepting relationship, monitoring, and behavioral involvement) and good adolescent self-regulation that facilitates management behaviors. Second, utilizing the broader developmental literature, we trace how this coordinative process begins early in infancy through attachment processes and develops across childhood, adolescence, and emerging adulthood. We also show that the coordinative process between parents and children serves as an important foundation for the development of new coordinations with close relationships outside of the family (Smetana, Campione-Barr, & Metzger, 2006). During adolescence especially, other relationships such as friends and romantic partners may enter into this coordinative process, as individuals solicit the instrumental and emotional support needed to manage chronic illness during young adulthood. Third, we illustrate how this model can identify forms of coordination across development and reduce the number of variables that are used to characterize these coordinative patterns. Finally, we conclude by noting the implications of the model for a life-span approach to chronic illness management, interventions for families, and the generalizability of our model beyond chronic illness into multiple domains of youth functioning. The model holds promise for a dynamic life-span perspective of the development of self-regulation skills within close relationships that views the parent-child relationship as setting the stage for the successful development of a larger coordinated system involving romantic partners and close friends as well as parents (Berg & Upchurch, 2007; Dinero, Conger, Shaver, Widaman, & Larsen-Rife, 2008; Nosko, Tieu, Lawford, & Pratt, 2011).

Developmental Model of Parent-Child Coordination for Self-Regulation Skills for Type 1 Diabetes Management

The Context of Type 1 Diabetes

We utilize the chronic illness of type 1 diabetes to illustrate the developmental model of parent-child coordination for illness management. Type 1 diabetes is a prevalent chronic illness affecting some 1 in 400 children (Mayer-Davis et al., 2009), caused by an autoimmune mediated deficiency of insulin secretion (Kaufman, 2012) by the pancreas. It is a serious illness that is associated with substantial decreases in longevity for those diagnosed during childhood (Pambianco et al., 2006). The goal of treatment is to achieve glycemic control that avoids both hypo- and hyper-glycemia. This is accomplished through adjusting the amount and timing of insulin together with multiple daily blood glucose tests (typically a minimum of 4 per day) as well as the timing and amount of food intake and the frequency and intensity of physical activity. Diabetes management, including adherence to this daily and demanding regimen, is crucial as it promotes better glycemic control, which

substantially decreases potential long-term complications of the disease such as kidney problems, retinopathy, and cardiovascular disease (Hood, Peterson, Rohan, & Drotar, 2009; Writing Team for the Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications Research Group, 2003). For example, maintaining good blood glucose control reduces long-term health complications such that a one percentage drop in HbA1c (a metric of how well blood glucose has been controlled over the past 3-4 months with higher numbers reflecting poorer control, e.g., 9%-8%) is associated with a 40% risk reduction of developing retinopathy (Hood, et al., 2009; Lachin, Genuth, Nathan, Zinman, & Rutledge, 2008).

To illustrate the daily self-regulation skills required of type 1 diabetes management for children and the coordination between children and parents, imagine a day in the life of an adolescent and his or her parents. The adolescent needs to test blood glucose at school, which involves adolescents' self-regulation in planning to bring test supplies to school, dealing with negative emotions of feeling different because of one's diabetes, and maintaining self-efficacy in the face of high blood glucose readings. The test may reveal a high blood glucose value, which then requires a calculation of the amount of insulin needed, depending on dietary information, and decisions as to whether to retest. Adolescents' self-regulation skills are likely coordinated with numerous aspects of parental involvement. Parents' knowledge and monitoring of their adolescents' diabetes management may facilitate adolescents' self-regulation: parents may remind their youth to take test supplies to school or bolster the adolescent's efficacy that he or she can perform diabetes tasks at school. The manner in which adolescents' and parents' behaviors are coordinated may affect whether youth disclose, thereby affecting parents' knowledge about such problems. For instance, parent-youth dyads or triads where parental negative affect is in direct relation with youth's experience of problems may experience a pattern of low adolescent disclosure as adolescents begin to anticipate the negative repercussions of disclosing problems to their parents (Tilton-Weaver et al., 2010). Such blood glucose testing and adjustments in insulin and dietary intake take place multiple times each and every day for the person with diabetes and their parents.

Successful management behaviors (Modi, et al., 2012) such as checking blood glucose and adjusting insulin in response are especially difficult to maintain during adolescence (Bryden et al., 2001; Johnson et al., 1992; Morris et al., 1997; Rausch et al., 2012), but can be facilitated by parents' greater involvement (Berg, et al., 2011; Ellis et al., 2007). A key tenant of our model is that facets of parental involvement (e.g., warmth, support) are coordinated with self-regulatory skills in the child together with illness management. Although the available body of literature in diabetes is only beginning to examine parent-child relationships as coordinative patterns (Butner, Berg, Baucom & Wiebe, 2014; Butner et al., in press), we use the literature to demonstrate linkages between multiple facets of parental involvement, adolescents' self-regulatory skills and diabetes management.

Dynamic Approach to Self-Regulation and Parental Involvement

Better illness management (including adherence and metabolic control) during childhood and adolescence has been associated with a broad array of parental involvement measures

including support, monitoring, criticism, behavioral involvement. We focus in this review (see Table 1) on three facets of parental involvement that have guided the study of parent-child interactions more broadly in developmental psychology (Beveridge & Berg, 2007; Dishion & McMahon, 1998) and diabetes more specifically (Palmer et al., 2011): *high quality accepting parent-child relationships*, which involve an accepting relationship characterized by parental responsiveness, warm communication and encouragement of autonomy (Miller-Johnson, et al., 1994; Skinner, John, & Hampson, 2000), *monitoring*, which involves regular contact with children regarding their daily activities, knowledge and supervision of those activities, and children disclosing to their parents so that they can be knowledgeable (Ellis et al., 2007; Stattin & Kerr, 2000), and *behavioral involvement*, which involves parents taking responsibility for diabetes management tasks (Anderson, Ho, Brackett, Finkelstein, & Laffel, 1997; Palmer et al., 2009; Wysocki & Gavin, 2006). The focus of research on parental involvement has largely been on mothers with a growing literature noting the important (and sometimes different) role played by fathers (Berg et al., 2013; Queen et al., 2016; Wysocki & Gavin, 2006). We highlight throughout the review aspects of parental involvement that may be different for mothers and fathers.

This research is beginning to show evidence that parents' involvement may be beneficial for diabetes management by facilitating the development and execution of many self-regulation skills including regulation of affect (Fortenberry, et al., 2009), active coping strategies and cognitive restructuring (Band & Weisz, 1990; Grey et al., 2009; Jaser & White, 2011), self-efficacy (Berg, et al., 2011; Iannotti et al., 2006; King, et al., 2014; Wiebe, et al., 2014), and goal-directed behavior (J. M. Butler et al., 2011; Helgeson & Takeda, 2009). In this review we adopt Baumeister's framework (Baumeister, Vohs, & Tice, 2007) of self-regulation that defines self-regulation as an ongoing process of regulating *one's behaviors, cognitions, and emotions*, in the service of goals relevant to diabetes management. Utilizing this approach to self-regulation, we will focus our review on constructs that relate to regulation of behavior (e.g., adherence behaviors including BG testing), cognitions (e.g., self-efficacy, beliefs about diabetes, planning), and emotions (negative affect including the persistent experience of negative affect as represented by elevated depressive symptoms or low quality of life).

Our approach highlights that diverse elements of parental involvement and the developing child's self-regulation skills are coordinated, moving through time together in important ways along with illness management (see Figure 1), rather than guided by a particular direction of effects. Ongoing transactions among facets of parental involvement, self-regulation skills, and illness management occur in a dynamic system, with these elements moving together over time but also constraining one another, creating a coordinated system. Consistent with a dynamic systems approach, variables are assumed to be part of a multidirectional causal system (Butner, Amazeen, & Mulvey, 2005), represented in Figure 1 by springs rather than arrows (as relationships are transactional). That is, facets of parental regulation (e.g., parental monitoring) may push for greater coordination among a child's facets of self-regulation. Relatedly, a child's greater adherence behaviors (one facet of self-regulation) may push for low levels of parental behavioral involvement. Further, within self-regulation and parental involvement, some facets may serve to drive the coordination of the other aspects. For instance, within self-regulation fewer self-regulatory failures may serve to coordinate a system of lower negative affect and better adherence across time. Our

approach is consistent with other developmental systems approaches (Fogel, 2011; Lewis, 2011; Smith & Thelen, 2003), that link aspects of parent-child relationships through a coordinative process.

Across developmental time, the specific manifestation of parental involvement important as inputs to this system may vary (depicted in the box on the left in Figure 1). During infancy, relationship quality may be key as attachment processes provide the foundation for the parent-child relationship. During early and middle-childhood, behavioral involvement may be most important in driving parental involvement as parent and child begin to negotiate new forms of relating as the child takes on more responsibility for diabetes management. During adolescence, parental monitoring may take on increasing importance as a driver of parental involvement as parents make adjustments to monitor their adolescent's diabetes management behaviors as adolescents disclose relevant information to their parents. These foundations of parental involvement provide the basis for new relationships with friends and romantic partners to develop in adolescence and emerging adulthood, supplementing and even replacing the involvement that parents have provided.

A large literature in developmental psychology supports this transactional view of the parent-child relationship, whereby children are simultaneously affected by their parents, while also affecting their parents (Sameroff, 2009). That is, parental involvement not only affects youths' self-regulation skills, but youths' regulation skills affect parental involvement and parental development as well. For instance, a child's ability to regulate emotions and cope with problems affects parents' regulatory skills involved in parenting (Dix, 1991; Pettit, Keiley, Laird, Bates, & Dodge, 2007). Thus, children and parents are developing together across time in an interdependent fashion (Bell, 1968; Kim, Conger, Lorenz, & Elder, 2001; Nicholson, Deboeck, Farris, Boker, & Borkowski, 2011; Yates, Obradovic, & Egeland, 2010). Management of chronic illnesses such as diabetes is difficult and can engender family conflict (Anderson, et al., 2009; Hilliard, Harris, & Weissberg-Benchell, 2012), which may subsequently hinder effective parenting. Some evidence of the detrimental effect of adolescents' daily problems with diabetes on subsequent parental daily mood has been found (Queen, Butner, Wiebe, & Berg, 2016). These parent-child coordinations can become self-organizing systems that are associated with positive regulatory skills or negative skills (Patterson, Debaryshe, & Ramsey, 1989; Repetti, et al., 2002).

There is a view in the literature that coordination between parents and children may change in nature across time, especially in terms of symmetries of influence, although the empirical support for this view is scarce. The coordination may be stronger earlier in development than later, with asymmetries such that parents may have a greater influence on children early in development with bidirectional effects between parents and youth strengthening over time (Pardini et al., 2008). In fact, adolescence may be a time during development when greater variability in aspects of the parent-child relationship may allow for these shifts in influence to occur (Granic, Hollenstein, Dishion, & Patterson, 2003).

