Assessment of transition readiness skills and adherence in pediatric liver transplant recipients

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Abstract: To examine transition readiness, adherence, and health outcomes in pediatric liver transplant recipients using a clinically administered screening measure. Seventy-one pediatric liver transplant recipients (11–20 yr) and 58 parents completed a clinic-based TRS measuring perceived and demonstrated self-management skills, AoR for health-related tasks, regimen knowledge, and psychosocial adjustment. Adherence was measured using s.d. of immunosuppressants, proportion of immunosuppressant blood levels out of target range, and clinic attendance. Health outcomes included liver test panels, biopsies, rejection episodes, and hospitalizations. Results indicate that all domains of transition readiness, with the exception of demonstrated skills, and non-adherence were positively correlated with age. Proportion of immunosuppressant blood levels below target range was positively correlated with self-management skills and increased responsibility for medication tasks. Parent regimen knowledge was associated with clinic attendance. Health outcomes were significantly related to medication non-adherence, but not to transition readiness domains. Medication adherence is considered to be a key factor in the transition from pediatric to adult-centered transplant care. Non-adherence is associated with an increased risk for medical complications and is potentially modifiable. Interventions to promote self-management skills and adherence should be an essential component of transition planning.

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With increased short-term survival rates among pediatric solid organ transplant recipients, health care providers have shifted focus to long-term outcomes. Long-term patient survival is limited by chronic rejection and graft loss, which is more common in adolescents (1). There is also an increased risk for medical complications following the transfer from pediatric to adult-centered transplant services (2). Thus, there is a critical need to develop strategies to assess the readiness to move from pediatric to adult-centered care (3–6).

"Transition" is an active process that addresses the medical, psychosocial, and educational/vocational needs of adolescents as they prepare to move from child- to adult-centered health care (7), while "transfer" refers to the change in the location where care is provided (8, 9). The transition process is twofold as it includes the transition of responsibility for health care tasks from the parent to the patient, as well as the preparation to transfer to adult-centered care. Beginning in late childhood/early adolescence, the management of a chronic illness begins to shift from the primary responsibility of the

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Abbreviations: A/YA, adolescent/young adult; ALT, alanine aminotransferase; AoR, allocation of responsibility; AST, aspartate transaminase; CFA, confirmatory factor analysis; OTIS, Organ Transplant Information System; PCA, principal components analysis; s.d., standard deviation; TBili, total bilirubin; TRS, transition readiness survey.
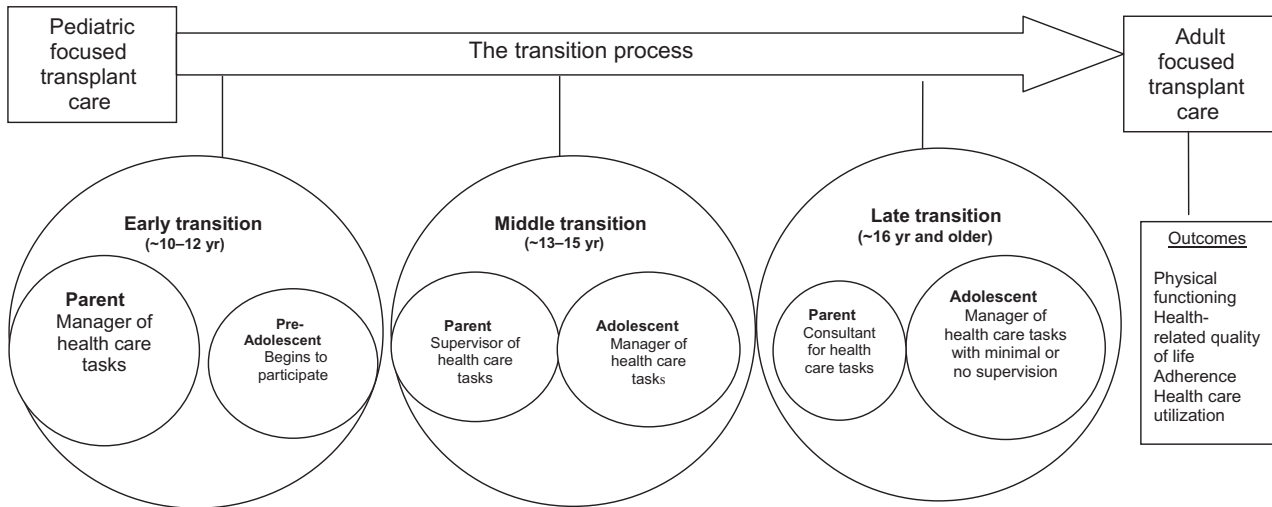
Fig. 1. The transition process: transition of responsibility of health management tasks and transition from pediatric to adult-centered care.

