Journal of Pediatric Psychology, 43(4), 2018, 434–442
doi: 10.1093/jpepsy/jsx124
Advance Access Publication Date: 11 October 2017
Original Research Article

Earlier Pediatric Psychology Consultation Predicts Lower Stem Cell Transplantation Hospital Costs

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Received May 4, 2017; revisions received September 22, 2017; accepted September 24, 2017

Abstract

Objective The purpose of this study was to examine the hypothesis that earlier time to psychology consultation would predict lower costs for the initial stem cell transplant (SCT) hospitalization among patients receiving care at a children's hospital. **Methods** A retrospective medical record review identified 75 patients (ages 0–32 years) with one or more visits by a licensed clinical psychologist during the initial SCT hospitalization from 2010 to 2014. Demographic and clinical variables were obtained from the electronic medical record and hospitalization costs were obtained from patient billing records. A generalized linear model with a gamma distribution and log link function was used to estimate the relationship between time to psychology consultation and cost for the initial SCT hospitalization while controlling for demographic, clinical, and utilization factors. **Results** After controlling for age at SCT, gender, race, insurance status, diagnosis, SCT type, length of stay, and number of psychology visits, earlier time to psychology consultation predicted lower costs for the initial SCT hospitalization ($\chi^2 = 6.83$, $p = .01$). When the effects of covariates were held constant, every day increase in the time to psychology consultation was associated with a 0.3% increase in SCT hospitalization costs ($\beta = 0.003$, SE = 0.001). **Conclusions** Results suggest that facilitating consultations with a pediatric psychologist early in the initial SCT hospitalization may reduce costs for patients undergoing SCT at children's hospitals. Future research is needed to determine the optimal timing of psychology consultation and quantify the economic impact of psychological services.

Key words: behavioral medicine; costs and cost analysis; pediatric; stem cell transplantation.

For many pediatric oncologic, hematologic, and immunologic conditions, stem cell transplantation is a potentially life-saving and curative, but costly, treatment option (Khera, Zeliadt, & Lee, 2012). The initial stem cell transplant (SCT) hospitalization alone typically lasts at least 1 month and includes transplantation procedures, laboratory services, radiological investigations, pharmacy services, blood components, and physician services that cost >$4,000 per day (Lin et al., 2010; Majhail, Mau, Denzen, & Arneson, 2013; Majhail et al., 2010; Matthes-Martin et al., 2012). The initial hospitalization may extend to several months and daily costs may increase if other complications arise (e.g., graft-vs.-host disease) and/or medical (i.e., blood cell count recovery, immunological functioning) and behavioral (e.g., caregiver ability to administer necessary medications and nutrition) indicators of discharge readiness are not met. Despite national efforts in the United States to reduce health care costs (Institute for Healthcare Improvement, 2016),

costs for SCT hospitalizations increased by 26% from 2004 to 2007 (Stranges, Russo, & Friedman, 2009), and the estimated annual costs for pediatric SCTs in the United States now exceed $395 million (2012 US$, Agency for Healthcare Research and Quality, 2012).

Over the past 30 years, payment models to cover the significant and growing costs of pediatric SCT have largely shifted to bundled payment plans in which hospitals are provided a single payment per episode of care (U.S. Government Accountability Office, 2011). Bundled payment plans are intended to promote collaborative and efficient care by incentivizing hospitals to minimize unnecessary costs (Centers for Medicare and Medicaid Services, 2017). Failing to keep costs within the range of those reimbursed by bundled payment plans results in losses that may threaten the financial feasibility of the transplant center and ultimately limit the hospital's ability to provide high-quality patient care (Khera et al., 2012; Maziarz, Farnia, Martin, & Komanduri, 2014).

While bundled payment plans offer multiple advantages, ensuring the continued coverage of behavioral health services under bundled payment plans (or other alternative payment models) may require that pediatric psychologists are able to demonstrate their ability to not only improve patient outcomes, but also enhance health care efficiency (i.e., reduced costs; Friedman, Sobel, Myers, Caudill, & Benson, 1995; Hubley & Miller, 2016; Miller et al., 2017; Rozensky & Janicke, 2012). Although the relationship between pediatric psychology services and health care costs in pediatric patients undergoing SCT has not yet been examined, studies of adults suggest that higher functioning on the psychosocial and behavioral factors commonly targeted by pediatric psychologists is linked to better health outcomes and lower health care utilization. Specifically, greater depressive symptoms, fewer positive coping strategies, and nonadherence to treatment recommendations are associated with poorer immunological response following SCT (i.e., days until neutrophil engraftment, number of infections) even after controlling for clinical and demographic factors (Foster, McLellan, Rybicki, Dabney, Visnosky, & Bolwell, 2009; Pulgar, Garrido, Alcalá, & Reyes del Paso, 2012). A poorer immunological response delays recovery and hospital discharge, and thus, it is not surprising that psychosocial and behavioral difficulties (i.e., depression, limited coping skills, nonadherence) are also associated with an increased length of stay (Foster et al., 2009; Hoodin, Uberti, Lynch, Steele, & Ratanatharathorn, 2006; Prieto et al., 2002).