Evidence for Coordination Between Self-Regulation and Parental Involvement for Diabetes Management

Both cross-sectional and longitudinal research provide evidence for relationships among parental involvement, chronic illness management, and some aspects of children's self-regulatory skills (see Table 1). A large body of cross-sectional research demonstrates that parental warmth, acceptance, and emotional support are associated with better illness management during childhood and adolescence (Berg, et al., 2011; Davis et al., 2001; Eckshtain, Ellis, Kolmodin, & Naar-King, 2010; Miller-Johnson, et al., 1994; Skinner, et al., 2000). In addition, high quality parent-child relationships appear linked with good diabetes management through self-regulatory skills of adolescents such as self-efficacy (Berg, et al., 2011; Ott, Greening, Palardy, Holderby, & DeBell, 2000), being able to prioritize diabetes over peer influence (Drew, Berg, & Wiebe, 2010), and developing cognitive beliefs regarding how treatment may be effective (Skinner, et al., 2000). Parental support has also been associated with monitoring (i.e., what parents know about adolescents' diabetes such as what their blood glucose readings are as well as what adolescents disclose to their parents and how frequently parents solicit information), and with better adherence and metabolic control (Ellis et al., 2007; Osborn, Berg, Hughes, Pham, & Wiebe, 2013).

The absence of positive aspects of high quality parental involvement (e.g., low support, low warmth) typically co-occur with the presence of more negative aspects of parental involvement (Anderson et al., 2002; J. M. Butler, Skinner, Gelfand, Berg, & Wiebe, 2007) such as hostility, criticism, control, and nagging, which have been associated with poorer adherence during adolescence (Armstrong, Mackey, & Streisand, 2011; Chisholm, et al., 2011; Grabill, et al., 2010; Jaser & Grey, 2010; Wiebe, et al., 2005). Further, such poor-quality relationships are also associated with self-regulatory challenges involved in emotion regulation such as increased parent-adolescent conflict (Anderson, et al., 2009; Herzer, Vesco, Ingerski, Dolan, & Hood, 2011; Hilliard, Wu, Rausch, Dolan, & Hood, 2013; Hood, Butler, Anderson, & Laffel, 2007) and negative emotions (Berg, et al., 2007). Critical parenting is also associated with lower self-efficacy (Armstrong, et al., 2011) and more depressive symptoms (Jaser & Grey, 2010). Conflict has been associated with greater depressive symptoms for adolescents (Barzel & Reid, 2011), greater parent and child negative affect surrounding blood glucose monitoring, a key metric of management (Hood, et al., 2007) and reduced levels of blood glucose monitoring (Ingerski, Anderson, Dolan, & Hood, 2010).

A number of recent longitudinal studies on developmental trajectories of diabetes management (Helgeson, et al., 2010; Hilliard, Wu et al., 2013; King, et al., 2014; King, et al., 2012; Luyckx & Seiffge-Krenke, 2009) provide further support for the idea that parental involvement, self-regulatory skills and illness management are coordinated across time. In one study, adherence deteriorated across adolescence in tandem with declines in maternal and paternal acceptance and monitoring (King, et al., 2014). Further, longitudinal associations between maternal acceptance and diabetes monitoring and subsequent adolescent adherence were mediated by changes in adolescents' self-efficacy, an important self-regulatory skill (King, et al., 2014).

Longitudinal studies are also beginning to identify typologies of families characterized by patterns of family involvement and adolescent regulatory skills that support parent-child coordination. Research has identified at least two different trajectories of diabetes outcomes among adolescents: a group that begins adolescence in good or moderate metabolic control (Hilliard, Harris, & Weissberg-Benchell, 2012; King, et al., 2012; Luyckx & Seiffge-Krenke, 2009) and deteriorates modestly across adolescence, and a group that begins adolescence with quite poor metabolic control and deteriorates rapidly across adolescence (Helgeson, et al., 2010; Hilliard, et al., 2012; King, et al., 2012). Consistent with the idea that various elements of parental involvement are coordinated with child regulatory skills and diabetes management, King et al. (2012) found that adolescents with a better metabolic control trajectory reported greater paternal monitoring and scored higher on measures of self-control and autonomy. Hilliard et al. (2012) found that those with better metabolic control reported less family conflict, less depressive symptoms, and less negative affect regarding blood glucose monitoring and Helgeson et al. (2010) found similarly that a better metabolic control trajectory was associated with less negative emotions.

The cross-sectional and longitudinal research reviewed above points to consistent relationships among elements of parental involvement, youth self-regulation, and good illness management. Although few studies have included multiple facets of parental involvement, youth self-regulation skills and illness management (see Berg, et al., 2011; Ellis et al., 2007) or multiple directions of effects, taken as a whole the literature is consistent with the type of relationships depicted in Figure 1. That is, a broad array of parental involvement measures move together through time with self-regulation skills of the child and illness management outcomes. Further, the research is supportive of the idea of a bi-directional system of influence, whereby children and parents (and others) influence each other through time by pushing and pulling each other at different times across childhood and adolescence. Such coordinative patterns may be stable or labile at various times, and asymmetric or symmetric. The parent-child coordinations found during adolescence may derive from earlier foundations of effective coordinations between parents and children (attachment) that inform adolescents' and emerging adults' relationships with high quality friend, romantic, and health care relationships. We now describe this developmental coordinative process and provide evidence from the developmental literature for its emergence.

Developmental Perspective on Parent-Child Coordination

Our perspective characterizes the developmental progression of chronic illness management as moving from the highly interdependent relationship with parents that occurs early in development, where parents are integral in the coordination process, to one that remains interdependent but begins to involve other relationships (such as peers and romantic partners) in the coordination later in development. This is in contrast to the position frequently portrayed in the literature that the adolescent moves toward independent chronic illness management as they emerge into adulthood (Weissberg-Benchell, Wolpert, & Anderson, 2007). Thus, this model links to adult life-span models of dyadic coping in couples (Berg & Upchurch, 2007; Revenson, Kayser, & Bodenmann, 2005), which view adults dealing with chronic illness as interdependent within close relationships.

We illustrate developmental changes in the coordinative process that facilitate diabetes management in conjunction with other close relationships using the metaphor of a child riding a bicycle. During infancy, the parent has primary responsibility for management, much as when riding a bicycle the parent may do the work of pedaling and steering with the infant positioned in a seat carrier. Even during this early development period, however, the parent-infant relationship is characterized as involving a coordinative system (Biringen & Easterbrooks, 2012). That is, although the parent has primary responsibility for diabetes management, parental involvement may be affected by temperamental characteristics of the infant, much as slight shifts in the position of the infant on a bicycle affect the balance of the parent and vice versa. During childhood, as the child gains skills, the child begins to perform diabetes tasks independently, much as a child is taught to ride a tricycle and then a bicycle with extensive assistance from parents. Parental involvement is crucial during this phase, as premature autonomy granting can be detrimental (poor metabolic control for aspects of diabetes management, (Wysocki, et al., 1996); cut knees and broken bones in the case of bicycle riding). Parental involvement can help to foster self-regulatory skills such as emotion regulation (Morris, et al., 2007) and self-efficacy (Berg, et al., 2011; King, et al., 2014) that allow for greater adolescent independence in management behaviors. The success of the child's growing independent attempts may affect parental well-being (Berg, et al., 2013) and parents' subsequent parental involvement. During adolescence, the child manages diabetes sometimes independently from parents (as when riding their own bicycle on separate trips), sometimes in parallel (as when riding a bicycle at the same time, but separately) and sometimes with still extensive coordination (as when riding a tandem bicycle together). A key component of successful coordination that results in good diabetes outcomes requires a skillful dance between parent and adolescent in fitting the level of parental involvement to the competence of the developing child (Palmer, et al., 2009; Palmer, et al., 2004; Wiebe et al., 2014). It is during this time that additional close relationships may play an important role in the coordinative process (e.g., the adolescent rides a bicycle alongside a friend or adult healthcare provider or in tandem with a relationship partner). These additional relationships may produce changes in how parent and child relate to each other (e.g., the parent may no longer have the same opportunity to ride alongside the adolescent or emerging adult), with parents' involvement still important (King, et al., 2014), especially when stressors or problems arise (Berg, et al., 2013).

Our model highlights the fact that this coordinative process of parent and child begins in infancy and provides a foundation for the emergence of later forms of coordination. We now highlight that across development, the specific components of parental involvement that may drive coordination may vary (see Figure 1) with features such as the high quality of the relationship (i.e., through attachment processes) being especially important in infancy, behavioral involvement important during early childhood, and monitoring and the adolescent's ability to engage their social network through disclosure increasingly important across adolescence. However, at each point in time, there is evidence that parental involvement is linked to self-regulation of the child in ways that are associated with diabetes management. These coordinations provide the basis for how new relationships (friends, romantic partners, health care providers) enter this system and are coordinated and potentially move the system to new stable patterns throughout time. We now describe

these coordinations that have been identified in the developmental literature on parent-child relationships and self-regulation and link these findings to the diabetes literature when possible.

Attachment as a Foundation for Parent-child Coordination

During infancy parental involvement has been captured via attachment processes that have themselves been characterized as a coordinated system (Coleman & Watson, 2000). Attachment processes serve as a foundation for numerous facets of an infant's self-regulation and create a potential developmental cascade (Masten et al., 2005) involving progressive and more diffuse effects on a large number of other elements in the system. Thus, the high quality warm and accepting relationships that are important for effective diabetes management during adolescence likely have their foundation in secure attachment relationships that were formed well before adolescence, during infancy, and contribute to adolescents' effective regulation skills (Allen et al., 2003). Support for this idea in the diabetes literature comes from Korbel (personal communication) who found that adolescents' perceptions of mothers as warm and accepting were associated with greater attachment security. Greater evidence for this idea is available in the developmental literature that finds that maternal support and warmth during adolescence is associated with reports of early attachment security (Allen, et al., 2003; Kerns, Brumariu, and Seibert, 2011).