parent to self-management by the adolescent (Fig. 1) (10). By shifting responsibility for health-related tasks in a developmentally appropriate manner, the adolescent gains the knowledge, skills, and experiences necessary to master the independence required to be successful in the adult health care system.

Self-management skills are integral to the achievement of independence necessary for successful health care transitions (11, 12). Researchers and clinicians agree that adolescents and young adults should not transfer from pediatric to adult health services unless they have the skills necessary for functioning effectively in the adult health care system, including adhering to medication regimens (13, 14). The Pediatric Committee of the American Society of Transplantation has recommended that prior to transferring to adult-centered care, the pediatric transplant recipient should demonstrate the ability to independently manage their health (5). In addition, the pediatric patient should adhere to their immunosuppressant medications to avoid increased risk of graft loss and rejection following the transfer to adult-centered care (3, 4).

The specific aims were to (i) describe A/YA and parent responses on a clinically developed TRS that assesses perceived and demonstrated skills, as well as the AoR for health management tasks and (ii) explore the relationship between the TRS, measures of adherence, and health outcomes. We hypothesized that higher scores on the TRS indicated greater transition-related self-management skills and would be associated with higher rates of medication adherence and better health outcomes.

Materials and method

Participants

Approval from the medical center's Institutional Review Board was obtained prior to conducting a retrospective chart review for the present cross-sectional study. A review of the pediatric liver transplant clinic registry identified patients who had completed the TRS since October 2007 as part of routine follow-up in the Pediatric Liver Transplant Clinic. Patients completed this survey if they were 11 yr of age and older and more than six months post-transplant. We included patients as young as 11 yr given that previous research with pediatric liver transplant recipients found that the transition of responsibility for health-related tasks occurs between the ages of nine and 17 yr, with a mean age of 12 yr (15). When present, parents completed a parallel version of the measure.

Measures

Transition readiness
Assessment of transition readiness occurred through the use of a clinically derived measure designed to guide individualized assessment and intervention as part of transition planning. Survey items were selected by clinical observations, review of the transition, self-management, and medication adherence literature, and discussions with members of the pediatric liver transplant team (13, 16). The team was comprised of a pediatric hepatologist, transplant surgeon, pediatric psychologist, social worker, dietician, and transplant nurse coordinator. Administration time for the surveys was approximately 15 min. The A/YA and parent versions are described below.

TRS:A/YA

The TRS:A/YA consisted of 38 written items and four healthcare provider administrated questions. Responses elicited ranged from self-report using Likert scales to direct demonstration of skills. Items were grouped conceptually into four domains: Self-Management, Regimen Knowledge, Demonstrated Skills, and Psychosocial Adjustment (Table 1). The Self-Management domain also included a subscale

Table 1. Domains of the TRS

Domain	Number of items	Example item(s)
Adolescent report (TRS:A/YA)		
Self-management	12	I wear a Medicalert ID; Who notices when prescriptions needs to be refilled?
AoR	5	In the past two wk, how often did you remember to take your medications without an adult reminding you? How often did your parent remind you to take your medication?
Perceived regimen knowledge	10	I can name all of my medications; I know how often I need to come to appointments
Demonstrated skills	9	Name your medications; John took his morning dose of medicine at 7 AM. He takes his 2nd dose 10 h later. What time does he take his 2nd dose?
Psychosocial adjustment	11	I have no control over my health in the future; I am limited in what I can achieve in the future because of my transplant
Parent report (TRS:P)		
Adolescent self-management	11	My child wears a Medicalert ID; Who notices when prescriptions need to be refilled?
AoR	5	In the past two wk, how often did you remind your child to take his/her medication?
Adolescent regimen knowledge	7	My child can name all of their medications; My child knows how often they need to come to their appointments
Demonstrated skills	5	John took his morning dose of medicine at 7 AM. He takes his 2nd dose 10 h later. What time does he take his 2nd dose?
Adolescent psychosocial adjustment	11	My child feels they have little control over their health; Because of their transplant, my child cannot pursue certain jobs in the future
Regimen knowledge	2	My child needs to take medications for the rest of their life