Taken together, findings from the adult SCT literature suggest that providing pediatric psychology services during the initial SCT hospitalization may have the potential to contribute to efforts to minimize unnecessary costs. The general consultation-liaison literature supports this hypothesis and suggests that the economic benefit of psychology services may be maximized when services are provided early in the admission. In a recent study of 279 general pediatric patients admitted for a range of conditions (i.e., mental diseases and disorders—19%; diseases and disorders of the nervous system—17%; diseases and disorders of the digestive system—15%), a 10% decrease in psychiatry/psychology referral time was associated with a 7.9% decrease in hospital charges (Bujoreanu, White, Gerber, & Ibeziako, 2015). Despite the promising results of the study by Bujoreanu et al. (2015), to our knowledge, researchers have not yet evaluated the relationship between time to pediatric psychology only (vs. combined psychology and psychiatry service) service and cost within any specific medical population (McGrady & Hommel, 2016). This represents a missed opportunity for the larger field to advocate for psychology services as a part of medical care and is particularly relevant for pediatric SCT, a population of patients with a high prevalence of behavioral/psychosocial difficulties and severe medical conditions requiring invasive procedures with significant and growing costs.

The purpose of the current study is to begin to fill this gap in the literature and examine the relationship between the timing of psychology consultation and costs for the initial SCT hospitalization among patients undergoing SCT at a children's hospital. It was hypothesized that earlier consultations (consultations occurring closer to the date of admission) would be associated with lower hospitalization costs after controlling for demographic, clinical, and utilization variables. Pending significant findings, our secondary aim was to explore the hypothesis that earlier time to pediatric psychology consultation predicts shorter length of stay. If these hypotheses are supported, findings will highlight a systems-level intervention with the potential to reduce costs for hospitals (as a result of reducing the length of stay) and serve as one of the first examples of the economic advantages of integrating clinical psychologists within pediatric specialty medical teams (Bujoreanu et al., 2015; McGrady & Hommel, 2016; Rozensky & Janicke, 2012).

Methods

This study includes patients who underwent SCT at a Midwestern children's hospital between 2010 and 2014. The SCT program performs over 100 transplants each year for children, adolescents, and young adults with a range of oncologic, hematologic, and immunologic disorders. All study procedures, including a

waiver of consent, were approved by the hospital's institutional review board.

Patients

Results of an electronic medical record review identified 410 patients who underwent SCT at our children's hospital between January 1, 2010 and September 3, 2014. Two trained study staff reviewed the electronic medical records of all 410 patients to extract information regarding the number, timing, and duration of pediatric psychology visits. For purposes of this study, pediatric psychology visits were defined as individual or family therapy provided by a licensed clinical psychologist with specialized training in pediatric psychology and did not include visits conducted for assessment purposes only (i.e., neuropsychological evaluation). Patients with no history of pediatric psychology visits ($n = 305$) were excluded. In addition, as the purpose of this study was to examine the relationship between pediatric psychology consultation timing and initial SCT hospitalization costs, patients with pediatric psychology consultations during subsequent SCT-related hospitalizations ($n = 30$) were excluded. The final sample included 75 patients (Figure 1).

While the age at which patients transition to adult hospitals varies by clinic/division, the Cancer and Blood Diseases Institute at our children's hospital (which houses our SCT program) provides care to children, adolescents, and young adults (defined per National Cancer Institute guidelines as 15–39 years of age; Barr, Ferrari, Ries, Whelan, & Bleyer, 2016). To ensure the sample was representative of SCT patients seen by psychologists in our Cancer and Blood Diseases Institute, no limits were placed on patient age. As a result, the final sample included children, adolescents, and young adults and could include patients up to 39 years of age.

Pediatric Psychology Service

All patients undergoing SCT at our institution are offered services from a social worker, child life specialist, chaplain, and integrative health provider, with the frequency and content of specific interventions provided determined by patient/family need and preferences. In addition to these psychosocial services, which are offered to all patients, pediatric psychology services are provided based on patient and/or family need following a referral. Throughout the study period (from 2010 to 2014), referrals for a consultation with a pediatric psychologist were placed through our electronic medical record. Referrals could be requested by a member of the medical or psychosocial team (typically the patient's attending physician, nurse practitioner, or social worker) or the family themselves. Referrals for a pediatric psychologist were received by the Division of Behavioral Medicine's intake service and routed to one of our pediatric psychologists (licensed clinical psychologists with specialized training in pediatric psychology) dedicated to treating populations seen within our Cancer and Blood Diseases Institute. Per the pediatric psychologist currently serving the SCT population at our institution, the most common reasons for referral included: adjustment to diagnosis/hospitalization/treatment, behavioral challenges, challenges with adherence to medication/treatment, pain management, and parent coping as it impacts child coping.