According to theorists, attachment behaviors to parents are formed during infancy through parent-child interactions that are key for early emotional development (e.g., Bowlby, 1969; Calkins & Leerkes, 2011; Main, Kaplan, & Cassidy, 1985; Main & Solomon, 1990). Children's repeated experiences of communicating to their caregivers that they are in distress together with caregivers' consistent responses to these distress signals establish in the child a set of internal working models (Bowlby, 1969, 1989) of the cognitions and behaviors to engage in and expect in others. When these sensitive responses occur, children develop a sense of self-confidence in their ability to clearly and accurately communicate physical and emotional needs without either exaggerating or minimizing their intensity (Bretherton, 1987; Sroufe, 1996). However, when parents are not able to sensitively and appropriately respond to their children's distress signals, by reacting in ways that are either unresponsive (e.g., withdraw) or inappropriate (frightened/frightening behavior, intrusive/over-stimulating) (Ainsworth, 1991; Etzion-Carasso & Oppenheim, 2000), children are unable to develop secure attachments. Children with insecure attachments either minimize their expression of needs to their caregiver and withhold the desire for closeness within interpersonal relationships (anxious avoidant attachment) or foster a communication style with others characterized by exaggerated emotional expression and communication (anxious-ambivalent) (Carlson & Sroufe, 1995; Cassidy & Kobak, 1988).

The available research base, albeit small, is supportive of the idea that diabetes management during childhood and adolescence is associated with these early attachment relationships. Attachment security to mother has been associated with lower levels of depressive symptoms (Korbel, 2009) and better metabolic control among adolescents with type 1 diabetes (Rosenberg & Shields, 2009; note only maternal reports of attachment were

associated with metabolic control). Further, attachment insecurity in the form of anxiety and avoidance has been associated with greater depressive symptoms and marginally with poorer adherence, and anxious attachment has been associated with poorer metabolic control in adolescents (Korbel, 2009). A larger literature on adult attachment style and diabetes management (both type 1 and type 2 diabetes) exists that is supportive of the relationships between insecure attachments and diabetes outcomes (Ciechanowski, Hirsch, & Katon, 2002; Ciechanowski, Katon, Russo, & Walker, 2001; Ciechanowski et al., 2004; Turan, Osar, Turan, Ilkova, & Damci, 2003). Adults who classified themselves as exhibiting a dismissing style characterized by high attachment avoidance showed poorer adherence and metabolic control as compared to those with other attachment organizations (Ciechanowski, et al., 2001; Ciechanowski, et al., 2004) (see discussion below in section on Coordination with Parents and Health Care Providers Across Development for further detail).

Parental Involvement in Young Children

The central role of attachment in the system of parent-child coordinations during young childhood can be seen in the far reaching effects of attachment on emotion regulation, social competence, and health during early and middle-childhood as well as adolescence (Calkins & Leerkes, 2011; Diamond & Fagundes, 2010). A secure attachment relationship has been associated with better emotion regulation skills during young childhood (Calkins & Leerkes, 2011). Of particular relevance to families dealing with a young child with type 1 diabetes who may find adherence behaviors demanding, secure attachments in infancy have been associated with the young child's ability to engage in attention shifting strategies especially during times of frustration (Gilliom, Shaw, Beck, Schonberg, & Lukon, 2002). A secure attachment relationship is also associated with greater parental knowledge of children's activities and greater cooperation by children in monitoring situations during middle childhood (Kerns, Aspelmeier, Gentzler, & Grabill, 2011).

The links between aspects of parental involvement and self-regulation in young children with type 1 diabetes have been much understudied, potentially as the incidence of type 1 diabetes is lower in this age group than during adolescence (Liese et al., 2006). The literature depicts mothers of young children with diabetes as experiencing high stress, anxiety, and depression (Monaghan et al., 2009; Streisand, Swift, Wickmark, Chen, & Holmes, 2005), especially among those mothers whose children have been newly diagnosed. Greater distress associated with diabetes management among parents has been associated with their lower self-efficacy surrounding diabetes care activities (Streisand et al., 2008) and their reports of greater child behavior problems (Hilliard, Monaghan, Cogen, & Streisand, 2010). Further, greater parental stress has been associated with greater parental fears of hypoglycemia (Streisand et al., 2005), with such fears associated with poorer blood glucose control (Patton et al., 2007). Fathers report lower distress than do mothers and their distress shows weaker associations with the child's diabetes management, potentially due to their lower involvement in the day to day tasks of diabetes management (Mitchell, Hilliard, Mednick, Henderson, Cogen, & Streisand, 2009). Supporting coordination between a child's self-regulation and parents, greater child's self-control has been associated with lower parent distress (Monaghan, Clary, Stern, Hilliard, & Streisand, 2015). Although links between

parenting distress and poor blood glucose control have been found, the specific elements of parental involvement affected by high distress have yet to be uncovered.

Some links between parental involvement and aspects of the young child's regulation have been examined in the context of parent-child mealtime behaviors. From the perspective of parent-child coordination, mealtime behaviors provide an ideal setting in which to examine both the child's self-regulation (especially emotional regulation) together with parental involvement in a context that involves key aspects of diabetes management (e.g., blood glucose testing, insulin administration, selection of foods). Parents of young children with type 1 diabetes report more concerns about feeding issues and mealtime behavior than parents of healthy children (Patton, Dolan, Mitchell, Byars, Standiford, & Powers, 2004). Parents' poorer psychosocial functioning has also been associated with greater parental reports of their own as well as their child's problematic mealtime behaviors (Monaghan et al., 2015). The kinds of behaviors examined in these interactions do not map well onto the components of parental involvement examined in our model. However, parents' use of ineffective mealtime strategies (e.g., high control and frequent reminders for the child to eat) have been associated with poorer adherence to dietary recommendations (Patton, Piazza-Waggoner, Modi, Dolan, & Powers, 2009). In addition, having to deal with emotional issues surrounding food intake during mealtimes has been associated with poorer glycemic control (Patton et al., 2009), suggesting that emotion regulation in the developing child is an important component to effective diabetes management.

Recent interventions to help assist parents with their distress surrounding diabetes are suggestive of the coordination that may take place between parental involvement and children's self-regulation. For instance, a parent-based educational intervention aimed at changing mealtime behaviors decreased both parent and child problematic mealtime behaviors as well as lowered blood glucose levels (Patton, Odar, Midyett, & Clements, 2014). Much more research is needed as to the specific components of parental involvement that may be associated with children's self-regulation in the context of diabetes management and factors that may be key in this coordination.

Coordination of Parental Monitoring and Adolescent Disclosure

A high quality parent-child relationship laid down in infancy and early childhood allows for the emergence of new patterns of relating between parents and children during adolescence that facilitate self-regulatory skills of adolescents relevant to diabetes management. Positive aspects of maternal involvement co-occur together. Specifically, maternal warmth is associated with greater maternal knowledge during early adolescence (Grundy, Gondoli, & Salafia, 2010). The parent-child relationship during adolescence undergoes significant changes as individuals try to balance autonomy and connectedness (Allen, Porter, McFarland, McElhaney, & Marsh, 2007; Smetana et al., 2006). Parents and children who have developed a warm and trusting relationship in which the parent has operated as an effective secure base are at an advantage for developing effective partnerships during adolescence (Scott, Briskman, Woolgar, Humayun, & O'Connor, 2011; Waters, Kondo-Ikemura, Posada, & Richters, 1991), whereas those with insecure attachments are at greater risk during adolescence (Kochanska & Kim, 2012).

During adolescence, this partnership involves a transaction whereby parents monitor adolescents' behavior together with adolescents disclosing information to their parents (Stattin & Kerr, 2000). Parental knowledge may become increasingly dependent on adolescent disclosure, that is, the way in which adolescents communicate and manage the flow of information about their lives with their parents, and how parents themselves use different strategies to gain knowledge about their child (Allen & Manning, 2007; Branstetter, Furman, & Cottrell, 2009; Wampler & Downs, 2010; Wilkinson, 2004). As adolescents spend more time away from their parents, they are uniquely positioned to influence how much parents know about their lives by using strategies such as self-disclosure, secret keeping, and lying (Almas, Grusec, & Tackett, 2011; Frijns, Keijsers, Branje, & Meeus, 2010). Adolescent outcomes like delinquency and risky health behaviors have been linked to lower levels of adolescent voluntary disclosure of information (e.g., Darling, Cumsille, Caldwell, & Dowdy, 2006; Kerr, Stattin, & Burk, 2010; Smetana, Villalobos, Tasopoulos-Chan, Gettman, & Campione-Barr, 2009; Stattin & Kerr, 2000), higher levels of secret-keeping (e.g., Bumpus & Hill, 2008; Cumsille, Darling, & Martinez, 2010; Frijns, et al., 2010), and more lying (e.g., Marshall, Tilton-Weaver, & Bosdet, 2005).

A growing literature indicates that adolescents' willingness to disclose personal information to a parent and parental knowledge occurs through a transactional and dynamic process based in warm, trusting, and responsive parent-adolescent relationships (Hamza & Willoughby, 2011). Adolescents share more information with parents when parents are more warm and responsive and employ less psychological control (e.g., intrusive parenting) (e.g., Fletcher, Steinberg, & Williams-Wheeler, 2004; Soenens, et al., 2006). As evidence of the coordination between adolescents' regulatory capacities underlying disclosure and parents' emotion regulation skills, when the risk of disclosure may be associated with parental anger (Almas, et al., 2011) or disapproval (Darling, et al., 2006), secrecy or lying rather than disclosure may result. Further, longitudinal analyses reveal that adolescent disclosure contributes to better psychological functioning (lower depressive symptoms) through increasing parents' knowledge; simultaneously, depressive symptoms limit subsequent parental knowledge and adolescent disclosure over time (Hamza & Willoughby, 2011).

As indicated above, the current literature on diabetes management clearly points to the importance of a high quality relationship, where parents monitor and are behaviorally involved in diabetes management (Berg, et al., 2008; Ellis, Podolski, et al., 2007; Main et al., 2014), despite the fact that parental involvement declines across adolescence (King et al., 2014; Wiebe et al., 2014). Consistent with the broader developmental literature (Racz & McMahon, 2011; Stattin & Kerr, 2000), the diabetes literature is beginning to acknowledge that effective parental monitoring involves not only active attempts by parents to solicit information from adolescents, but also adolescents' willingness to disclose information to their parents (Berg et al., 2017; Ellis, Templin, Naar-King, & Frey, 2008; Osborn, et al., 2013) as well as to avoid keeping information secret (Main et al., 2015; Osborn, et al., 2013). Although parental monitoring of diabetes in the form of parents having knowledge of their adolescents' diabetes management is associated with features of accepting and supportive parent-child relationships (Berg, et al., 2008; Ellis et al., 2007), longitudinal data are not available during early and middle childhood to trace whether effective monitoring and disclosure of diabetes information during adolescence emerges from earlier high-quality

relationships during early childhood. However, the larger developmental literature does seem supportive of these links (Racz & McMahon, 2011).