which assessed AoR in the two wk preceding the survey. AoR was assessed using five items to examine the distribution of medication-taking responsibility between the A/YA and the parent/caregiver. These items were adapted for use with pediatric transplant recipients from measures used to assess AoR in families of children diagnosed with asthma (17) and type 1 diabetes (18). For each item, respondents indicated the frequency of involvement of the A/YA or the parent/caregiver.

Scoring of the TRS varied with each item and yielded a total score of 126 with higher scores reflecting increased skill acquisition. For items assessing perceived skills, knowledge or attitudes, patients responded using three- or four-point Likert scales. Higher scores reflected perceived presence of knowledge/skills or agreement with items. Items requiring direct observation of skills included symptom recognition and health literacy. These were scored using percentage correct and assigned a value on a three-point scale (1 = <33% correct, 2 = 34–65% correct; 3 = >66%). To further assess medication knowledge, upon completing the written portion of the survey, patients were asked to verbally list their medications, as well as the dosages, timing of dose administration, and function of the medications. Responses to each question were coded on a three-point scale (1 = none, 2 = some, 3 = all) indicating extent of patient's knowledge.

TRS: parent report

The TRS:P consisted of 36 items yielding a total possible score of 108. Parents were assessed on their perception of their adolescent's skills using parallel items from the A/YA measure. Similar to the TRS:A/YA, higher scores reflected increased perceived skills needed to transfer from pediatric to adult-centered care. Items were grouped conceptually into five domains (Table 1). Three domains were proxy reports of the adolescent's skills, and the remaining two assessed parents' knowledge of their adolescent regimen, and demonstration of regimen knowledge.

Adherence

A multi-method assessment of the adolescent's adherence to immunosuppressant medications and clinic visits in the 12 months preceding administration of the TRS was conducted using a retrospective review of the patient's medical record. Adherence measures were used as continuous and categorical variables in analyses.

Immunosuppressant levels: The degree of fluctuation in immunosuppressant blood levels has been used to assess the variability of medication administration, with higher fluctuations indicating medication non-adherence (15, 19–24). Data from routine monitoring of tacrolimus and cyclosporine blood levels were obtained from the participant's medical record and the University of Michigan's OTIS for the previous year. Immunosuppressant levels obtained during inpatient hospitalization stays were not included in the analyses. s.d. of consecutive blood levels obtained retrospectively were calculated. In addition, the proportion of immunosuppressant blood levels outside of the adolescent's recommended target therapeutic range (above and below) was also calculated using laboratory values for the preceding 12 months. To avoid the potential introduction of bias, adherence data were collected in a systematic method by a research assistant who was not involved in direct patient care. Based on previous studies of the association between immunosuppressant variability and risk for poor health outcomes, such as late allograft rejection, adherence was defined as a tacrolimus s.d. < 2 and cyclosporine s.d. < 30 (20, 22, 25, 26), and/or <50% of immunosuppressant blood values out of the target range (15, 22). Given the clinical context, our definitions for adherence are conservative as we routinely examine variability in immunosuppressant blood levels to identify patients who may be at risk for medication non-adherence.

Clinic attendance: Adherence to clinic visits was assessed retrospectively by comparing actual clinic attendance to the

frequency recommended by the transplant team. The rate of clinic attendance for the year prior to study participation was obtained from the adolescent's medical record. Adherence was defined as a clinic attendance rate of ≥85%. This definition is consistent with the pediatric adherence literature (27), and previous work in pediatric liver transplantation, wherein the rate of clinic attendance was significantly related to hospital admissions, liver biopsies, and rejection episodes (20).

Health outcomes
Measures of A/YA health outcomes including liver panel tests (AST, ALT, TBili), graft function, frequency of hospital admissions, liver biopsies, and episodes of rejection for the year prior to study participation were obtained from a review of medical records.

