Clinical Transplantation

WILEY

Clinical TRANSPLANTATION
The Journal of Clinical and Translational Research

ORIGINAL ARTICLE

Development and Evaluation of an Inpatient Rehabilitation Model of Care Tailored to Solid Organ Transplantation

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Received: 18 March 2025 | **Revised:** 29 August 2025 | **Accepted:** 5 September 2025

Keywords: functional improvement | implementation | model of care | rehabilitation | solid organ transplant

ABSTRACT

Introduction: Postoperative rehabilitation is essential to post-transplantation recovery and a key component of comprehensive transplant care, with inpatient rehabilitation providing intensive, interdisciplinary support to restore function and enhance quality of life. In 2019, the Brooks Rehabilitation Transplant Program (BRTP) was implemented to address the specialized rehabilitation needs post solid organ transplantation as an interdisciplinary, comprehensive, and tailored model of care.

Methods: Five main pillars comprise BRTP: (1) organizational commitment; (2) collaborative relationship with acute care providers; (3) early identification of appropriate patients; (4) interdisciplinary rehabilitation care tailored to transplant needs; and (5) continuous evaluation of quality outcomes. A retrospective observational cohort study evaluated both implementation and clinical outcomes over the program's first 5 years. Implementation outcomes included feasibility, fidelity, and sustainability. The primary clinical outcomes were changes in the CMS standardized functional assessment Section GG Mobility and Self-care scores. Wilcoxon signed rank sum test was used to compare admission and discharge scores. Secondary outcomes included IRF length of stay, discharge to community, acquired pressure injuries, falls, and feeding tube removal.

Results: Between January 2019 and December 2023, 202 solid organ transplant patients participated in BRTP. For the 154 completing their inpatient rehabilitation facility (IRF) stay, significant functional improvements were observed for the Section GG Mobility and Self-Care composite scores and across all individual functional items ($p < 0.001$). Ultimately, 82% of the cohort discharged to community, with eight returning to inpatient rehabilitation following an acute readmission and zero patients acquiring a pressure injury. Implementation outcomes indicated that the program was feasible, delivered with fidelity, and demonstrated sustainability over time.

Conclusion: The BRTP provides effective, sustainable, evidence-based approaches to improve function and quality outcomes following transplantation.

Abbreviations: ACCI, age-adjusted Charlson comorbidity index; BRTP, Brooks Rehabilitation Transplant Program; CMS, centers for Medicare and Medicaid services; EPIS, exploration, preparation, implementation, sustainment; FIM, functional improvement measure; IQR, interquartile range; IRB, Institutional Review Board; IRF, inpatient rehabilitation facility; IRF-PAI, inpatient rehabilitation facility patient assessment instrument; LOS, length of stay; SNF, skilled nursing facility.

1 | Introduction

Inpatient rehabilitation facilities (IRFs) provide interdisciplinary rehabilitative services to those who have experienced physical traumatic injury and/or disease to help individuals achieve their highest level of recovery and participation in life. This structured and comprehensive approach to recovery involves intensive therapeutic modalities at a minimum of 3 h per day, 5 days a week of personalized care involving physicians, nurses, physical therapists, occupational therapists, and speech-language pathologists to increase independence as well as physical, cognitive, and psychosocial recovery. The benefits of inpatient rehabilitation are well documented, and the Centers for Medicare and Medicaid Services stated in a 2024 report to Congress that IRFs provide better functional improvement and reduced hospitalization compared to other post-acute options, and that decreased complications and institutionalization lead to long-term cost savings [1]. The functional independence improvements attributed to IRF care also extend to medically complex patients, regardless of comorbidity or demographic variables [2]. However, less is currently understood regarding the processes and outcomes associated IRF admissions after solid organ transplantation.