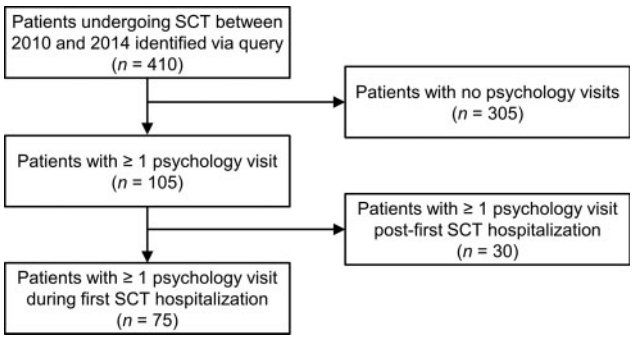

Figure 1. Participant flow diagram. SCT = stem cell transplant.

Within 24 hours of the referral, the pediatric psychologist initiated communication with the medical team and assessed reason for referral and level of urgency. The pediatric psychologist typically completed the initial intake evaluation with the patient and family in the same day. In rare instances where the pediatric psychologist's schedule was full and the patient's need was identified as relatively low and non-time sensitive, the initial intake evaluation occurred within a few days. Following the intake interview, the pediatric psychologist communicated the diagnostic impressions, planned course of psychological treatment, and treatment goals to the team. Throughout the course of treatment, the pediatric psychologist worked closely with the psychosocial team (i.e., social work, child life, pastoral care) to promote collaborative care.

Variables

Predictor Variable: Time to Pediatric Psychology Consultation

The primary predictor variable, time to pediatric psychology consultation, was defined as the difference (in days) between the first day of the initial SCT hospitalization and the day the intake evaluation was completed by the pediatric psychologist.

Covariates: Demographic and Clinical Variables

Demographic (age, gender, race) and clinical (diagnosis, SCT source, date of SCT) characteristics were obtained from the electronic medical record by members of the study team trained by the first author.

Demographic and clinical characteristics were checked by the first author for accuracy with the master patient database maintained by the children's hospital for SCT registry reporting. Discrepancies were resolved via consultation with the electronic medical record. For analytic purposes, diagnoses were categorized as oncologic, hematologic, immunologic, or other (i.e., nonmalignant, metabolic) and SCT source was categorized as autologous (stem cells come from the patient who receives the transplant), allogeneic—related donor (stem cells come from a related donor), allogeneic—unrelated donor (stem cells come from an unrelated donor), or syngeneic (stem cells come from an identical sibling; The American Cancer Society Medical and Editorial Content Team, 2016). The initial categorization was completed by a trained member of the study team. The resulting code was then verified by a nurse practitioner and physician from the SCT team. Initial inter-rater reliability for diagnosis and SCT source categorization was high (Cohen's $\kappa = .94–.98$) and discrepancies were resolved via discussion.

Primary Outcome Variable: Initial SCT Hospitalization Cost

The resources associated with the initial SCT hospitalization are typically quantified as "costs" or "charges" (Khera et al., 2012). The cost is the cumulative value of all resources used to provide care during the initial SCT hospitalization. The charge is the amount billed by the hospital to provide these services. Charges are typically inflated value estimates and vary across institutions owing to differences in accounting methods, insurance contracts, and hospital policies. Costs, thus, are the preferred outcome variable in economic analyses of SCT (Preussler et al., 2016). However, the laws that mandate the collection of economic data in the United States vary by state. In most states (including ours), cost data are not routinely collected (Catalyst for Payment Reform—Health Care Incentives Improvement Institute, 2015). In these instances, it is possible to estimate the cost of providing care by multiplying the charge billed by the hospital by a cost-to-charge ratio, a hospital-specific multiplier calculated by the Centers for Medicare and Medicaid Services to reflect the relationship between charges and actual costs in that institution (Riley, 2009). For this study, in the absence of cost data, total charges for the initial SCT hospitalization were obtained from the hospital's billing database. Total charges for the initial SCT hospitalization were adjusted to 2015 U.S. dollars using the Medical Care Component of the Consumer Price Index (U.S. Department of Labor, 2016) and converted to costs using the institution-specific Medicare inpatient cost-to-charge ratio.

Secondary Outcome Variable: Length of Initial SCT Hospitalization

The admission date and discharge date of the initial SCT hospitalization for each patient were obtained from the hospital's billing database. The length of the initial hospitalization was calculated by taking the difference between the two dates and was checked by the first author for accuracy with the electronic medical record.

Analyses

Descriptive statistics were used to summarize the demographic and clinical characteristics of the sample.

Aim 1 Model

The primary aim was to examine the relationship between time to pediatric psychology consultation and costs for the initial SCT hospitalization. As is typical with health care cost data, costs for the initial SCT hospitalization were nonnormally distributed and positively skewed. Model selection procedures developed for the analysis of health economic data (i.e., evaluation of log-scale residual kurtosis, Manning, Basu, & Mullahy, 2005; Manning & Mullahy, 2001) and goodness-of-fit indices (mean absolute percentage error, log likelihood, Akaike information criterion, and Bayesian information criterion, Buntin & Zaslavsky, 2004) suggested a generalized linear model (GLM) with gamma distribution and log link was the most appropriate model to estimate (using maximum likelihood estimation) the relationship between time to pediatric psychology consultation and costs for initial SCT hospitalization. This analytic approach is commonly used for the analysis of skewed health economic data (Basu, Manning, & Mullahy, 2004; Blough & Ramsey, 2000; Gregori et al., 2011; Manning et al., 2005) and, in simulation studies, performs well with sample sizes ($N = 25–100$, Malehi, Pourmotahari, & Angali, 2015) similar to that of the current study ($N = 75$).