Data analysis

To examine the factorial structure of the TRS for data interpretation, we conducted a CFA with four factors to test the hypothesis that the TRS measured a unitary construct underlying transition readiness. We hypothesized that the construct was comprised of four subdomains: self-management, regimen knowledge, demonstrated skills, and psychosocial adjustment. To accomplish this, a PCA with a varimax rotation was performed on the 38 items of the TRS:A/YA and the 36 items of the TRS:P. Given the negatively skewed distribution of the data, a non-parametric approach with a varimax rotation was used to isolate factor loadings that discriminate based on the explained variability (28).

Results from the surveys were analyzed using descriptive statistics (e.g., means, s.d.) to explore patterns of transfer readiness. Pearson's product moment correlation coefficients were calculated whenever the assumptions underlying parametric statistical testing were met. Given the significant skewness of the TRS, Spearman's rank correlation coefficients were calculated to examine the associations between scores on the TRS domains, measures of adherence, health outcomes, and demographic factors (age, time since transplantation). All analyses were conducted using SPSS for Windows (Version 16.0, SPSS, Inc., Chicago, IL, USA).

Results

Participant characteristics

The total sample consisted of 71 pediatric liver transplant recipients, which represented approximately 98% of the clinic population in the targeted age range. Of these, 58 (82%) adolescents had parallel parent reports. Mean adolescent age was 15.6 ± 2.7 yr (range 11–20 yr) with an average time since transplant of 9.4 ± 5.4 yr (range 1–19 yr). Fifty-six percent of the adolescents were women and 37% belonged to a minority group. Most adolescents (85%) used tacrolimus as their primary immunosuppressant with the remainder using cyclosporine. All adolescents were on twice-daily dosages of their immunosuppressant medications.

Transition readiness scale psychometric properties

TRS:A/YA version
Each of the original 36 items was examined to determine its contribution to the scale. Items were not omitted from analyses given their apparent conceptual relevance. It is recommended that items assessing construct-relevant information be retained until measures can be evaluated across broader samples (29). Given the skewness of the data, items were entered into a non-parametric PCA with varimax rotation. The joint criteria of Eigen values > 1 and Cattell's elbow criteria on the scree plot (30) indicated that a four factor solution accounted for 32.5% of the variance in responses. We examined the number of specific items on each factor that had loadings of > 0.4, Factor 1, labeled Demonstrated Skills, included 3/9 proposed items (factor loadings range 0.73–0.85). Factor 2, labeled Self-Management, contains 6/12 proposed items (factor loadings range: 0.60–0.77). Factor 3, labeled Psychosocial Adjustment, contains 3/11 proposed items (factor loadings range: 0.48–0.85). Factor 4, labeled Perceived Regimen Knowledge, contains 2/10 proposed items (factor loadings: 0.69, 0.75). All domains of the adolescent version of the TRS had acceptable internal consistency, with Cronbach alphas ranging from 0.68 to 0.81 (Table 2). The Cronbach alpha for the entire 38-item adolescent version was 0.85.

TRS: parent version
Similar to the TRS:A/YA, each of the original 36 items was examined to determine its contribution to the scale using the same procedure outlined above. The results indicate that a four factor solution accounted for 32.5% of the

Table 2. Descriptive statistics for domains of the TRS

Domain	Mean	s.d.	Range	Cronbach's alpha
Adolescent report (TRS:A/YA)				
Self management	26.23	4.98	7–35	0.68
AoR	11.75	2.95	0–15	0.80
Regimen knowledge	23.44	3.07	12–27	0.71
Demonstrated skills	19.42	4.79	0–26	0.81
Psychosocial adjustment	26.82	5.12	2–33	0.82
Total	95.90	14.78	28–117	0.85
Parent report (TRS:P)				
Adolescent self-management	22.66	4.21	11–32	0.63
AoR	11.27	2.73	5–15	0.79
Adolescent regimen knowledge	18.26	2.32	9–21	0.60
Demonstrated skills	11.90	3.69	0–15	0.75
Adolescent psychosocial adjustment	26.21	3.38	17–32	0.56
Regimen knowledge	4.47	1.01	1–6	0.19
Total	83.48	9.13	56–97	0.75