Rehabilitation in the inpatient hospital should play a critical role in post-transplantation recovery, addressing medical, physical, psychological, and social aspects of their well-being. Physical rehabilitation is instrumental in restoring strength, mobility, activities of daily living, and improving quality of life. Organ transplant patients often have an extensive hospital stay and experience deconditioning and weakness with muscle atrophy, malnutrition and significant loss of endurance [3]. Rehabilitation programs that focus on these key factors to promote successful recovery are integral in the post-transplantation return to community-based functional activities [4]. In addition, rehabilitation addresses the psychological and emotional aspects of solid organ transplant recipients [5]. The rehabilitation program, when working closely with the transplant team, can create an optimal environment to help patients achieve an exceptional recovery. A well-organized and coordinated rehabilitation program promotes a smooth transition back into daily life with improved quality of life [3].

Postoperative rehabilitation plays a crucial role in the optimization of post-transplantation recovery. Intensive interdisciplinary approaches in inpatient rehabilitation for lung and liver transplantation are associated with improved functional outcomes such as functional capacity, endurance, mobility, balance, upper and lower body strength, ability to perform daily activities, and health-related quality of life [6]. Inpatient rehabilitation is also associated with reduced readmissions and related costs by addressing transplant-specific related risk factors [7]. This evolving body of literature reflects the dynamic nature of research in the field, continually addressing the diverse needs of transplant patients and advancing the understanding of effective rehabilitation practices.

The goal of the Brooks Rehabilitation Transplant Program (BRTP) was to implement an interdisciplinary and comprehensive approach to treating individuals post solid organ transplantation who require the intensity of inpatient rehabilitation. The objectives of this program were to improve function and quality of life, reduce re-admissions, improve discharge to home, and manage post-transplant risk factors such as decreased mobility and self-care. To develop this program effectively, formal processes were required to conduct continuous quality improvement with the potential to make informed changes and improvements in real-time. This study aims to outline the development of an inpatient rehabilitation program tailored to solid organ transplant recipients; evaluate key implementation outcomes; and assess clinical outcomes across organ transplant groups for the first 5 years of the program.

2 | Methods

2.1 | Program Development

The BRTP was developed in 2018 by an interdisciplinary team of physiatrists, nursing and therapy clinicians, and administrators at Brooks Rehabilitation IRFs. This quality improvement initiative was based upon a practical application of the Exploration, Preparation, Implementation, Sustainment (EPIS) implementation framework [8].

Consistent with the EPIS model, during the initial exploration phase clinical and operational shareholders identified the need for specialized, tailored rehabilitation care for patients with organ transplants. The following were prioritized for program development: care transitions from the acute care provider to IRF, transplant-related medical management, functional improvement, successful discharge home, and data analysis for continuous improvement.

During the preparation phase, potential implementation barriers were identified as a lack of internal processes specific to transplant care and limited communication between acute and IRF care teams. Facilitators included leadership support, already established interdisciplinary rehabilitation care teams, and a growing learning health system infrastructure. The BRTP was built and adapted based on these inputs. Specifically, standardized processes following evidence-based practices for rehabilitation care for individuals with a solid organ transplant, such as IRF admissions from acute care and medical management of transplant-specific potential complications were developed to support program implementation.

In January 2019, the BRTP was fully implemented at the Brooks Rehabilitation Hospital. University campus. The program was successfully expanded to the Brooks Rehabilitation Hospital – Bartram campus when it opened in April 2022. All patients with solid organ transplants, regardless of the time since their transplant, are admitted into the program as standard care. The coordinated program is provided at no additional cost to patients, as services are included in routine rehabilitation coverage. The program is now in the sustainment phase, with ongoing improvements at both locations.