To control for the influence of demographic and clinical variables on SCT hospitalization costs, age, gender, race, diagnosis, and SCT source were included as covariates. Length of stay was also included as a covariate as it is highly correlated with SCT hospitalization costs and may serve as a proxy for "severity" in the absence of other standardized measures ($r = .39–.90$, Khera et al., 2012). Year of pediatric psychology consultation was included as a covariate to control for the potential confound of changes in pediatric psychology service utilization over time (i.e., the potential that medical providers may refer more frequently after becoming more aware of psychology services). Finally, number of pediatric psychology visits was included as a covariate to control for the potential confound that earlier pediatric psychology consultation would be

Table I. *Demographic and Clinical Characteristics*

Variable	No. (%)
Age at SCT, M (SD)	10.69 (7.91)
Sex	
Male	44 (59%)
Female	31 (41%)
Race	
White	59 (79%)
Black or African-American	12 (16%)
Biracial	3 (4%)
Asian	1 (1%)
Ethnicity[a]	
Non-Hispanic or Latino	68 (91%)
Hispanic or Latino	6 (8%)
Diagnosis	
Oncologic	28 (37%)
Immunologic	25 (33%)
Hematologic	19 (25%)
Other (i.e., nonmalignant, metabolic)	3 (4%)
SCT donor	
Allogeneic—unrelated	45 (60%)
Allogeneic—related	19 (25%)
Autologous	10 (13%)
Syngeneic	1 (1%)
Health insurance	
Private	42 (56%)
Medicaid	27 (36%)
Other (i.e., international payer)	6 (8%)

[a] $n = 1$ missing; SCT = stem cell transplant.

related to lower costs as a result of more frequent pediatric psychology service use. As our institution provides care to children, adolescents, and young adults, a subgroup analysis with pediatric patients only (patients ages 0–18 years at SCT) was conducted to explore whether results were influenced by the definition of the patient population.

Aim 2 Model

A second GLM with gamma distribution and log link was used to estimate (using maximum likelihood estimation) the relationship between time to pediatric psychology consultation and length of the initial SCT hospitalization. As in the primary model, age, gender, race, diagnosis, SCT source, year of pediatric psychology consultation, and number of pediatric psychology visits were included as covariates.

There were no missing data in the data set. Parameter estimates for time to pediatric psychology consultation and covariates were interpreted as statistically significant at $p < .05$ (for Wald χ^2). All analyses were performed using SAS software Version 9.3.

Results

Patient Demographic and Clinical Characteristics

Demographic and clinical characteristics are presented in Table I. On average, patients were 10.69 (SD = 7.91, range = 0.79–32.79) years of age at SCT. Most patients were covered by private insurance ($n = 42$, 56%), with a smaller percentage covered by Medicaid ($n = 27$, 36%) or another provider (i.e., international payer, $n = 6$, 8%). Patients underwent SCT for one of 33 conditions, with 37% ($n = 28$) classified as oncologic, 33% classified as immunologic ($n = 25$), 25% classified as hematologic ($n = 19$), and 4% classified as other ($n = 3$, i.e., nonmalignant, metabolic). The majority of SCTs were from an unrelated ($n = 45$, 60%) or related ($n = 19$, 25%) donor, with 10 patients (13%) undergoing autologous SCT and one patient undergoing syngeneic SCT ($n = 1$%).

Initial SCT Hospitalization

On average, the initial SCT hospitalization was 95.71 days (SD = 75.22, range = 18–372 days) in duration and cost $605,494.82 (median, range = $128,127.55–$6,756,883.20). The average time to psychology consultation was 21.27 days (SD = 32.76, range = 0–154) post-SCT. For 64% of patients, psychology consultation occurred within 2 weeks of SCT. During the initial SCT hospitalization, patients and/or families participated in an average of 7.09 psychology visits (SD = 3.85, range = 1–12).

Time to Pediatric Psychology Consultation and SCT Hospitalization Costs

Results of the GLM indicated that older age at SCT ($\beta = 0.019$, $p < .001$) and longer length of stay ($\beta = 0.009$, $p < .001$) significantly predicted higher SCT hospitalization costs (Table II). After controlling for these variables along with demographics (gender, race, insurance status), clinical characteristics (SCT type, diagnosis), and number of pediatric psychology visits and year of pediatric psychology consultation, time to pediatric psychology consultation remained a significant predictor of SCT hospitalization costs ($\beta = 0.003$, $p = .01$). When the effects of covariates were held constant, every day increase in the time to pediatric psychology consultation was associated with a 0.3% increase in SCT hospitalization costs. In this sample, 0.3% of the average total average cost of the initial SCT hospitalization was $3,140.46. A subgroup analysis of pediatric patients only (patients 0–18 years of age at SCT) yielded a consistent pattern of findings, with longer time to pediatric psychology consultation associated with higher SCT hospitalization costs ($p = .02$) after controlling for covariates. The magnitude of the effect of time to pediatric psychology consultation remained 0.3% in this subgroup.