variance in responses. We examined the number of specific items on each factor that had loadings of > 0.4. Factor 1, labeled Self-Management, contains 5/11 proposed items (factor loading range: 0.45–0.76). Factor 2, labeled Demonstrated Skills, contains 4/5 proposed items (factor loadings range: 0.66–0.9). Factor 3, labeled Psychosocial Adjustment, contains 4/11 proposed items (factor loadings range: 0.41–0.84). Factor 4, labeled Adolescent Regimen Knowledge, contains 4/7 proposed items (factor loadings range: 0.43–0.54). For the parent version, Cronbach alphas ranged from 0.18 to 0.75 (Table 2). The Cronbach alpha for the entire 36-item parent version was 0.75.

Transition readiness scale descriptives

TRS:A/YA

The mean total score on the TRS:A/YA was 95.9 (76.1%, s.d.: 14.8), with a range of 28–117 (22.2–92.9%). Each domain had a similarly wide range of scores (Table 2). Most adolescents (90%) correctly named their medications; however, 73% could not state dosages, 51% were unable to specify prescribed timing between doses with a minimum acceptable answer being some variation of "in the morning and at night," and 41% could not identify the basic function of their immunosuppressants, with a minimum acceptable answer being some variation of "they are for my liver."

TRS:P

The mean total score on the TRS:P was 83.5 (77.3%; s.d.: 9.1), with a range of 56–97 (51.85–89.8%). Each domain had a similarly wide range of scores (Table 2).

Transition readiness and participant characteristics

Table 3 presents the correlations between the TRS and participant characteristics. Age at survey was positively correlated with the TRS:A/AYA Total Score and domain scores including Perceived Self-Management, Regimen Knowledge, and Psychosocial Adjustment. Age was also positively correlated with the TRS:A/YA AoR subscale. Adolescent age was not significantly related to Adolescent Demonstrated Skills.

Of the 58 dyads, there were positive and significant correlations between adolescent age and TRS:P Total Score, including parent reported domains assessing Adolescent Knowledge, Adolescent Self-Management, and Adolescent Psychosocial Adjustment. Age was also positively correlated with the parent reported AoR subscale. Adolescent age was not related to Parent Demonstrated Skills or Parent Regimen Knowledge.

To further explore the association between age and the AoR subscale, we compared TRS:A/YA and TRS:P scores across adolescents aged 11–13, 14–17, > 18 yr. Based on adolescent self-reports, the 11- to 13-yr-old age group was significantly lower in their responsibility for health-related tasks (mean = 9.5 ± 3.8) compared to the 14- to 17-yr-olds (mean = 12.2 ± 2.3, p = 0.002) and > 18-yr-olds (mean = 12.7 ± 2.4, p = 0.001). There were no differences between the 14- to 17-yr-olds and the > 18-yr-old groups. Similarly, based on parent reports, the 11- to 13-yr-old age group was significantly lower in their responsibility for health-related tasks (mean = 9.4 ± 3.0) compared to 14- to 17-yr-olds (mean 11.8 ± 2.3, p = 0.004) and > 18-yr-olds

Table 3. Correlations between TRS, participant age, and adherence measures

	Age	Rate of attendance	Cyclosporine s.d.	IS out of range	IS below range
Age		r = −0.26; p = 0.03	r = 0.78; p = 0.005	r = 0.25; p = 0.03	–
Adolescent TRS					
Total score	rs = 0.51; p = 0.000	–	–	–	–
Self-management	rs = 0.44; p = 0.000	–	rs = 0.72; p = 0.01	–	rs = 0.27; p = 0.02
AoR subscale	rs = 0.44; p = 0.000	–	rs = 0.68; p = 0.02	–	rs = 0.23; p = 0.05
Perceived regimen knowledge	rs = 0.46; p = 0.000	–	–	–	–
Demonstrated skills	–	–	–	–	–
Psychosocial adjustment	rs = 0.51; p = 0.000	–	–	–	–
Parent TRS					
Total score	rs = 0.43; p = 0.001	–	–	–	–
Adolescent self-management	rs = 0.44; p = 0.001	–	–	–	–
AoR subscale	rs = 0.43; p = 0.001	–	–	–	–
Adolescent regimen knowledge	rs = 0.42; p = 0.001	–	–	–	–
Demonstrated skills	–	–	–	–	–
Adolescent psychosocial adjustment	rs = 0.29; p = 0.026	–	–	–	–
Regimen knowledge	–	rs = 0.40; p = 0.002	–	–	–

(mean = 11.3 ± 2.7, p = 0.005). There were no differences between the 14- to 17-yr-olds and the >18-yr-old groups.