The BRTP is comprised of five main pillars: (1) organizational commitment; (2) collaborative relationship with acute care providers; (3) early identification of patients appropriate for

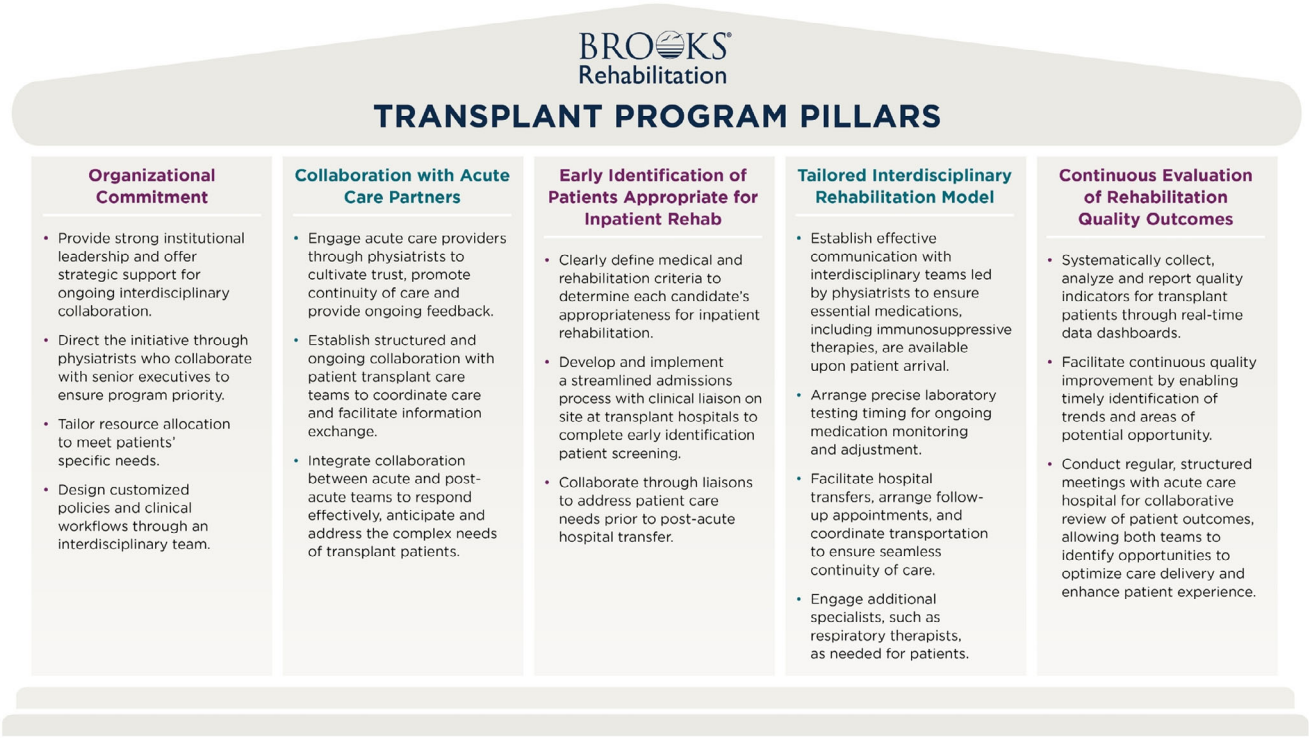

FIGURE 1 | Brooks Rehabilitation Transplant Program pillars.

inpatient rehabilitation; (4) interdisciplinary rehabilitation care tailored to transplant needs; and (5) continuous evaluation of rehabilitation quality outcomes (Figure 1). Strong institutional leadership and strategic resource allocation, guided by physiatrists, established the program as a priority and enabled the development of specialized clinical workflows. Close, ongoing collaboration with acute care transplant teams ensures continuity of care across the patient journey. A streamlined admissions process, led by clinical liaisons, supports early identification of eligible patients and coordination of regulatory and insurance requirements. The program's interdisciplinary model leverages the expertise of physiatrists, pharmacists, nurses, case managers, and other specialists to provide comprehensive, individualized care. Finally, quality outcomes are continuously monitored using real-time dashboards and joint reviews with acute care partners, enabling data-driven improvements in care delivery and patient experience. Additional details on each program pillar are provided in Appendix A.