A growing literature indicates that the level and nature of mothers' and fathers' involvement may vary for diabetes management. In general, mothers are more behaviorally involved, monitor more their adolescents' diabetes, solicit more information and have adolescents disclose more information to them than do fathers (Berg et al., 2017; King et al., 2014). When comparing mothers' and fathers' daily involvement and links to diabetes management, mothers' involvement has been somewhat more consistently associated with changes in daily blood glucose and adherence (Berg et al., 2013; Berg et al., 2016). However, despite their lesser involvement in diabetes management, greater paternal monitoring especially has been associated with better adherence (Hilliard, Rohan, Rausch, Delamater, Pendley, and Drotar, 2014; King et al., 2014) and HbA1c (Berg et al., 2011; Hilliard et al., 2014).

In sum, the high quality parent-adolescent relationship that is found to be important in fostering good regulatory skills necessary for effective diabetes management likely emerges from early attachment relationships that foster effective emotion regulation skills that allow young children and their parents to deal with the challenges of managing a chronic illness. The foundation of a high quality relationship allows for the emergence of a transactional relationship during adolescence whereby adolescents disclose to their parents problematic aspects of their diabetes management, thereby providing parents with the knowledge of the adolescent's behavior. Such disclosure and knowledge is important in fostering effective diabetes management during late adolescence and emerging adulthood, when other relationships such as friends and romantic partners are incorporated into this coordination.

The Addition of Others in the Coordinative Process (Parents+)

Coordination with parents, peers, and romantic partners across development.

—From the developmental literature we know that early parent-child relationships lay the foundation for the formation of relationships with friends and romantic partners that serve increasingly important roles across adolescence (De Goede, Branje, Delsing, & Meeus, 2009). These changing relationships introduce new elements into the coordinated system between parents and children (see Figure 1) that may spark new organizations of the system as adolescents seek acceptance and belonging with peers and potentially receive support from their peers for illness management. The capacity to utilize peers as a source of support is likely to be quite important for maintaining or strengthening self-regulation skills such as emotional competence (Laible, 2007) and mastery (Conger, Williams, Little, Masyn, & Shebloski, 2009) during adolescence. Consistent with these ideas, Beyers and Seiffge-Krenke (2007) found that adolescents who experienced trajectories in family relationships characterized by sustained connection and increases in mutual respect for individual decision-making across adolescence displayed greater support and lower negativity in friendships in late adolescence. Importantly, these peer relationships in late adolescence were associated with self-regulation skills such as lower internalizing symptoms in young adulthood.

Family and peer relationships form the staging ground for romantic relationships (Collins, Welsh, & Furman, 2009; Seiffge-Krenke, Overbeek, & Vermulst, 2010), and peer and

romantic relationships become increasingly integrated and influential in this coordinative system as adolescents emerge into early adulthood (Collins, et al., 2009; Seiffge-Krenke, et al., 2010). By late adolescence, interactions with romantic partners are more frequent than with parents or friends, and provide as much support as relations with mothers (Smetana, Campione-Barr, et al., 2006). Although parents continue to be important elements of this coordinative system, their role changes and influence wanes as peers and then partners become increasingly important. Surjadi, Lorenz, Wickrama, and Conger (2011) demonstrated that parental support was associated with higher mastery in middle adolescence, and with greater partner support across the subsequent transition to adulthood. Partner support, but not parental support, was associated with increases in mastery during the transition to adulthood.

These changes in the social context provide the opportunity for new patterns of coordination among parents, adolescents, and friends surrounding diabetes management during adolescence and emerging adulthood. As in the general developmental literature, peers become increasingly influential sources of support for diabetes management during adolescence (see Burroughs, Harris, Pontious, & Santiago, 1997; Gallant, 2003; La Greca, Bearman, & Moore, 2002; Palladino & Helgeson, 2012 for reviews).This developmental shift is evident in several ways. Friends are more commonly cited as a source of support for diabetes by adolescents than by children (Shroff-Pendley et al., 2002) and while peer support for diabetes remains stable across adolescence, family support declines (Bearman & La Greca, 2002; Carcone, Ellis, Weisz, & Naar-King, 2011; Skinner, et al., 2000). Support from family also appears to serve different functions than support from friends during adolescence, with families providing more instrumental support for diabetes (e.g., help with insulin dose) and friends providing emotional support and companionship (Bearman & La Greca, 2002; La Greca et al., 1995). Skinner and Hampson (1998) found that family support (but not friend support) was associated with better diabetes adherence, while friend support (but not family support) was associated with lower adolescent depression.

The literature is beginning to note the important interplay between parents and friends in the developing adolescents' self-regulation skills and chronic illness management. Wallander and Varni (1989) demonstrated that the presence of both family and peer support was necessary for optimal adjustment among adolescents dealing with type 1 diabetes or other chronic conditions. Support from friends can compensate for negative aspects of parental involvement such as control (Helgeson et al., 2014; Herzer, Umfress, Ajadeff, Ghai, & Zakowski, 2009) and parental support can compensate for conflict with friends in diabetes management. When the links between parents, children, and friends, however, are not coordinated well with the self-regulatory skills of the child, disruptions in illness management may take place. For instance, declines in parental involvement across adolescence (King, et al., 2014) occur at a time when friends' involvement increases, which may be detrimental if such changes are not accompanied by the effective self-regulatory skills of the child.

When peers are not supportive, they can present tension and conflict that tax adolescents' regulatory capabilities and have a negative effect on the coordinative system in managing diabetes. Storch et al. (2006) found adolescents may be bullied because of their diabetes, and

that diabetes- related bullying was associated with poorer adherence and metabolic control via higher depressive symptoms. Similarly, adolescents' reports of conflict with friends predict poorer adherence and metabolic control (Helgeson, Lopez, & Kamarck, 2009; Helgeson, et al., 2010), and rejection by friends is associated with poorer psychosocial well-being (Helgeson et al., 2009). Even positive peer relationships have been associated with poorer metabolic control among adolescents with diabetes (Hains et al., 2007; Helgeson et al., 2010), potentially because adolescents often expect friends to react negatively when they follow their diabetes regimen (Hains, et al., 2007), and may neglect their diabetes in order to socialize with peers (Delamater, Smith, Kurtz, & White, 1988; Drew, et al., 2010; Thomas, Peterson, & Goldstein, 1997). Taken together, such findings reveal that early parent-child relationships that are warm and accepting co-occur with positive and supportive peer relationships that further foster good self-regulatory skills into late adolescence as they increasingly manage their illness in social contexts away from parents.

In our model, we argue that these self-regulatory skills oriented toward the regulation of the interpersonal context develop out of adolescents' relational history with parents, and some data exist to support this hypothesis in the context of diabetes management. Adolescents who report higher family support for diabetes also report higher peer support for diabetes (Bearman & La Greca, 2002; Carcone, et al., 2011; Skinner, et al., 2000), and adolescents who feel rejected by their parents also report higher rejection from peers (Herzer et al., 2009). In a more direct test of this hypothesis, Drew and colleagues (2010) found that adolescents who reported high quality relationships with parents (i.e., warmth and acceptance) achieved better diabetes management through being less likely to choose to socialize with peers at the expense of their diabetes management.

Minimal research has examined the role of romantic partners for supporting diabetes management during adolescence and emerging adulthood. The challenges of managing an illness such as type 1 diabetes may alter the development of intimate friendships and romantic relationships during adolescence and beyond. Seiffge-Krenke (2000) found that late adolescents with diabetes were less likely to have romantic partners than those without diabetes. However, those who had romantic partners were more satisfied with the relationship compared to those without diabetes, and the partners served different roles by providing more instrumental support. Qualitative research suggests that close friends and romantic partners gain a more prominent role in supporting diabetes management during emerging adulthood, although parents continue to be a trusted resource (Hanna, Weaver, Stump, Guthrie, & Oruche, 2014) providing guidance regarding diabetes management to their adult child as well as to their child's friends and partners (Sparud-Lundin, Öhrn, & Danielson, 2010).

Coordination with parents and health care providers across development.—An additional relationship that has been infrequently examined in the coordinative system is the relationship with the physician and other health care providers. Diabetes management is improved when patients and parents are able to develop collaborative partnerships with health care providers (Drotar, 2009). These collaborative relationships involve many of the same key facets of relationships found in parental involvement. That is, a collaborative relationship with one's health care provider is one that is warm and accepting, where there

is active exchange of information so that providers are knowledgeable, and provide the context for shared decision-making among patient, parent and provider. Not surprisingly, positive patient-provider relationships are associated with higher patient satisfaction, better adherence and self-care, and better illness outcomes across a range of conditions, including type 1 diabetes (Drotar, 2009; Naar-King, Podolski, Ellis, Frey, & Templin, 2006). Such positive patient-provider relationships may relate to higher adherence to the diabetes regimen through heightened perceptions of the adolescent's competence in diabetes management (Croom et al., 2010). In addition to empowering adolescents to manage their diabetes, physicians may be positioned to provide feedback to the family about developmentally appropriate shifts in parental involvement to ensure that there is a fit between child's capabilities and the parent's involvement (Wiebe et al., 2008).

Parents' and children's relationships with health care providers change across development in a manner that reflects the growing regulatory capacities of the developing child (see De Civita & Dobkin, 2004 for review). Because pediatric conditions are managed primarily by parents during infancy and early childhood, parents' relationship with the provider is initially a primary focus and children are rarely involved in medical decisions (Cahill & Papageorgiou, 2007; Coyne, 2008). As older children and adolescents assume increasing responsibilities for managing diabetes, potentially because older youth have a greater capacity to develop a treatment alliance with physicians (Gavin, Wamboldt, Sorokin, Levy, & Wamboldt, 1999), more time is spent on relationship building in interactions with providers (Cox, Smith, Brown, & Fitzpatrick, 2009). This increasing prominence of the adolescent-provider relationship is likely to provide an important training ground for the adolescent as he or she prepares to leave the pediatric setting and transition to adult care, a setting that is likely to pose new regulatory challenges for the young adult (Weissberg-Benchell, et al., 2007).

The ability to develop positive and collaborative partnerships with physicians and to navigate the health care system efficiently and effectively may develop out of positive relationships with parents. Ciechanowski and colleagues (2004) demonstrated that adults with diabetes who had secure attachment relationships with early caregivers reported more satisfaction with their relationship with their physician than those with insecure attachments, and that more satisfying doctor-patient relationship mediated associations between attachment security and better diabetes self-care. Secure attachments with early caregivers have also been associated with patients' greater ability to trust providers and to value their relationship with providers (Ciechanowski & Katon, 2006), missing fewer scheduled clinic appointments (Ciechanowski et al., 2006), and having lower subsequent mortality (Ciechanowski et al., 2010).

Given the somewhat infrequent contact that adolescents have with their healthcare provider, it may be difficult to establish whether adolescents are in fact coordinated in important ways with their physician. Recent e-health technologies that offer the opportunity for those with chronic illness to be in more regular contact with health care professionals may, in fact, provide a greater opportunity for coordination to occur (Froisland, Olsen, Robinson, & Mandleco, 2012).