Adolescent age was significantly related to time since transplantation, although time since transplantation was not significantly related to any domain of the TRS.

Adolescent/parent agreement

For the 58 dyads in which adolescent and parent reports on the TRS were available, paired correlations are as follows: Self-Management: $r = 0.47$, p = 0.000; AoR: $r = 0.47$, p = 0.000; Perceived Regimen Knowledge: $r = 0.58$, p = 0.000; Adolescent Psychosocial Adjustment: $r = 0.47$; p = 0.000; Demonstrated Skills: $r = -0.26$, p = 0.84. With the exception of the Demonstrated Skills domain, all correlations are in the moderate agreement range.

Patterns of adherence

Table 4 displays descriptive statistics for the adherence variables. Thirty-one percent (n = 22) of adolescents were non-adherent using s.d. of tacrolimus (s.d. > 2) or cyclosporine (s.d. > 30) and 26.8% (n = 19) were non-adherent based on having >50% of immunosuppressant laboratory values out of the target range. Thirty-two percent (n = 23) of adolescents were non-adherent as measured by clinic attendance <85% over the preceding 12 months. Overall, 43% of adolescents (n = 31) were classified as adherent across all measures, 29.6% (n = 21) were classified as non-adherent on one variable, 19.7% (n = 14) were classified as non-adherent on two variables, and 7.0% (n = 5) were classified as non-adherent on all variables.

Participant age was significantly related to measures of adherence with older adolescents demonstrating lower rates of clinic attendance ($r = -0.26$; p = 0.03), higher s.d. of cyclosporine ($r = 0.78$; p = 0.005), and a higher proportion of immunosuppressant blood levels >1 s.d. out of the target range ($r = 0.25$; p = 0.03). The association between adolescent age and tacrolimus s.d. was not significant ($r = 0.24$; p = 0.06). Follow-up univariate analyses indicated significant differences between adolescents <16 yr old and >16 yr old with respect to measures of adherence. Compared to the younger adolescents, those who were >16 yr (n = 36) had lower rates of clinic attendance (79% vs. 90%; p = 0.05), higher tacrolimus s.d. (2.69 vs. 1.58, p = 0.035), and a higher percentage of immunosuppressant blood levels out of target range (42% vs. 32%; p = 0.05).

Transition readiness domains and adherence

Table 3 presents correlations between the TRS and measures of adherence. No significant associations were found between the TRS: A/YA and adherence as measured by tacrolimus s.d. or rate of clinic attendance. The TRS:A/YA domains measuring Adolescent Perceived Self-Management was positively correlated with the percentage of immunosuppressant levels below the target range, and cyclosporine s.d. Within the Self-Management domain, the AoR subscale was positively correlated with cyclosporine s.d. and the percentage of immunosuppressant levels below the target range. On the TRS:P scale, there were no significant associations between parent reports and adherence as measured by tacrolimus or cyclosporine s.d., or immunosuppressant laboratory values out of target range. However, the rate of clinic attendance was significantly related to the TRS:P domain measuring Parent Regimen Knowledge.

Health outcomes

Within the 12 months prior to participation, 20% of the adolescents had been hospitalized at least once, 15.5% underwent at least one liver biopsy, and 1.4% had a documented biopsy-proven episode of rejection. Across all participants, there were a total of 25 hospital admissions, 155 inpatient days, 12 liver biopsies, and one biopsy-proven episode of rejection. In the year prior to participation, average ALT was 50.7 (s.d. = 50.0), average AST was 48.26 (s.d. = 54.4), and average TBili was 0.88 (s.d. = 0.94).