2.2 | Study Design and Sample

This retrospective, observational cohort study assessed implementation and clinical outcomes, using data extracted from the electronic health record (EHR) for all adult patients with a solid organ transplant within 1 year of admission to a Brooks Rehabilitation IRF from January 1, 2019, through December 31, 2023. Patients with multiple organ transplants were excluded from analysis because of the small sample size of this subgroup ($n = 3$). This study was determined to be exempt from IRB oversight under the Department of Health and Human Services regulations at 45 CFR 46.104(d)(4).

2.3 | Implementation Outcome Measures

Proctor's framework [9] was used to guide selection of implementation outcomes, which included feasibility, fidelity, and sustainability. Feasibility was assessed as the extent to which transplant-specific care could be delivered as part of routine inpatient rehabilitation care [9, 10]. Feasibility was measured as (a) the percentage of patients with a solid organ transplant who received transplant-specific services as standard care in inpatient rehabilitation and (b) the percentage of patients with follow-up appointments with the acute transplant team during their IRF stay. These indicators reflect the practicality of integrating the BRPT protocols within usual rehabilitation workflows. Fidelity was defined as the degree to which BRPT protocols were implemented as intended by the clinical teams [9, 11, 12]. Central to the BRPT model are two core requirements: immediate initiation of transplant-specific medical management upon admission and structured coordination of care with the acute transplant team prior to discharge. Accordingly, fidelity was operationalized through two indicators that reflect adherence to core protocol elements: (a) the percentage of patients with immunosuppressant medications ordered immediately upon admission and (b) the percentage of patients discharging to community with follow-up appointments with the transplant team scheduled before leaving the IRF. Sustainability was defined as the extent to which a newly implemented treatment is maintained or institutionalized within a service setting's ongoing, stable operations [9] and was measured as the volume of patient enrollment over the initial 5 years of the program. Sustained or increasing enrollment indicates the BRTP program has become routine and integrated into organizational processes, reflecting successful institutionalization.

2.4 | Clinical Outcome Measures

Selected clinical outcomes represent standard rehabilitation outcomes. Primary clinical outcomes include change in function measured by the Section GG Self-Care and Mobility items from the CMS Inpatient Rehabilitation Facility Patient Assessment Instrument (IRF-PAI) [1]. Section GG0170 Mobility includes 15 items, such as sit to stand, toilet transfer, and walking, with a composite score of 90. Section GG0130 Self-Care consists of seven items such as eating, toilet hygiene, and body dressing, with a composite score of 42. Each item is scored on a 6-point scale indicating the level of assistance needed to perform the functional task, as 1: dependent, 2: substantial/maximal assistance, 3: partial/moderate assistance, 4: supervision or touching assistance, 5: setup or clean-up assistance, 6: independence. Mobility and Self-Care items are collected for all Brooks Rehabilitation IRF patients within 3 days of admission and at discharge. Aligned with CMS methodology, functional change was examined for individual GG-section item scores and composite scores for mobility and self-care [1]. If a functional task was not attempted or unsafe to perform, it was coded to a 1 in accordance with CMS guidelines (CMS). Section GG items were not administered to patients discharging to an acute care hospital. Change in function was calculated as the difference in score collected at admission and at discharge for each Section GG item and the composite scores for Mobility and Self-care function. Change in function was assessed only for patients discharging from inpatient rehabilitation to a home or SNF setting, as functional outcomes are not collected for those discharged to an acute care hospital.

Secondary clinical outcomes included IRF length of stay (LOS), discharge location, IRF-acquired pressure injury, fall during IRF stay and feeding tube removal. Discharge location from IRF included discharge to community (home with or without home health services), skilled nursing facility (SNF), or return to acute care hospital.