Time to Pediatric Psychology Consultation and Length of Initial SCT Hospitalization

As depicted in Table III, results of the second GLM indicated that after controlling for demographics (age,

Table II. *Predictors of Initial Stem Cell Transplant Hospitalization Cost*

Variable	Coefficient	Std. error	Lower 95% CI	Upper 95% CI	χ^2	*p*
Age at SCT	0.019	0.004	0.011	0.028	18.92	<.001
Race (White)	−0.047	0.081	−0.206	0.112	0.34	.56
Gender (female)	−0.063	0.065	−0.190	0.065	0.92	.34
Insurance (nonprivate)	0.004	0.071	−0.136	0.143	0.00	.96
Diagnosis (Reference: Immunologic)						
Oncologic	−0.092	0.088	−0.265	0.081	1.08	.30
Hematologic	−0.029	0.087	−0.200	0.142	0.11	.74
Other	−0.105	0.175	−0.448	0.238	0.36	.55
SCT type (Reference: Allogeneic—unrelated)						
Autologous	−0.069	0.116	−0.297	0.159	0.35	.55
Allogeneic—related	−0.144	0.085	−0.310	0.021	2.91	.09
Syngeneic	−0.142	0.274	−0.678	0.395	0.27	.60
Length of stay	0.009	0.001	0.007	0.010	201.50	<.001
Year of psychology consultation	−0.044	0.026	−0.096	0.007	2.87	.09
Number of psychology visits	0.004	0.010	−0.016	0.024	0.14	.71
Time to psychology consultation	0.003	0.001	<0.001	0.006	6.83	.01

SCT = stem cell transplant.

Table III. *Predictors of Initial Stem Cell Transplant Hospitalization Duration*

Variable	Coefficient	Std. error	Lower 95% CI	Upper 95% CI	χ^2	*p*
Age at SCT	−0.007	0.008	−0.024	0.009	0.76	.38
Race (White)	−0.139	0.154	−0.442	0.164	0.81	.37
Gender (female)	−0.155	0.127	−0.403	0.093	1.50	.22
Insurance (nonprivate)	0.169	0.137	−0.100	0.438	1.52	.22
Diagnosis (Reference: Immunologic)						
Oncologic	−0.109	0.170	−0.443	0.224	0.41	.52
Hematologic	−0.297	0.172	−0.634	0.041	2.97	.08
Other	0.255	0.339	−0.409	0.919	0.57	.45
SCT type (Reference: Allogeneic—unrelated)						
Autologous	−0.580	0.222	−1.015	−0.145	6.83	.01
Allogeneic—related	−0.640	0.158	−0.946	−0.326	16.17	<.001
Syngeneic	−0.786	0.521	−1.807	0.235	2.28	.13
Year of psychology consultation	0.043	0.047	−0.050	0.135	0.82	.36
Number of psychology visits	0.023	0.020	−0.015	0.062	1.40	.24
Time to psychology consultation	0.007	0.002	0.003	0.011	13.26	<.001

SCT = stem cell transplant.

gender, race, insurance status), clinical characteristics (SCT type, diagnosis), and number of pediatric psychology visits and year of pediatric psychology consultation, longer time to pediatric psychology consultation significantly predicted a longer length of stay ($\beta = 0.007$, $p < .001$). Each day increase in the time to pediatric psychology consultation was associated with a 0.7% increase in the length of the initial SCT hospitalization when the effects of covariates were held constant.

Discussion

The purpose of this study was to explore the relationship between pediatric psychology consultation timing and hospitalization costs in a population of patients with a high prevalence of behavioral/psychosocial difficulties and severe medical conditions requiring invasive procedures and extensive resources. In this sample of 75 patients undergoing SCT at a children's hospital, the average initial SCT hospitalization lasted 96 days and cost >$600,000 (or $9,000 per day), exceeding the mean duration (26–43 days) median overall and daily costs (approximately $200,000 and $4,000) estimated from larger studies (Majhail et al., 2013). These differences are likely due, at least in part, to the clinical complexity (e.g., number of medications, frequent lab and clinic visits, and increased need for intensive care) of our patient population. Compared with samples in previously published research, the current sample includes a higher percentage of patients undergoing allogeneic SCT (85% vs. 63%) and over 10 years of age (47% vs. 43%), two factors predictive of higher treatment-related mortality (source odds ratio [OR] = 2.7, age OR = 2.3, Matthes-Martin et al., 2008) and higher overall costs

(source β = 63,467€ [2008 €], age β = 32,637€ [2008 €], Matthes-Martin et al., 2012). In addition, this difference may reflect the fact that referral to the pediatric psychology service was need-based, with pediatric psychologists seeing patients identified (by the medical or psychosocial team or patient/family) as potentially benefitting from services owing to behavioral/psychosocial difficulties or an anticipated difficult medical course. Thus, the current population may also include a higher percentage of families with behavioral/psychosocial difficulties and medical complications, both of which predict higher costs among adult SCT populations (Khera et al., 2012; Prieto et al., 2002).