Transition readiness domains, adherence, and health outcomes

There were no significant associations between TRS:P or TRS:A/YA and measures of health outcomes. Significant associations were found

Table 4. Descriptive statistics for measures of adherence

	Mean	s.d.	Range
Tacrolimus s.d. (n = 60)	2.12	2.05	0.32–11.45
Cyclosporine s.d. (n = 11)	23.81	10.76	8.0–42.0
Percent of immunosuppressant levels out of range	37.66	23.96	0.00–100.0
Percent of immunosuppressant levels below range	15.57	17.57	0.0–75.0
Percent of immunosuppressant levels above range	22.10	19.42	0.0–80.0
Clinic attendance (%)	84.97	24.52	0.0–100.0

between measures of adherence and health outcomes. Average ALT levels for the year prior to participation were significantly related to tacrolimus s.d. ($r = 0.41$; $p = 0.001$) and percentage of immunosuppressant laboratory values out of target range ($r = 0.33$; $p = 0.005$). Average AST levels for the year prior to participation were also significantly associated with tacrolimus s.d. ($r = 0.42$; $p = 0.001$), cyclosporine s.d. ($r = 0.61$; $p = 0.047$) and percentage of immunosuppressant laboratory values out of target range ($r = 0.28$; $p = 0.017$). The number of biopsies, which suggests increased concern for rejection, was significantly related to the percentage of immunosuppressant laboratory values out of target range ($r = 0.34$, $p = 0.004$) and tacrolimus s.d. ($r = 0.33$, $p = 0.01$).

Discussion

Results of the current study indicate that nearly 30% of the participants were non-adherent with their immunosuppressant medications, and over 30% were non-adherent to recommended clinic visits. This is consistent with previous reports that medication non-adherence is common among adolescent transplant recipients (15, 31, 32). There was a significant association between age and non-adherence, with older adolescents and young adults demonstrating higher rates of non-adherence compared to the younger children. This is concerning as chronological age is the most common criterion used to determine readiness to transfer from pediatric to adult-centered care, with 16–22 yr being the most frequently cited age range to start the transition process (33). As medication adherence and health outcomes may both be affected by changes associated with a transfer to a new medical provider, this is a time of increased risk for adolescent and young adult transplant recipients.

With respect to the assessment of transition readiness, perceived self-management skills, perceived regimen knowledge, and psychosocial adjustment increased with chronological age. Yet, the association between age and performance on the demonstrated skills domain did not reach statistical significance. This suggests that while older adolescents and young adults may perceive that they have sufficient regimen knowledge and self-management skills, their chronological age is not associated with demonstrated self-management skills, including the ability to describe their medical regimen or the ability to recognize critical health symptoms. The ability to recognize symptoms and demonstrate when and how to seek urgent medical care is cited as

an important component of the transition process (5).

We hypothesized that higher TRS scores would be associated with higher rates of adherence. On the contrary, this study found that increased scores on the A/YA self-management skills scale were associated with higher rates of medication non-adherence. Specifically, higher scores on the self-management scale were associated with higher cyclosporine s.d. and increased proportion of immunosuppressant blood values below target range, which is indicative of suboptimal medication intake (22). Within the self-management domain, increased AoR for medication-related tasks to the A/YA was also associated with higher proportion of immunosuppressant blood levels below range.

Although older adolescents/young adults perceived greater self-management, they were at higher risk for medication non-adherence. Moreover, with increasing age, this population is being monitored less by their parents/caregivers. Thus, the transition of medication-related responsibilities from parents to adolescents may not be successful as evidenced by poor medication adherence in the older adolescents/young adults. Likewise, research has demonstrated that increased parental monitoring is associated with improved adherence and health outcomes in other chronic illness groups, including adolescents with diabetes (34), HIV (35), and asthma (17). In addition, a recent report suggests that adolescent liver transplant recipients are inconsistent with their health management tasks (36).Thus, it is critical that attention be given to the role of parental monitoring and supervision of medication-related tasks during the transition process as adolescents begin to demonstrate mastery of health management tasks.

Parents' knowledge of the adolescent's medical regimen was significantly correlated with the rate of clinic attendance. It is possible that the rate of clinic attendance is a measure of parental adherence to the regimen rather than the A/YA's adherence. Further research to investigate the impact of adolescent clinic attendance without their parent on transition readiness and adherence is warranted, particularly as it relates to the allocation of regimen responsibility.