2.5 | Analysis

Patient characteristics, implementation outcomes and clinical outcomes were summarized with frequency distributions and descriptive statistics. Categorical variables were analyzed using Pearson's Chi-square tests or Fisher's exact tests for small cell sizes. Continuous variables were assessed for normality using the Shapiro–Wilk test and summarized as mean and standard deviation or median and interquartile range (IQR), as appropriate. Within-group analyses were conducted using the paired t-test and Wilcoxon Signed-Rank test. Given the number of within-group comparisons of functional scores ($n = 24$), p values were adjusted using the Bonferroni correction (adjusted $\alpha = 0.0021$). Between-group analyses were conducted using the Mann–Whitney U test and the Kruskal–Wallis test for multiple comparisons. Between group significance was defined as p values < 0.05. To visually represent changes in function for individual functional items, radar graphs were employed, providing a clear representation of functional score profiles across multiple domains. Analyses were performed using SAS 9.4 (SAS Institute Inc., Cary, NC, USA).

3 | Results

3.1 | Baseline Patient Characteristics

A total of 202 patients with solid organ transplantation received care through BRTP between January 2019 and December 2023 (Table 1). The median age was 64 years (IQR 57–69 years) with 112 male patients (55.4%). Transplanted organs included heart (18%), kidney (12%), liver (52%), and lung (17%).

The median time from transplant surgery to IRF admission was 29 days (IQR 16–57 days) with most patients admitted directly from the acute hospital post-surgery (167, 82.7%). Complex conditions were prevalent among this cohort. Although nearly half of the patients (99, 49.0%) were admitted to IRF with a primary diagnosis of "medically complex", other primary diagnoses included "brain dysfunction" (43, 21.3%), "cardiac" (23, 11.4%), and "stroke" (15, 7.4%). Upon admission to IRF, 50 (24.8%) patients required tube feeding. The largest cohort requiring tube feeding were those with a transplanted liver (43, 40.6%). The mean age-adjusted Charlson Comorbidity index (ACCI) score was 5.3 (SD 1.8), with patients with liver transplantation having the highest ACCI of 5.5 (SD 1.9).

The median composite score for Section GG Mobility at admission was 27 (IQR 21–32) out of a possible 90, corresponding to an average score of 1.8 for each mobility item and indicating a level of assistance ranging from substantial or maximal assistance to dependent. The median composite score for Section GG Self-Care at admission was 18 (IQR 15–22) out of a possible 42, corresponding to an average score of 2.6 for each self-care item and indicating a level of assistance ranging from partial/moderate assistance to substantial or maximal assistance. No significant differences in composite admission scores for Section GG Mobility or Self-Care were observed across transplant organ types.

3.2 | Implementation Outcomes

3.2.1 | Feasibility

Implementation of transplant-specific, coordinated care within the IRF setting was feasible. All 202 patients with a solid organ transplant received transplant-related services as part of standard care during their IRF stay. The specific services varied and were tailored to individual patient needs. Although not medically necessary for all patients in BRTP, a substantial proportion (59%) required coordinated follow-up visits with the acute care transplant team during their IRF stay. Among these patients with off-site visits, 95 (79%) had one follow-up visit, 18 (15%) had two visits, and seven (6%) had three or more visits.

3.2.2 | Fidelity

Adherence to key components of the BRTP protocols was high. Immunosuppressant medications were recommended by the acute care transplant team for 175 patients (87%) upon admission to the IRF. In alignment with program protocols, all patients (100%) had immunosuppressant medications orders

TABLE 1 | Characteristics of patients in the Brooks Rehabilitation Transplant Program (2019–2023), $n = 202$.