Even after controlling for length of hospitalization and disease and demographic characteristics, shorter time to pediatric psychology consultation predicted lower costs for the initial SCT hospitalization. Each day increase in time to pediatric psychology consultation was associated with an increase of >$3,000 (0.3%) in initial SCT hospitalization costs. Results suggest that the relationship between early psychiatry/psychology involvement and lower hospital costs for general medical populations (Bujoreanu et al., 2015) may also extend to the pediatric SCT population. Of note, while our institution treats children, adolescents, and young adults, the consistency of our findings when Aim 1 was examined with a subgroup of pediatric patients only (ages 0–18 years at SCT) suggest that results may also apply to children's hospitals who treat only pediatric patients. Consulting pediatric psychologists early in the initial pediatric SCT hospitalization may be one method of enhancing health care efficiency.

While exploring the reasons why earlier pediatric psychology consultations were linked to lower SCT hospitalization costs was beyond the scope of this study, previous research suggests several potential explanatory mechanisms. As the number of pediatric psychology visits did not significantly predict initial SCT hospitalization duration or costs, we do not hypothesize that the shorter length of stay and lower costs associated with earlier consultation were a result of families receiving more services. In addition, as the year of psychology consultation was not significantly related to the initial SCT hospitalization duration or costs, we do not hypothesize that the effect of consultation timing was due to systems-level changes in our pediatric psychology service (e.g., medical providers becoming more familiar with pediatric psychology services over time). Instead, earlier consultations may have enabled pediatric psychologists to provide anticipatory guidance and teach patients and families coping strategies to maximize participation in health behaviors (i.e., medication adherence, physical therapy [Rossi et al., 2016], oral hygiene [Glenny et al., 2010]) that predict improved health outcomes and are often used as indicators of readiness for discharge. For example, the psychologist may work with an adolescent who is refusing oral medication to improve adherence, engaging the patient in motivational interviewing while simultaneously developing a plan with the family to track success and support patient autonomy. This hypothesis is supported by the results of our secondary aim in which earlier time to pediatric psychology consultation predicted shorter length of stay. In addition, supporting parent coping during the hospitalization may have enabled parents to play a more active role in promoting these health behaviors and provide the emotional support that has been previously linked to longer survival among adult SCT recipients (Ehrlich et al., 2016).

The limitations of this study highlight several important directions for future research. First, the need-based referral system for pediatric psychology services and assessment procedures at our institution precluded the inclusion of a comparison cohort and thus, conclusions about the relative economic benefit of pediatric psychology services. Specifically, because referrals for pediatric psychology services at our institution are need-based, the group of patients not receiving services likely includes patients who do not require services, patients who declined services, and patients whose needs were not identified by the medical team. In the absence of a standardized measure of psychological functioning for all patients, it was not possible to compose a comparison cohort with a similar likelihood of benefitting from pediatric psychological services from the group of patients not receiving services. Future clinical trials in which patients are randomized to a pediatric psychology intervention (including standardized treatment components) or control group are needed to identify the mechanisms through which pediatric psychology service delivery may impact outcomes and the ideal timing of pediatric psychology consultation. Collection of economic and health outcome data as part of these trials will allow for quantification of the cost-effectiveness or cost-offset of pediatric psychological services for SCT patients. Second, as the purpose of this study was to evaluate the relationship between pediatric psychology consultation and costs during the initial SCT hospitalization, medical record review was limited to the initial SCT hospitalization period. Evaluating the potential impact of pediatric psychology consultation before SCT (e.g., during previous admissions for cancer treatment) was beyond the scope of this study and will require attention in future work. Finally, as models of psychosocial care (i.e., pediatric psychology services), models of clinical care (i.e., standard procedures), and patient populations (i.e., demographic and clinical characteristics) differ across institutions,

results of this single site study may not apply to all pediatric SCT samples.

Results of this study provide further support for the integral role of pediatric psychologists on multidisciplinary medical teams and suggest that providing pediatric psychological services early in the initial SCT hospitalization may be one method of reducing costs while providing additional support aimed at improving patient outcomes. Future research is needed to determine the ideal timing of consultations and quantify the potential economic impact of providing pediatric psychological services.

Acknowledgments

The authors gratefully acknowledge Gabriella Breen for her assistance with data collection and manuscript formatting and Vincent D'Anniballe for his assistance with manuscript formatting.

Funding

This work was supported by the National Cancer Institute of the National Institutes of Health under Award Number K07CA200668 to M.E.M. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

Conflicts of interest: None declared.