The results of this study should be viewed in light of study limitations. The TRS used in this study was developed for clinical use to guide intervention. This was not a prospective measurement development study, thus the construct and content validity of the TRS were not investigated prior to its administration for

clinical purposes. Moreover, given the retrospective nature of this study, the predictive validity of the TRS as it relates to medication adherence and successful transfer of care is not known. Lastly, this retrospective, cross-sectional study was conducted within a single pediatric liver transplant program which limits generalizability. Within this single center study, relatively few participants were receiving cyclosporine as their primary immunosuppressant medication (n = 11). Thus, the significant association between higher cyclosporine s.d. and higher perceived self-management skills should be interpreted with caution. Further multi-center study of the association between medication adherence as measured by immunosuppressant variability and transition readiness skills is warranted.

Unfortunately, while many clinical programs strive to enhance the acquisition of self-management skills in adolescents, they do not routinely assess transition readiness, including the ability to independently manage health care needs (37, 38). One barrier to the routine assessment of transition skills may relate to the lack of a validated instrument to assess transition-related self-management skills. There is a critical need for the development and validation of objective assessment tools to empirically evaluate the pediatric patient's readiness to move from a pediatric to adult-focused transplant health care. We are presently revising the TRS by conducting additional quantitative analyses as well as qualitative research with key informants regarding areas of transition which need further development. These data will inform the development of a revised TRS which will be piloted with a broader sample of A/YA transplant recipients across transplant centers. Future research will also incorporate other measures of self-management, allocation of health care responsibility, and health outcomes, to evaluation the concurrent and predictive validity of the TRS. This will allow for the refinement of questions and domains within the instrument.

Limitations aside, this study has notable clinical implications. The current literature recommends that medical stability is a critical variable in the transfer from pediatric to adult-centered care (5, 39). Given that medication non-adherence is associated with increased risk for medical complications, particularly among adolescent transplant recipients (40, 41), targeting problems of medication non-adherence should be an essential component of the transition process. While medication adherence may not be sufficient for optimal health care transitions, it is an essential component.

Self-management interventions are effective in promoting medication adherence in children with other chronic health conditions (42, 43), and there is increasing recognition that self-management skills should be the goal of any transition program (11, 12). Interventions to promote transition readiness should also target parental monitoring and the transition of responsibility of health-related tasks from the parent to the A/YA. The inverse relationship between medication adherence and perceived self-management skills suggests that although adolescents perceive that they have adequate knowledge and management skills, they are not demonstrating the skills necessary for optimal medication management. This may relate to a variety of individual, family, and/or provider factors including motivation, health literacy, and communication with health care provider. In addition, the role of peer support has been suggested to be an important factor for adolescents and young adults transitioning from pediatric to adult-centered care (5, 39). This study did not investigate the impact of peer and social support on medication adherence or transition-related skills. We are currently conducting prospective studies to examine factors that relate to medication adherence and self-management skills throughout the transition process.

Using this clinical tool, we have developed a transition program in our clinic which involves patient and parent education, behavioral goals and skill building and systematic planning for the transfer to adult care. Clinic-based adherence interventions incorporate educational, motivational, behavioral, and organizational strategies to foster the acquisition of self-management skills. We are currently engaged in ongoing quality improvement efforts to evaluate the effectiveness of our programs to promote medication adherence and transition skills in a systematic and developmentally appropriate manner.

Conclusions

Medication adherence is a key factor in the transition from pediatric to adult-centered transplant care. This study demonstrated that chronological age was associated with perceived self-management skills, yet older age was associated with increased risk for non-adherence. Thus, despite increased independence over health-related tasks, age alone should not determine readiness to transfer from pediatric to adult-focused health care given the risk of medical complications. Rather, the timing of transfer

from pediatric to adult-focused care should be individualized and based on the acquisition and mastery of self-management skills. Medication non-adherence is associated with an increased risk for medical complications including graft loss and rejection. Therefore, the promotion of medication adherence should be an essential component of transition planning. Interventions to promote transition readiness should also target parental monitoring and the developmentally appropriate transition of responsibility of health-related tasks from the parent to the A/YA.

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