Characteristic	Heart $n = 36$	Kidney $n = 25$	Liver $n = 106$	Lung $n = 35$	p value	Total $N = 202$
Age (years): median (IQR)	61.5 (51.5–68)	67 (59–72)	64 (58–68)	68 (57–72)	*	64 (57–69)
Gender: *n* (%)					*	
Male	25 (69.4)	18 (72.0)	50 (47.2)	19 (54.3)		112 (55.4)
Female	11 (30.6)	7 (28.0)	56 (52.8)	16 (45.7)		90 (44.6)
Race: *n* (%)					—	
White	23 (63.9)	13 (52.0)	80 (75.4)	28 (80.0)		144 (71.3)
AA/Black	6 (16.7)	10 (40.0)	6 (5.7)	2 (5.7)		24 (11.9)
Other	2 (5.6)	0 (0.0)	6 (5.7)	3 (8.6)		11 (5.4)
Unknown	5 (13.8)	2 (8.0)	14 (13.2)	2 (5.7)		23 (11.4)
Primary insurance					—	
Medicare	18 (50.0)	21 (84.0)	55 (51.9)	25 (71.4)		119 (58.9)
Private/Commercial	16 (44.4)	4 (16.0)	49 (46.2)	8 (22.9)		77 (38.1)
Other	2 (5.6)	0 (0.0)	2 (1.9)	2 (5.7)		6 (3.0)
Transplant to IRF Admit (days): median (IQR)	34.5 (20–56.5)	25 (13–56)	22.5 (13–35)	62 (43–122)	***	29 (16–57)
Care setting before IRF: *n* (%)					*	
Acute care hospital	30 (83.3)	17 (68.0)	94 (88.7)	26 (74.3)		167 (82.7)
Intermediary care setting	6 (16.7)	8 (32.0)	12 (11.3)	9 (25.7)		35 (17.3)
IRF primary diagnosis: *n* (%)					—	
Brain dysfunction	2 (5.6)	0 (0.0)	39 (36.8)	2 (5.7)		43 (21.3)
Cardiac	22 (61.1)	1 (4.0)	0 (0.0)	0 (0.0)		23 (11.4)
Medically complex	4 (11.1)	23 (92.0)	60 (56.6)	12 (34.3)		99 (49.0)
Neurologic	2 (5.6)	0 (0.0)	2 (1.9)	3 (8.6)		7 (3.5)
Orthopedic	0 (0.0)	0 (0.0)	1 (0.9)	0 (0.0)		1 (0.5)
Pulmonary	0 (0.0)	0 (0.0)	0 (0.0)	14 (40.0)		14 (6.9)
Stroke	6 (16.7)	1 (4.0)	4 (3.8)	4 (11.4)		15 (7.4)
ACCI: mean (SD)	5.2 (1.3)	5.4 (1.8)	5.5 (1.9)	4.4 (1.7)	NS	5.3 (1.8)
Mobility score on admit: median (IQR)	28.5 (21.5–34)	28 (23–32)	26 (19–31)	28 (23–30)	NS	27 (21–32)
Self-care score on admit: median (IQR)	21 (14.5–24)	18 (15–21)	18 (14–21)	20 (16–23)	NS	18 (15–22)
Tracheostomy: *n* (%)					—	
Yes	0 (0.0)	0 (0.0)	5 (4.7)	2 (5.7)		7 (3.5)
No	36 (100)	25 (100)	101 (95.3)	33 (94.3)		195 (96.5)
Tube feeding: *n* (%)					—	
Yes	5 (13.9)	1 (4.0)	43 (40.6)	1 (2.9)		50 (24.8)

Abbreviation: NS, not significant.

*$p < 0.05$.

***$p < 0.001$.

placed immediately upon arrival, reflecting full fidelity to this aspect of care delivery.

Discharge planning protocols required that follow-up appointments with the transplant team be arranged prior to discharge from the IRF. Among the 154 patients not discharged to an acute hospital setting, 79% (121) had follow-up appointments already scheduled prior to discharge from IRF and an additional 14% (22) had an appointment ordered but not yet scheduled. Fifteen patients without scheduled transplant team follow-up had

appointments arranged with other relevant services, including primary care, laboratory, radiology, pulmonology, cardiology, gastroenterology, and oncology, reflecting individualized care planning based on patient needs.

3.2.3 | Sustainability

The number of solid organ transplant recipients admitted to BRPT increased steadily over the 5-year period. Annual program admissions rose from 27 patients in 2019 to 56 patients in 2023, representing a 107% increase in patient volume over the study period. Intermediate annual counts were 36 in 2020, 38 in 2021, and 48 in 2022.