Summary

The broader developmental literature is consistent with the view that the coordinations between parents' involvement and children's regulatory skills found during adolescence have their foundations earlier in development in the formation of the parent-child relationship. Further, the positive facets of parental involvement together with developing regulatory skills allow for the emergence of new relationships with peers, romantic partners, and health care providers that emerging adults can draw on to facilitate diabetes management. This coordinated system begins early in development and may be maintained across time through psychosocial and biological processes (Lansing & Berg, 2014). However, such coordinations are not static or predetermined from early childhood, but rather move as new elements enter into the system (e.g., peers, healthcare providers). We now provide a specific illustration of how such coordinations can be modeled across time and the potential of our model as an effective data reduction technique.

Modeling Parent-Child Coordination in Diabetes Management

Forms of Coordination

The notion that development emerges from coordinations among elements of a child's and parent's functioning has much support in the developmental literature from infancy through adolescence (Evans & Porter, 2009; Fogel, 1993, 2011; Granic & Patterson, 2006; Lewis, 2000; A. J. Sameroff & Mackenzie, 2003; H. Steenbeek & van Geert, 2005; Thelen & Smith, 1994). Of particular relevance to our framework, specific modeling of elements of a child's self-regulation (emotional functioning, social interactions) and parental involvement (e.g., coercion, warmth) from a coordination perspective have been undertaken (Granic, 2000; Hollenstein, Granic, Stoolmiller, & Snyder, 2004; Lichtwarck-Aschoff, Hasselman, Cox, Pepler, & Granic, 2012). Mathematical models are used to capture these coordinations and how elements change together over time through principles of self-organization (e.g. Lewis, 2000; Smith, 2005; Thelen & Smith, 1994). In addition, coordinations among elements have been modeled using coupled equations (e.g. H. Steenbeek & van Geert, 2008; H. W. Steenbeek & van Geert, 2007). In the dyadic interaction literature, such coupled equation approaches (Boker & Laurenceau, 2006; Hamaker, Zhang, & van der Maas, 2009; Steele & Ferrer, 2011; H. W. Steenbeek & van Geert, 2007) generate one-to-one synchronous behaviors, which is only one of many coordinations that could be modeled in parent-child relationships across childhood, adolescence, and emerging adulthood.

Coordination can be viewed as a more general framework for characterizing patterns of how elements such as parents and children move together (E. A. Butler, 2011), with coordination varying along a continuum (Beek & Beek, 1988; Turvey, 1990). At one end of the continuum is a lack of coordination that can also be called asynchrony, such that two or more elements are completely independent of one another through time. Although it may be difficult to imagine how parents and children may be completely independent when dealing with type 1 diabetes, a recent example demonstrates that it may be possible. Berg et al. (2013) reported a lack of relationship between adolescents' daily blood glucose and fathers' efforts to persuade them to better manage their diabetes. This asynchrony may have resulted from fathers' lack of knowledge about adolescents' blood glucose levels. At

the other end of the continuum is synchrony where there is a direct relationship between elements of the system moving together through time. Synchrony can occur in a one to one relationship (e.g., ingestion of carbohydrates together with change in blood glucose) or a different scaling relationship (Stewart & Golubitsky, 1992; Treffner & Turvey, 1993).

Between asynchrony and synchrony is an area commonly known as entrainment where elements have periods of moving together with periods of asynchrony (Bernieri, Reznick, & Rosenthal, 1988; Butner, Diamond, & Hicks, 2007). In the case of chronic illness management, this may characterize the period of preadolescence through late adolescence, as parental involvement declines across time, but not always in tune with adolescents' competencies (Palmer, et al., 2009; Wiebe et al., 2014; Wysocki, et al., 1996). Across adolescence parental involvement may decline due to normative changes in parental involvement and adolescent autonomy needs, but not their competencies. Problematic episodes, such as severe hypo- or hyper-glycemia may signal to parents that they need to increase their involvement. Thus, at times across development parent involvement may not be coordinated with adolescents' competences, but such problematic episodes may be key in getting this coordination between parental involvement and the child's developing skills back on track.

Recent analyses of coordination have begun to identify how two or more elements become linked in a stable pattern of relationship through time. For instance, adolescents' daily problems in diabetes management are associated with increases in parents' worry and decreases in parents' views of adolescents' self-efficacy, and these patterns of association occur repeatedly in the daily lives of families managing diabetes (Berg et al., 2013). These same sorts of coordinations have been identified in dyadic interactions more generally regarding influence and appraisal among child peers (Steenbeek & van Geert, 2008; Steenbeek & van Geert, 2007), couples' affect (Butner, et al., 2007; Steele & Ferrer, 2011), and couples' intimacy and disclosure (Boker & Laurenceau, 2006). In essence, coordination describes the stable pattern of relationship between two or more elements through time.

Current approaches for modeling coordination and testing bidirectional relationships allow us to identify both a coupling relationship that pulls elements together through time (known in early work as the magnet effect) and, independent of this coupling relationship, the intrinsic pattern of change in each element involved in the coordination (known in early works as the maintenance tendency) (Von Holst, 1939, 1973). For example, individuals are fairly stable in their relative position in metabolic control (HbA1c) across time (King, et al., 2014), which would be considered the natural (maintenance) tendency for HbA1c. However, there are mean level increases in HbA1c (indicating deterioration) across adolescence, likely pulled in that direction by changes in physiology associated with puberty, increased influence of the peer context, and reduced influence of parents (Drew, et al., 2010; Helgeson, et al., 2010; King, et al., 2012). Thus, an analysis of change patterns in the elements in our model (parental involvement, diabetes management, and self-regulation) would examine not only natural tendencies in each of these elements, but also their coordination.

Approaches for identifying these natural tendencies and coupling relationships are plentiful. In structural equation modeling alone techniques include, but are not limited to dynamic

factor models (Molenaar, 1985), latent differential equation modeling (Boker et al., 2011), continuous time models (Oud, 2007), and latent change score modeling (McArdle & Hamagami, 2001). Such models are also conducive to multilevel modeling techniques (J. Butner, Amazeen, & Mulvey, 2005) and time series approaches more generally (see Guastello & Gregson, 2011). Each circumstance characterizes the time evolution of two or more outcomes and the linkages between them. Primarily, the techniques vary on their treatment of time (continuous or discrete), the assumption underlying natural tendency (e.g. trajectory-like or oscillatory), and their treatment of additional variability (e.g. models of error and perturbations).

We have recently applied these techniques to aspects of self-regulation and parental involvement in late adolescents with type 1 diabetes (Butner, Berg, Wiebe, Lansing, Munion, & Turner, in press). Dynamic systems modeling, via Structural Equation Modeling, was conducted examining the relationship between changes in a number of facets of self-regulation (adherence, daily diabetes problems, self-regulatory failures, positive and negative affect, self-confidence) and parental involvement (parents' knowledge of diabetes, adolescents' disclosure to parents, and perceived helpfulness of parents) separately from mothers and fathers over a 14-day diary period. Coordination in changes in these variables was then captured through the identification of latent factors of these changes. Coupling relationships were captured through predicting these latent coordination factors as a function of the current variables, and the stability information captured by how the variable predicted its own change, controlling for the coordination factor.

The results revealed that self-regulation functioned as one coordinative structure whereby self-regulation involved changes toward increased adherence, efficacy, and positive affect, and decreases in negative affect, self-regulatory failures, as well as daily problems. Parental involvement was separate from self-regulation, and mothers' and fathers' involvement were coordinated separately from each other. The coordinative structure for both mothers' and fathers' involvement consisted of changes toward greater knowledge of their adolescents' diabetes behavior, greater disclosure from the adolescent to the parent, and greater helpfulness. The connection between parental involvement and adolescent self-regulation was most clear for mothers' perceived helpfulness as it served as a key variable in returning adolescents' self-regulation back to homeostasis. Fathers' involvement did not move adolescents' self-regulation across the 14 days.

These results are very consistent with our model of parent-child coordinations and hold promise for how we might utilize coordination as a way to understand parental involvement, self-regulation, and illness management. Within a developmental framework, coordination is the mechanism by which we observe stable trajectories over time. The developmental trajectories emerge from the combination of the maintenance tendencies of each element (i.e., the trajectory each would naturally traverse over time), and the inherent perturbations of the other elements that are constantly affecting one another.

Coordination as a Data Reduction Technique

A coordination model such as that described above may result in effective data reduction. When several variables are coordinated through time, they inherently display some

concordance as they pull and push one another repeatedly. Thus, providing a good description of the temporal patterning of one variable will invariably depict the properties of other variables that are coordinated through time. For instance, in our above example, multiple facets of self-regulation (self-regulation failures, self-efficacy, adherence, positive and negative affect, and diabetes problems) were all coordinated throughout time. Thus, understanding the temporal patterning of one variable such as self-regulation failures may depict the properties of the system across time. Coordination involves a model of data reduction in process throughout time in much the way that factor analysis involves data reduction in actual values at a single point in time.

Coordination models also highlight variables that are not coordinated, but have the ability to alter how coordination works. For example a variable that has the ability to strengthen the connections between variables or divorce them from one another has the potential to greatly alter trajectories in time. In contrast, a variable that is part of the coordination itself can potentially change behavior, but will likely be pulled back to the old state after some period of time because each part of the coordination process helps stabilize the observed pattern.

Summary

Coordination captures a variety of ways of depicting the emergent patterns in which elements move together through time. Such patterns can involve synchrony of varying degrees or periods of synchrony-like behavior with periods of asynchrony. Models of coordination do not require equal influence, but allow for asymmetries in the influences between elements. As a set, these models can depict the changing transactional relationships (parental involvement, self-regulation, diabetes management) for our developmental model through advanced statistical approaches for the study of change. These techniques articulate that when many elements are coordinated, the dance depicted through time can often be described by a single element. Thus, coordination is an argument for data reduction at the level of change processes through time rather than at the level of any moment in time.

Implications of Developmental Model of Parent-Child Coordination

The developmental model of parent-child coordination described here has numerous implications for work in chronic illness management behaviors as well as other domains of functioning (e.g., academic, social, and health risk behaviors) for families across development. This model holds a new perspective on the development of children as they develop management behaviors, noting the inextricable connection that developing individuals have with their parents and subsequently peers and romantic relationships. These connections form early in infancy and provide a foundation for the emergence of other relationships. The coordinative process is dynamic as new relationships enter the process and self-regulatory skills change. Both parent and child are active agents in this coordinative process and elements of their regulatory skills may push and pull the system throughout time. We now provide the implications of this model for future research in chronic illness management, interventions to improve management, and the generalizability of the model beyond the domain of chronic illness management.