References

Agency for Healthcare Research and Quality. (2012). *Healthcare cost and utilization project kids' inpatient database*. [Data file]. Retrieved from: http://hcupnet.ahrq.gov/

Barr, R. D., Ferrari, A., Ries, L., Whelan, J., & Bleyer, A. (2016). Cancer in adolescents and young adults: A narrative review of the current status and a view of the future. *JAMA Pediatrics*, *170*, 495–501. doi:10.1001/jamapediatrics.2015.4689

Basu, A., Manning, W. G., & Mullahy, J. (2004). Comparing alternative models: Log vs Cox proportional hazard? *Health Economics*, *13*, 749–765. doi: 10.1002/hec.852

Blough, D. K., & Ramsey, S. D. (2000). Using generalized linear models to assess medical care costs. *Health Services and Outcomes Research Methodology*, *1*, 185–202. doi: 10.1023/A:1012597123667

Bujoreanu, S., White, M. T., Gerber, B., & Ibeziako, P. (2015). Effect of timing of psychiatry consultation on length of pediatric hospitalization and hospital charges. *Hospital Pediatrics*, *5*, 269–275. doi: 10.1542/hpeds.2014-0079

Buntin, M. B., & Zaslavsky, A. M. (2004). Too much ado about two-part models and transformation? Comparing methods of modeling medicare expenditures. *Journal of Health Economics*, *23*, 525–542. http://dx.doi.org/10.1016/j.jhealeco.2003.10.005

Catalyst for Payment Reform - Health Care Incentives Improvement Institute (2015). Report card on state price transparency laws. Retrieved from http://www.hci3.org/wp-content/uploads/files/files/2015_Report_PriceTransLaws_06.pdf

Centers for Medicare and Medicaid Services. (2017). Bundled payments for care improvement (BCPI) Initiative: General Information. Retrieved from https://innovation.cms.gov/initiatives/bundled-payments/.

Ehrlich, K. B., Miller, G. E., Scheide, T., Baveja, S., Weiland, R., Galvin, J., … Penedo, F. J. (2016). Pre-transplant emotional support is associated with longer survival after allogeneic hematopoietic stem cell transplantation. *Bone Marrow Transplantation*, *51*, 1594–1598. doi: 10.1038/bmt.2016.191

Foster, L. W., McLellan, L., Rybicki, L., Dabney, J., Visnosky, M., & Bolwell, B. (2009). Utility of the psychosocial assessment of candidates for transplantation (PACT) scale in allogeneic BMT. *Bone Marrow Transplantation*, *44*, 375–380. doi: 10.1038/bmt.2009.37

Friedman, R., Sobel, D., Myers, P., Caudill, M., & Benson, H. (1995). Behavioral medicine, clinical health psychology, and cost offset. *Health Psychology*, *14*, 509–518. http://dx.doi.org/10.1037/0278-6133.14.6.509

Glenny, A. M., Gibson, F., Auld, E., Coulson, S., Clarkson, J. E., Craig, J. V., … Pizer, B.; Children's Cancer and Leukaemia Group (CCLG)/Paediatric Oncology Nurses Forum's (CCLG-PONF) Mouth Care Group. (2010). The development of evidence-based guidelines on mouth care for children, teenagers and young adults treated for cancer. *European Journal of Cancer*, *46*, 1399–1412. doi: 10.1016/j.ejca.2010.01.023

Gregori, D., Petrinco, M., Bo, S., Desideri, A., Merletti, F., & Pagano, E. (2011). Regression models for analyzing costs and their determinants in health care: an introductory review. *International Journal for Quality in Health Care*, *23*, 331–341. doi: 10.1093/intqhc/mzr010

Hoodin, F., Uberti, J. P., Lynch, T. J., Steele, P., & Ratanatharathorn, V. (2006). Do negative or positive emotions differentially impact mortality after adult stem cell transplant? *Bone Marrow Transplantation*, *38*, 255–264. doi: 10.1038/sj.bmt.1705419

Hubley, S. H., & Miller, B. F. (2016). Implications of healthcare payment reform for clinical psychologists in medical settings. *Journal of Clinical Psychology in Medical Settings*, *23*, 3–10. doi: 10.1007/s10880-016-9451-1

Institute for Healthcare Improvement (2016). *The Triple Aim Initiative: The IHI Triple Aim*. Retrieved from http://www.ihi.org/engage/initiatives/tripleaim/Pages/default.aspx

Khera, N., Zeliadt, S. B., & Lee, S. J. (2012). Economics of hematopoietic cell transplantation. *Blood*, *120*, 1545–1551. doi: 10.1182/blood-2012-05-426783

Lin, Y. F., Lairson, D. R., Chan, W., Du, X. L., Leung, K. S., Kennedy-Nasser, A. A., … Krance, R. A. (2010). The costs and cost-effectiveness of allogeneic peripheral blood stem cell transplantation versus bone marrow transplantation in pediatric patients with acute leukemia. *Biology of Blood and Marrow Transplantation*, *16*, 1272–1281. doi: 10.1016/j.bbmt.2010.03.016

Majhail, N. S., Mau, L. W., Denzen, E. M., & Arneson, T. J. (2013). Costs of autologous and allogeneic hematopoietic cell transplantation in the United States: A study using a large national private claims database. *Bone Marrow Transplantation*, *48*, 294–300. doi: 10.1038/bmt.2012.133

Majhail, N. S., Mothukuri, J. M., Macmillan, M. L., Verneris, M. R., Orchard, P. J., Wagner, J. E., & Weisdorf, D. J. (2010). Costs of pediatric allogeneic hematopoietic-cell transplantation. *Pediatric Blood and Cancer*, *54*, 138–143. doi: 10.1002/pbc.22250