3.3 | Clinical Outcomes

3.3.1 | Functional Improvement

Of all 202 patients with Section GG Mobility and Self-Care function assessed at admission, 154 (76%) were assessed at discharge, representing those discharged to home or SNF. Significant improvements in function were observed for both composite scores and across all individual items (Table 2 and Appendix B). The Section GG Mobility composite score of the cohort was 27 (IQR 21–32) at admission and 61 (IQR 49–69) at discharge out of the total possible score of 90. The median change in mobility function admission to discharge was 33 points (IQR 23–40). The Section GG Self-Care composite score was 20 (IQR 15–23) at admission and 32 (IQR 30–36) at discharge out of the 42 possible points. The median of the change in Self-Care function was 14 points (IQR 10–17). Patients with liver and lung transplants had greater change in Self-Care function scores compared to those with heart and kidney transplants ($p = 0.02$); however, no differences in change in mobility function were observed between transplant groups (Table 3).

3.3.2 | Discharge to Community

Upon their index IRF stay, 73.3% (148) of the cohort discharged to community, 3.0% (6) discharged to SNF and 23.7% (48) discharged to an acute care hospital (Table 3). Among the 48 patients who were initially discharged to acute, 58% (28) returned to inpatient rehabilitation, with 17 ultimately discharging to community, three to a SNF and eight return to acute care. In total 82.0% (165) returned to community, 4.5% (9) to SNF and 13.9% (28) were readmitted to an acute care hospital. Reasons for acute readmission were varied and included infection related to transplantation (9, 19%), admitted to acute for medical reasons following scheduled appointment with transplant team (8, 17%), cardiopulmonary complications (7, 15%), respiratory complications (6, 13%), altered mental status (3, 6%), and other reasons (15, 31%).

3.3.3 | Other Clinical Outcomes

The median IRF LOS was 12 days (IQR 9–16), and no differences in IRF LOS were observed across transplant types. None of the patients in this cohort acquired a pressure injury during their inpatient rehabilitation stay and the majority did not experience a fall (188, 93.1%) (Table 3). There were no differences in falls across transplant types. Of the 50 patients admitted to IRF with a feeding tube, 70% (35) had the tube removed prior to discharge.

4 | Discussion

In this paper, we describe a rehabilitation model of care tailored to solid organ transplant recipients and implemented it across two IRFs. We retrospectively examined rehabilitation quality outcomes of patients receiving care through the BRTP during the first 4 years of the program. This patient cohort demonstrated outcomes reflective of high-quality rehabilitation care, including significant improvement in mobility and self-care functional capacity with the majority discharging home after inpatient rehabilitation.

The five pillars of the transplant program create a comprehensive model of care tailored to the complex needs of patients with a recent solid organ transplantation. To our knowledge, this is the first paper to describe in detail the components of a sustainable transplant program at a freestanding IRF. In 2013, Patcai and colleagues described a partnership between an IRF and multi-organ transplant unit at an acute hospital in Canada. However, no specific components of the rehabilitation program were adjusted for transplantation and medical complications were more often treated by the acute transplant team than the rehabilitation team [4]. The formal partnership allowed for improved care coordination and increased efficiency when sending patients to IRF (i.e., reduced time waiting for transfer to next level of care). Bowman and Faux described a cardio-pulmonary transplantation program at an in-hospital rehabilitation unit. The authors emphasized the importance of interdisciplinary, specialized rehabilitation and collaboration between transplant medical and rehabilitation teams [13]. The pillars of the BRTP expand on these strategies and address the challenges in managing complex patient care across healthcare organizations, focusing on collaboration between the acute care and rehabilitation hospital transplant teams. The BRTP offers a foundational framework for an effective and sustainable inpatient rehabilitation transplant program tailored to this specific setting. The applicability across different environments has not been evaluated and each healthcare system should design transplant programs to address the specific needs and challenges of their organization.