A Developmental Approach to Research on Chronic Illness Management

The Developmental Model of Parent-Child Coordination highlights the importance of taking a developmental perspective to the examination of management across time. The importance of both longitudinal research as well as intensive measurements such as daily diary and experience sampling methodologies will allow for modeling the coordinative process across time. There is a need for the measurement of multiple constructs in order to understand which variables may act as magnet effects, that push and pull the system, as well as variables that are redundant with elements of parental involvement and self-regulatory skills of the child.

In addition to the inclusion of children's self-regulatory skills and parents' involvement, our model points to the importance of examining regulatory skills of the parent as well as of other close relationships (e.g., peers, romantic partners). For instance, the increased incidence of depressive symptoms in parents with chronic illnesses such as type 1 diabetes (Frank, Hagglund & Schopp, 1998; Jaser, et al., 2009) together with the disruptions that depressive symptoms may have on parental involvement in diabetes management (Wiebe, et al., 2011) is suggestive of the role of parental depressive symptoms in impairing parents' skills. Depressive symptoms may undermine numerous parental self-regulatory skills essential for good parental involvement (e.g., reducing attention to child input and parental self-efficacy, increasing negative appraisals of children, activating low positive and high negative emotion) (J. M. Butler, et al., 2009; Dix & Meunier, 2009).

A developmental perspective also highlights that the time point in development when the family experiences the diagnosis of diabetes will hold implications for the development of regulatory skills and parenting skills. Type 1 diabetes is most frequently diagnosed during adolescence with the peak occurring around ages 10-14 years and an earlier peak at 4-6 years. A child diagnosed early in life will not have yet developed cognitive and emotional capacities that allow for certain coping responses (e.g., cognitive restructuring or secondary control strategies, see Compas, et al., 2012) or emotion regulation strategies (e.g., delay of gratification, inhibitory control) (see Eisenberg, et al., 2010). Thus, such capacities develop within the context of coping with a chronic illness rather than applying such capacities to the new context of chronic illness. When diagnosis occurs during adolescence, however, individuals may be able to apply well-developed emotional and cognitive regulatory skills to the new context of chronic illness (Masten & Cicchetti, 2010). For instance, Lansing et al. (2016) reported that adolescents' performance in school was an excellent predictor of adherence to the diabetes regimen, suggesting that adolescents' abilities to regulate a difficult task such as school work may be generalizable to the context of diabetes management. Furthermore, the dysregulating effects of hyper or hypoglycemia affect executive function abilities that are essential for the development of future regulatory skills (Gaudieri, Chen, Greer, & Holmes, 2008).

The timing of the diagnosis of illness may also affect the development of high quality parent-child relationships. The elevations in distress and depressive symptoms that many parents experience (Cline, Schwartz, Axelrad, & Anderson, 2011; Streisand et al., 2008) may affect their ability to parent in an effective manner, contributing to their inability to develop high quality relationships with their young child (Hammen, 2009) or make

fine-tuned adjustments in parental involvement in response to increasing demands during adolescence (Wiebe, et al., 2011).

The developmental model outlined in this paper bridges the pediatric and adult literatures which depict disparate views of how individuals adapt to chronic illness in the context of the family. The literature during childhood has focused on how children manage their illness together with their parents, with the focus being on how adolescents gain independence so that they can emerge during adulthood with the competence to manage their illness independently of their parents (Weissberg-Benchell, et al., 2007). However, the adult literature characterizes individuals as being connected with other close relationships (most especially the spouse) such that dyadic appraisal and coping are important elements of dealing with chronic illnesses throughout adulthood (Berg & Upchurch, 2007; Bodenmann, 2005; Revenson, et al., 2005). The current model bridges this gap by noting how the parent-child relationship serves as a training ground for the development of peer and romantic relationships that adolescents and emerging adults utilize as they develop long term relationships that they can draw on for coordination across adulthood. This model is embedded within a life-span perspective as to how individuals seek and receive support across development (Uchino, 2009) and as such traces the early relational history that may be important for understanding dyadic coping across the adult life span (see also Donato, Iafrate, Bradbury, & Scabini, 2012; Repetti, et al., 2002; Wiebe, Helgeson, & Berg, 2016).

A New Perspective on Interventions

Based upon this developmental model of parent-child coordination for the emergence of regulatory skills, there are multiple implications for psychosocial interventions. First, our model asserts that the emergence of clinical problems associated with disrupted self-regulation is attributable to patterns of coordination across parents and children over time. For example, a common clinical presentation in a child with diabetes who is non-adherent includes a child with less effective self-regulatory skills and a family higher in conflict and stress (Ellis et al., 2005). Second, our model also suggests that the changes underlying effective interventions are, in fact, the re-organizations of initial patterns of coordination linked with non-adherence (e.g., poor self-regulatory skills and impaired family functioning) into new patterns of coordination. These new patterns of coordination contribute to the emergence of improved self-regulation and decreased clinical problems. For example, if a multicomponent intervention for adolescents with poor adherence effectively targets both youth self-regulation and parent monitoring to improve adherence, the changes in coordination patterns among those characteristics would be evidenced in two key ways: (1) initial destabilization of the problematic pattern of coordination (caused by the intervention) and (2) restabilization of a new pattern of coordination resulting in the emergence of improved self-regulation, more parental monitoring and better adherence, with step 2 being the key for identifying a durable intervention effect.

These notions imply multiple future directions for clinical research, as we seek to identify new interventions or assess change mechanisms in current interventions. Clinical researchers will need to identify patterns of coordination that contribute to the presenting clinical problem, and identify patterns of coordination that contribute to stable and long-term

improvements. This would include research on how to effect re-organization in patterns of coordination into patterns that contribute to the emergence of long-term stability and improvements in the clinical problem (see Granic, O'Hara, Pepler, & Lewis, 2007). To this end, we must identify which variables hinder re-organization of initial patterns of coordination by stabilizing and maintaining those patterns. Also, we must research which variables - when modified by intervention - contribute to the de-stabilization of the initial pattern of coordination and support re-organization into a new pattern that is associated with stable and long-term change.

For example, some interventions to improve diabetes management in adolescence have had stable effects in increasing adherence behaviors, but not in improving metabolic control (Ellis et al., 2007), or only improving metabolic control for particular groups (e.g., middle adolescents; Nansel, et al., 2009). This would suggest that the new pattern of coordination resulting from the intervention was unstable and not maintained over-time, or was a stable pattern that did not contribute to the emergence of long-term changes in metabolic control. The efficacy of such interventions would improve by identifying variables that are most highly influential to re-organizing patterns of coordination into stable patterns that contribute to the emergence of good metabolic control. It is important to note that these key variables may not necessarily be those variables that are most predictive of the outcome, but are those that contribute most to the stability of the desired pattern of coordination. Also, these key variables may be unique in different periods of the development of the child and the parent, and within particular patterns of coordination occurring within families. This may explain group or individual differences in intervention efficacy.

Finally, many existing interventions may already be accomplishing the task of re-organizing patterns of coordination, but we simply have not studied this notion within those interventions. Evidence based-interventions that modify variables within the child, the parent and the family will remain essential to treatment (Ellis, Templin, et al., 2007; Wysocki, Harris, et al., 2008). Our model provides a new way of conceptualizing the mechanisms underlying effective change in clinical interventions in that they are examined as creating different patterns of coordination over time. Our model also points to additional ways to understand and address interventions that are relatively ineffective.

Generalizability To Other Domains of Family Functioning and Child Development

The Developmental Model of Parent-Child Coordination for Self-Regulation described in this paper was situated in the context of families where a child has type 1 diabetes. We chose this context as type 1 diabetes is a chronic illness that poses daily regulatory challenges for parents and children and a large literature exists demonstrating the importance of parental involvement. However, we expect that the major principles and benefits of this developmental approach will extend to other pediatric chronic illnesses (e.g., asthma, spina bifida, pediatric cancer). For instance, adherence to the regimen for spina bifida is best when children’s low self-regulatory skills are matched with high parental involvement (O'Hara & Holmbeck, 2013). Similar results have been theorized for the case of pediatric cancer as well (Peterson & Drotar, 2006). Links between family functioning, child self-regulation, and illness management have also been found for asthma (Rhee et al., 2010). Such links

between parental involvement and children's self-regulatory skills also eventuate in different trajectories (e.g., risky family trajectory) with respect to physical health for those without a specific chronic illness condition (Repetti, et al., 2002).

Given the ubiquity of effective parental involvement and self-regulation in broad domains outside of the context of chronic illness (Moffitt, et al., 2011), we also expect that this model will readily generalize to other domains of parent and child coordinations. A sizable literature has examined bi-directional relationships between parental involvement and child psychopathology, with some research noting the importance of rigidity in parent-child interactions as a pattern consistent with externalizing problems (Hollenstein, et al., 2004). Relatedly, Granic and Patterson (2006) have reconceptualized the pattern of family coercion and related adolescent cognitions such as the hostile attribution bias from a dynamic systems perspective, noting that this recurrent pattern becomes stabilized in the system. Belsky, Pasco Fearon, and Bell (2007) found that early maternal sensitivity was associated with fewer child externalizing behaviors through better child attention control, which was also associated with enhanced parenting over time. The crucial role of early parent-child coordinations for maintaining children on trajectories of psychopathology and conduct disorders (Belsky, et al., 2007; Masten & Cicchetti, 2010; Pardini, et al., 2008) is consistent with our approach and this literature has been used extensively throughout this paper.

Further, a large body of research has examined parental involvement and self-regulation as important in academic performance (Blair & Diamond, 2008; Bowers et al., 2011; Grolnick, Benjet, Kurowski, & Apostoleris, 1997). Transactions between children's academic performance and parents' intrusive support have been found such that children's low academic achievement may elicit maladaptive maternal involvement, which may be associated with at least short-term gains in performance (Pomerantz & Eaton, 2001). Such coordinations are also being explored between parents and adolescents as two interrelated identity systems in the emergence of identity development during adolescence and young adulthood (Koepke & Denissen, 2012).

Summary and Conclusions

In sum, the developmental model of parent-child coordination for self-regulation in type 1 diabetes integrates and extends the literature in important ways by noting the inextricable ties between parents and children that are initiated in infancy, extend into adolescence, and are transformed as new relationships enter the coordinative system. This systems perspective to parental involvement, children's self-regulatory skill, and illness management offers new ways of viewing the development of parent and child across development that highlights the mutual influence between parent and child rather than a particular direction of causality. The perspective also presents a life-span perspective to illness management that highlights how self-regulation and illness management are embedded in a rich and changing landscape of interpersonal relationships across development.