Malehi, A. S., Pourmotahari, F., & Angali, K. A. (2015). Statistical models for the analysis of skewed healthcare cost data: A simulation study. *Health Economics Review*, *5*, 11. doi: 10.1186/s13561-015-0045-7

Manning, W. G., Basu, A., & Mullahy, J. (2005). Generalized modeling approaches to risk adjustment of skewed outcomes data. *Journal of Health Economics*, *24*, 465–488. http://dx.doi.org/10.1016/j.jhealeco.2004.09.011

Manning, W. G., & Mullahy, J. (2001). Estimating log models: To transform or not to transform? *Journal of Health Economics*, *20*, 461–494. http://dx.doi.org/10.1016/S0167-6296(01)00086-8

Matthes-Martin, S., Pötschger, U., Barr, R., Martin, M., Boztug, H., Klingebiel, T., . . . Mann, G. (2012). Costs and cost-effectiveness of allogeneic stem cell transplantation in children are predictable. *Biology of Blood and Marrow Transplantation*, *18*, 1533–1539. http://dx.doi.org/10.1016/j.bbmt.2012.04.002

Matthes-Martin, S., Pötschger, U., Bergmann, K., Frommlet, F., Brannath, W., Bauer, P., & Klingebiel, T. (2008). Risk-adjusted outcome measurement in pediatric allogeneic stem cell transplantation. *Bioloyg of Blood and Marrow Transplantation*, *14*, 335–343. doi: 10.1016/j.bbmt.2007.12.487

Maziarz, R. T., Farnia, S., Martin, P., & Komanduri, K. V. (2014). Optimal benefits for hematopoietic stem cell transplantation: A consensus opinion. *Biology of Blood and Marrow Transplantation*, *20*, 1671–1676. http://dx.doi.org/10.1016/j.bbmt.2014.07.007

Miller, B. F., Ross, K. M., Davis, M. M., Melek, S. P., Kathol, R., & Gordon, P. (2017). Payment reform in the patient-centered medical home: Enabling and sustaining integrated behavioral health care. *American Psychologist*, *72*, 55–68. http://dx.doi.org/10.1037/a0040448

McGrady, M. E., & Hommel, K. A. (2016). Targeting health behaviors to reduce health care costs in pediatric psychology: Descriptive review and recommendations. *Journal of Pediatric Psychology*, *41*, 835–848. doi: 10.1093/jpepsy/jsv083

Preussler, J. M., Mau, L. W., Majhail, N. S., Meyer, C. L., Denzen, E. M., Edsall, K. C., . . . Vanness, D. J. (2016). Administrative claims data for economic analyses in hematopoietic cell transplantation: Challenges and opportunities. *Biology of Blood and Marrow Transplantation*, *22*, 1738–1746. doi: 10.1016/j.bbmt.2016.05.005

Prieto, J. M., Blanch, J., Atala, J., Carreras, E., Rovira, M., Cirera, E., & Gasto, C. (2002). Psychiatric morbidity and impact on hospital length of stay among hematologic cancer patients receiving stem-cell transplantation. *Journal of Clinical Oncology*, *20*, 1907–1917.

Pulgar, Á., Garrido, S., Alcalá, A., & Reyes del Paso, G. A. (2012). Psychosocial predictors of immune response following bone marrow transplantation. *Behavioral Medicine*, *38*, 12–18. doi: 10.1080/08964289.2011.647118

Riley, G. F. (2009). Administrative and claims records as sources of health care cost data. *Medical Care*, *47*, S51–S55.

Rossi, F., Coppo, M., Zucchetti, G., Bazzano, D., Ricci, F., Vassallo, E., . . . Fagioli, F. (2016). Rehabilitative intervention during and after pediatric hematopoietic stem cell transplantation: An analysis of the existing literature. *Pediatric Blood and Cancer*, *63*, 1895–1904. doi: 10.1002/pbc.26114

Rozensky, R. H., & Janicke, D. M. (2012). Commentary: Healthcare reform and psychology's workforce: Preparing for the future of pediatric psychology. *Journal of Pediatric Psychology*, *37*, 359–368. doi: 10.1093/jpepsy/jsr111

Stranges, E., Russo, C. A., & Friedman, B. (2009). Procedures with the most rapidly increasing hospital costs, 2004-2007 (HCUP Statistical Brief # 82). Agency for Healthcare Research and Quality. Retrieved from http://www.hcup-us.ahrq.gov/reports/statbriefs/sb82.jsp

The American Cancer Society Medical and Editorial Content Team. (2016, May 11). *Types of stem cell transplants for cancer treatment*. Retrieved from: https://www.cancer.org/treatment/treatments-and-side-effects/treatment-types/stem-cell-transplant/types-of-transplants.html[TQ1][TQ2]

U.S. Department of Labor (2016). Consumer price index: Medical care datatable. [Data file]. Retrieved from http://data.bls.gov/timeseries/CUUR0000SAM

U.S. Government Accountability Office. (2011). *Medicare: Private sector initiatives to bundle hospital and physician payments for an episode of care (GAO-11-126R)*. Retrieved from http://www.gao.gov/assets/100/97278.pdf.