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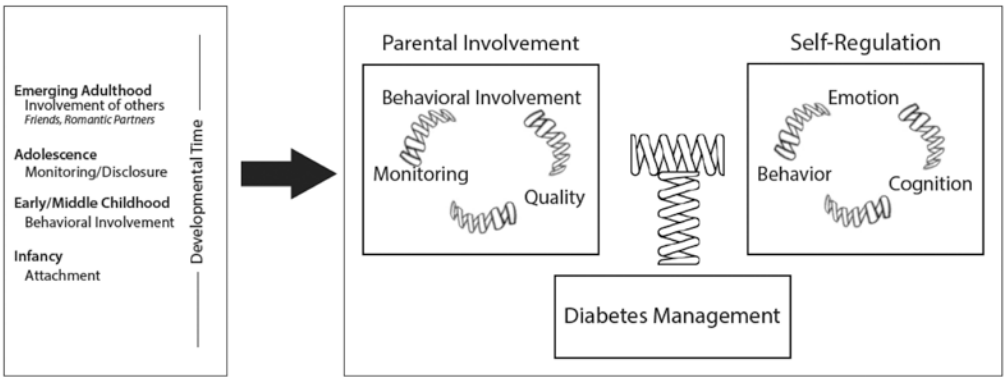

Figure 1:
Developmental Model of Parent-Child Coordination for Self-Regulation in Type 1 Diabetes Management

Table 1:

Studies of Parental Involvement, Self-Regulation, and Diabetes Management

Authors	Sample	Design	Parental Involvement	Regulation of Behavior, Emotion, and Cognition	Primary Findings
Anderson et al. (2002)	104 youth (ages 8-17) with "short-duration" **D** (.5 to 6 years) and **P**	Cross-sectional	**D** responsibility; **D**-specific family conflict	Adherence Behaviors	**P** responsibility was [+] associated with adherence to **BGM.** Conflict was [−] associated with adherence to **BGM** and [+] with HbA1c.
Armstrong, Mackey, & Streisand (2011)	84 youth (ages 9-11; *M* = 10.8, *SD* = .75)	Cross-sectional	Critical or negative (low quality)	Depressive symptoms (**A**), Self-efficacy (**A**) Adherence Behaviors	Critical parenting was [+] associated with depression and [−] to self-efficacy, but not adherence or HbA1c . Depressive symptoms were [−] associated with self-efficacy and adherence, but not HbA1c . Self-efficacy mediated relationship between depressive symptoms and adherence.
Berg et al. (2011)	252 youth with **D** (ages 10-14, *M* age=12.5)	Cross-sectional	**M** and **F** monitoring; parent-child relationship quality; **P** behavioral involvement in **D** management	Self-efficacy (**A**), Internalizing and externalizing behaviors (**A**)	Relationship quality and monitoring related to adherence [+], HbA1c [−], self-efficacy [+], externalizing and internalizing [−]. Relationship quality→self-efficacy→ adherence.
Berg et al. (2013)	180 youth (ages 10.50-15.58; *M* age = 12.87, *SD* = 1.53) and **M** (n=176) and **F** (n=139)	Longitudinal (daily assessments across 14 days)	Parental persuasive strategies (e.g., "How much did you remind your child of the things he or she needs to do to manage his or her diabetes?")	**P** confidence in adolescent's ability to manage **D**	**M** persuasive strategies [−] associated with next day BG. **M** persuasive strategies [−] associated with next day confidence for **A** with high self-efficacy, [+] associated with next day confidence for **A** with low self-efficacy.
Berg et al. (2017)	236 late adolescents (*M* age=17.76)	Cross-sectional Daily Diary	Acceptance, Monitoring, Disclosure (**A**)	Adherence Behaviors Self-regulation failures	Disclosure to **M** but not **F** associated with better daily adherence and fewer self-regulation failures.
Botello-Harbaum et al. (2008)	69 youth (ages 11-16, *M* age = 13.3, *SD* = 1.7)	Longitudinal (baseline, 12-month follow-up)	Authoritative parenting style (low quality): demandingness, responsiveness; **D** responsibility; **D** conflict.	Quality of Life	**P** responsiveness [+] associated with **QOL** at baseline and 12 months. **D** responsibility, **D** conflict, and demandingness not associated with **QOL** at either time point.
Butler, Skinner, Gelfand, Berg, & Wiebe (2007)	78 youth (ages 11.58 – 17.42; *M* age = 14.21) and **M**	Cross-sectional	**M** psychological control, firm control, and acceptance	Depressive symptoms, Self-efficacy Adherence Behaviors	Psychological control was [+] associated with **A** depression. **A** report of firm control was associated with **A** self-efficacy [+] and depressive symptoms [−] among older **A**. **A** report of **M** acceptance was associated with [−] depression and [+] with self-efficacy. **M** report of acceptance [+] associated with adherence.
Chisholm et al. (2011)	40 youth (ages 2-8, *M* age = 6.57, *SD* = 1.63)	Cross-sectional	Quality of communication (combination of cohesion, expressiveness, and conflict); Behavioral control: a) commands, b) assigns responsibility	Internalizing and Externalizing Behaviors	Assign responsibility was associated [−] with % energy intake from sugars (NMES). When NMES consumption >10%, **M** quality of communication associated [−] to HbA1c. Command statements [+] correlated with externalizing symptoms. Assign responsibility statements [−] correlated with internalizing symptoms.

Authors	Sample	Design	Parental Involvement	Regulation of Behavior, Emotion, and Cognition	Primary Findings
Davis et al. (2001)	55 youth (ages 4-10; *M* age = 7.5, *SD* = 1.9) and a **P**	Cross-sectional	Parenting style: a) warmth, b) restrictiveness, c) amount of control, d) physical punishment	Adherence Behaviors	Warmth alone was [+] associated with better adherence. No **P** measures were associated with HbA1c.
Drew et al. (2010)	252 youth with **D** (ages 10-14; *M* age = 12.5)	Cross-sectional	Relationship quality	Extreme peer orientation (i.e., prioritizing peers over **D** management) Adherence Behaviors	Relationship quality related to adherence [+], HbA1c [−], and extreme peer orientation [−]. Relationship quality →peer orientation→adherence, HbA1c.
Ellis et al. (2007)	103 youth (ages 12-18; *M* = 14.8, *SD* = 1.7)	Cross-sectional	Affective support for **D**; **D** and general monitoring	Adherence Behaviors	Monitoring (latent factor) was [+] associated with adherence, and indirectly [−] associated with HbA1c.
Hanna et al. (2011)	118 late adolescents (range age 17-19)	Longitudinal	**D** Responsibility	Self-efficacy Worry about hypoglycaemia	Greater youth **D** responsibility associated (+) with self-efficacy for those living independently, but (−) for those not living independently.
Hansen, Weissbrod, Schwartz, & Taylor (2012)	Parents (82 **M** and 43 **F**) of youth with**D** (ages 7-14)	Cross-sectional	**P** frequency and helpfulness of support for **D** management	Adherence Behaviors	**F** helpfulness associated with adherence [+].
Helgeson et al. (2014a)	112 youth with type 1 diabetes (*M* age=12) followed for 6 years	Longitudinal	**P** support and control	Adherence Behaviors Depressive Symptoms	**P** control associated with lower depressive symptoms among those with type 1 diabetes.
Helgeson et al. (2014b)	117 youth with type 1 diabetes and 122 without (*M* age=18.15 years)	Longitudinal	**P** support and control	Adherence Behaviors	**P** support associated with positive changes in adherence; parent control related to increases in depressive symptoms. Friend support buffered the negative effects of parent control on adherence
Helgeson, Reynolds, Siminerio, Escobar, Becker (2008)	132 youth ages 10.73 – 14.21; *M* = 12.10) and a **P**	Longitudinal, across 3 time points (some cross-sectional results also reported)	**D** responsibility: a) % parent responsibility, b) % child responsibility, c) % shared responsibility	Depression, anxiety, anger, social competence, global self-worth, **D** self-efficacy	Shared responsibility (**P**-report) [+] associated with adherence. Shared responsibility (**A**-report) associated with HbA1c [−], self-efficacy [+], depressive symptoms [−], anger [−]. **P** responsibility (**A**-report) [+] associated with adherence. Child responsibility (**A**-report) associated with HbA1c [+], global self-worth [−], self-efficacy [−], and anger [+].
Helgeson, Siminerio, Escobar, & Becker (2009)	132 youth (ages 10.73-14.21; *M* = 12.10)	Longitudinal, across 4 time points, some cross-sectional findings reported	General relationship quality between **P** and **A**; **P D**-specific support	Depressive symptoms	Relationship quality [−] associated with HbA1c for girls only (Cross-Sectional). Depressive symptoms associated with HbA1c over time [+], but this association dissipated over time.
Helgeson, Snyder, Seltman, Escobar, Becker, & Siminerio (2009)	132 youth (ages 10.73-14.21; *M* = 12.10)	Longitudinal across 5 years	Quality of parent relationship with **M** and **F** and emotional and instrumental support, friend support and conflict	Depressive symptoms, global self-worth	Deteriorating metabolic control trajectory associated [+] peer conflict and [+] poorer well-being.

Authors	Sample	Design	Parental Involvement	Regulation of Behavior, Emotion, and Cognition	Primary Findings
Herzer, Vesco, Ingerski, Dolan, & Hood (2011)	147 youth (ages 13-18; *M* age = 15.5, *SD* = 1.4	Longitudinal, across 3 time points	**D**-specific family conflict	Anxiety, Depressive symptoms	Conflict at baseline [+] associated with HbA1c at 9 months, Conflict →anxiety→HbA1c.
Hilliard et al. (2011)	136 youth (ages 9-12; *M* = 10.5, *SD* = .9)	Cross-sectional	**F** "involvement (frequency and helpfulness of **D**-supportive behaviors)	Adherence Behaviors	**F** involvement [−] associated with HbA1c, but not with adherence.
Hilliard et al. (2012)	257 youth (ages 11-14; *M* age = 12.8, *SD* = 1.2), **P**	Cross-sectional	**D** monitoring, **D**-specific conflict, general family conflict	Adherence Behaviors	Monitoring [+] and conflict [−] associated with adherence, and (indirectly) with HbA1c .
Hilliard, Holmes et al. (2013)	257 youth (ages 11-14, *M* age=12.8)	Cross-sectional	D monitoring and conflict	Adherence Behaviors	Conflict (+) and monitoring (−) independently associated with HbA1 through adherence behaviors.
Hilliard, Wu et al. (2013)	150 youth (ages 13-18; *M* = 15.5, *SD* = 1.4)	Cross-sectional	**D**-specific family conflict	Depressive symptoms, Negative Affect (NA) related to **BGM**	Identified 3 trajectories of HbA1c, one trajectory representing those meeting their HbA1c treatment target, and others with HbA1c values exceeding recommended levels. Higher family conflict, depressive symptoms, and NA associated [−] to **BGM** and predicted poorer HbA1c trajectories.
Hilliard et al., (2014)	136 families (**M** age=10.5)	Longitudinal	**F** involvement from **M** and **F** report.	Adherence Behaviors	Lower adherence was associated with increasing **F** involvement across time and higher F involvement associated with slower declines in adherence over time.
Hood, et al. (2007)	202 youth (ages 8.2 – 18.7; *M* = 13.3, *SD* = 2.4, and **P**	Cross-sectional	**D** family conflict	Negative affect (NA) responses to **BGM** results (**A, P**)	Conflict [+] associated with HbA1c. Conflict (**A**-report) associated with youth NA around **BGM** [+].
Hsin, La Greca, Valenzuela, Moine, & Delamater (2010)	111 youth (ages 10-17; *M* = 13.33, *SD* = 2.82) and a primary caregiver	Cross-sectional	**D** responsibility, **D** "support" (i.e., frequency of supportive behavior x helpfulness of behavior)	Adherence Behaviors	Family support [+] associated with adherence.
Ingerski, Anderson, Dolan, & Hood (2010)	147 youth (ages 13-18; *M* age = 15.5, *SD* = 1.4)	Longitudinal	**D** responsibility, **D** conflict	Depressive symptoms, anxiety BGM frequency	**BGM** frequency associated with **P** responsibility [+], **D** conflict [−]. **P**-reported child trait anxiety was [−] associated with **BGM**. Conflict [+] associated with HbA1c.
Iskander et al. (2015)	217 youth (9-11 years)	Longitudinal	**P** negative and positive communication in interactions.	Adherence Behaviors	**M** positive communication predicted (+) adherence 3 years later. Changes in communication did not predict changes in HbA1c or adherence.
Jaser & Grey (2010)	30 youth (ages 10-16; *M* = 12.6, *SD* = 1.6) and **M**	Cross-sectional	Ratings of a) hostility, b) parental influence, c) sensitive/child-centered, d) positive reinforcement during **P-A** interactions.	Depressive Symptoms	HbA1c associated with child-centered parenting [−], positive reinforcement [−], hostility [+], and parental influence [+]. **M** hostility associated with A depressive symptoms [+] and HbA1c [+]. Parental influence associated with child depression [+].

Authors	Sample	Design	Parental Involvement	Regulation of Behavior, Emotion, and Cognition	Primary Findings
King et al. (2012)	252 youth (ages 10-14, *M* = 12.49, SD = 1.52)	Longitudinal	**M** and **F** acceptance (relationship quality), **D** monitoring, and frequency of help	Behavioral self-control Externalizing Behaviors	Better trajectories of HbA1c over time were associated with **F** monitoring [+], **F** frequency of help, behavioral self-control [+], extreme peer orientation [−], and externalizing behavior [−].
King et al. (2013)	252 youth (ages 10-14, *M* = 12.49, *SD* = 1.52) and 252 **M** and 188 **F**	Longitudinal	**M** and **F** relationship quality, **D** monitoring, and behavioral involvement	**D** Self-efficacy Adherence Behaviors	**M** and **F D** monitoring and acceptance at baseline associated with less declines in adherence. Declines in **M** and **F** monitoring and acceptance predict declines in adherence. Tests of mediation indicated declines in **M** acceptance → less increase in self-efficacy → greater declines in adherence (**A**-report). Also, declines in maternal acceptance → less increase in self-efficacy → greater declines in adherence (**A** and **M** reports)
La Greca & Bearman (2002)	74 youth (ages 11-18; *M* = 14.2, *SD* = 2.3)	Cross-sectional	**D**-specific support (frequency x helpfulness)	Adherence Behaviors	**D**-specific family support (frequency x helpfulness) was [+] associated with adherence, after controlling for family cohesion.
La Greca, Follansbee, & Skyler, 1990	40 youth w/ **D** (ages 7-17; *M* "Preadolescents" = 9.5; *M* "Adolescents" = 13.0) and **M**	Cross-sectional	Transfer of responsibility from **P** to **A** Knowledge (Monitoring) of Diabetes	Adherence Behaviors	Earlier transfer of responsibility [+] associated with HbA1c. **M** knowledge of **D** [+] associated with adherence of younger **A**.
Law et al. (2013)	203 youth (*M* age=14.5 years)	Cross-sectional	Discrepancies in **D** responsibility	Perceived Consequences Dietary Self-efficacy	HbA1c (+) associated with disagreements about responsibility and (−) with self-efficacy.
Lewandowski & Drotar (2007)	51 youth (ages 13-18; *M* = 14.67, *SD* = 1.24) and **M**	Cross-sectional	**M-A D** conflict	Adherence Behaviors (**A and M**)	**D** conflict was [−] associated with adherence.
Luyckx et al. (2013)	109 youth (*M* age=13.17 at baseline)	Longitudinal	**P** conflict	Internalizing and externalizing behaviors Adherence Behaviors	Conflict with **M and F** associated with (−) adherence through (+) externalizing behaviors.
Main et al. (2014)	118 youth (*M* age=12.74)	Cross-sectional	**P** acceptance and conflict	Depressive Symptoms Adherence Behaviors	**M** and **F** acceptance associated (+) with adherence and conflict (−) with adherence and **M** conflict (+) with depressive symptoms. Conflict and adherence stronger associations among Caucasian rather than Latinos.
Main et al. (2015)	247 late adolescents (*M* age=17.76)	Cross sectional	**P** monitoring, acceptance, disclosure, secrecy.	Externalizing Behaviors Adherence Behaviors	**M** and **F** acceptance, monitoring, disclosure, (+) associated with adherence (−) to externalizing behaviors; secrecy associated (−) to adherence and (+) to externalizing behaviors. Externalizing behaviors (−) associated with adherence.
Miller & Drotar (2007)	63 youth with **D** (ages 11-17, *M* = 13.3) and **P**	Cross-sectional	**P-A** communication and conflict	Adherence Behaviors	Parent-adolescent communication [+] associated with adherence.
Monaghan et al. (2015)	134 children (ages=1 to 6)	Cross-sectional	**P** mealtime behaviors	Child's problematic mealtime behaviors	More child problematic mealtime behaviors (+) associated with HbA1c.

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Nansel, T., Rovner, A. J., Hayne, D., Iannottie, R. J., Simons-Morton, B., Wysocki, T., Anderson, B., Weissberg-Benchell, & Laffel, L. (2009)	122 youth (*M* age=12)	Cross-sectional	Collaboration Parent Responsiveness and Demandingness, D Responsibility	Adherence Quality of Life	Collaboration was [+] associated with responsiveness, adherence, and quality of life.
Oris et al. (2015)	228 youth (**M** age=13.9 years)	Longitudinal	**P** support	Internalizing Symptoms	**P** support associated (−) internalizing symptoms and HbA1c. HbA1c and depressive symptoms especially high when low **P** support is combined with low friend support.
Ott et al. (2000)	161 youth with **D** (ages 11-18, *M* = 13.97)	Cross sectional	**P** supportive and non-supportive behaviors	Self-efficacy for **D** management	Non-supportive behaviors→[−] Self-efficacy and [+] **A** non-adherence to **BGM**.
Palmer et al. (2004)	127 youth with **D** (ages 10-15; *M* = 12.85)	Cross-sectional	**M** involvement in **D** care	Autonomy	HbA1c higher when parental involvement was low among adolescents with low autonomy.
Palmer et al. (2009)	185 adolescents with **D** (ages 10-14, *M*=12.52), and 185 **M** and 145 **F**	Cross-sectional	**P** involvement in **D** care	Self-efficacy	**P** involvement [−] associated with self-efficacy. HbA1c higher when parental involvement was low among adolescents with low self-efficacy.
Patton, Piazza-Waggoner, Modi, Dolan, & Powers (2009)	35 families of Youth with **D** (*M* = 5.6 years)	Cross sectional	Family functioning during mealtimes: Task Accomplishment and Behavioral Control	Affect management	Children's dietary adherence [−] correlated with task accomplishment and behavioral control. Affect management [+] correlated with percentage of above-normal blood glucose levels.
Robinson et al. (2016)	257 youth (ages 11-14)	Cross-sectional	Authoritative parenting, monitoring	Adherence Behaviors	More authoritative parenting and more monitoring were associated (+) with adherence.
Ronan et al. (2014)	239 youth (ages 9-11)	Longitudinal	Family conflict	Executive Functioning, Adherence, Blood glucose monitoring	Higher family conflict and lower frequency of blood glucose monitoring associated with groups at elevated and high risk for poor HbA1c.
Skinner, et al. (2000)	52 youth with **D** (ages 12-18; *M* = 15.2)	Longitudinal	General and **D** -specific family support	"Personal model" of **D** care	Family support [+] associated with adherence. Beliefs about effectiveness of **D** treatment regimens was [+] associated with dietary self-care.
Sweenie et al. (2014)	86 youth (*M* =10.8 years)	Cross-sectional	Critical parenting	Child behavior problems	Critical parenting associated (+) with behavior problems and with HbA1c
Vesco et al. (2010)	261 adolescents (13-18 years)	Cross-sectional	D responsibility	BGM frequency	Greater parental responsibility associated with higher BGM frequency
Weissberg-Benchell et al. (2009)	121 youth with D (*M* age=12.1)	Cross-sectional	**P** responsiveness and demandingness, conflict, collaboration, positive and negative communication observed interactions	Quality of Life	Conflict and negative communication associated [−] quality of life, collaboration [+] associated with quality of life

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Wiebe et al (2005)	127 youth with **D** (ages 10-15 years)	Cross-sectional	**M** involvement in **D**	Adherence Behaviors	**M** uninvolvement was [−] associated with adherence. Collaboration was associated with adherence [+] and HbA1c [−]. Collaboration and HbA1c was partially mediated by adherence. Control was [−] associated with adherence only among older youth.
Wiebe et al. (2014)	252 youth, **M**, and **F** (M = 12.49 at baseline)	Longitudinal	**P** involvement	Adherence Behaviors Self-Efficacy	Longitudinal declines in parental involvement especially linked to declines in adherence when adolescents did not report growth in self-efficacy.
Wysocki et al. (2009)	309 youth (age range 9-14.5 years)	Cross-sectional	**M** and **F** collaborative involvement	Depressive Symptoms Self-Efficacy	Depressive symptoms and self-efficacy poor when both primary and secondary caregiver were low in collaboration.

A=Adolescent, BGM=blood glucose monitoring D=Diabetes, F=Father, M=Mother, P=Parent