The BRTP provides specialized rehabilitation care which is most adequately managed in the inpatient rehabilitation setting. Despite the need for advanced medical care, solid organ transplantation is not recognized as one of the core rehabilitation diagnoses for inpatient rehabilitation. The current “60% rule” mandates that 60% of patients admitted to inpatient rehabilitation must have 1 of 13 qualifying conditions, none of which specify transplantation [14]. In this study, more than half of patients had complex primary diagnoses including brain dysfunction and stroke, with 25% requiring tube feeding upon admission to IRF. The mean age-adjusted Charlson Comorbidity Index (ACCI) for this patient cohort was 5.3. To provide context, in a retrospective study of 886 kidney transplant recipients, participants with an ACCI value exceeding 3.0 exhibited increased risk of post operative complications, such as increased blood transfusions,

TABLE 2 | Section GG mobility and self-care functional outcomes ($n = 154$).

Functional items		Admission score Median (IQR)	Discharge score Median (IQR)	Change Median (IQR)
Section GG mobility items				
Overall Score		27 (21–32)	61 (49–69)	33 (23–40)***
GG0170A	Roll left and right	3 (2–4)	6 (4–6)	2 (2)***
GG0170B	Sit to lying	3 (2–4)	4 (4–6)	2 (2)***
GG0170C	Lying to sitting on side of bed	3 (2–4)	6 (4–6)	2 (2)***
GG0170D	Sit to stand	3 (2–3)	4 (4–6)	2 (2)***
GG0170E	Chair/bed-to-chair transfer	3 (2–3)	4 (4–6)	2 (2)***
GG0170F	Toilet transfer	3 (1–3)	4 (4–6)	2 (2)***
GG0170G	Car transfer	1 (1–1)	4 (3–4)	2 (1)***
GG0170I	Walk 10 f	1 (1–3)	4 (4–4)	3 (2–3)***
GG0170J	Walk 50 ft with two turns	1 (1–1)	4 (4–4)	3 (3–3)***
GG0170K	Walk 150 ft	1 (1–1)	4 (4–4)	3 (3–3)***
GG0170L	Walk 10 ft on uneven surfaces	1 (1–1)	4 (3–4)	3 (2–3)***
GG0170M	1 step (curb)	1 (1–1)	4 (3–4)	3 (0–3)***
GG0170N	4 steps	1 (1–1)	4 (1–4)	3 (0–3)***
GG0170O	12 steps	1 (1–1)	2 (1–4)	0 (0–3)***
GG0170P	Picking up object	1 (1–1)	4 (3–4)	3 (0–3)***
Section GG self-care items				
Overall score		20 (15–23)	32 (30–36)	14 (10–17)***
GG0130A	Eating	5 (4–5)	6 (6–6)	1 (1–2)***
GG0130B	Oral hygiene	3 (2–4)	6 (5–6)	2 (1–3)***
GG0130C	Toilet hygiene	2 (1–3)	4 (4–6)	2 (1–3)***
GG0130E	Shower/bathe self	2 (1–3)	4 (3–4)	2 (1–3)***
GG0130F	Upper body dressing	3 (2–4)	5 (4–6)	2 (1–3)***
GG0130G	Lower body dressing	2 (1–3)	4 (4–5)	2 (1–3)***
GG0130H	Putting on/taking off footwear	2 (1–3)	4 (4–5)	2 (1–3)***

***$p < 0.001$, IRF index stay including patients with score on discharge.

longer surgery times, and mortality in the acute hospital setting [15]. Consideration should be made to recognize transplant as a CMS qualifying rehabilitation diagnosis for Medicare's IRF admission benefits.

Effective care coordination during hospitalization is critically important for patients who have undergone solid organ transplantation [16–19], especially in the inpatient rehabilitation setting where patients often require off-site appointments for transplant-specific care. Our results demonstrated that 60% of the patients required at least one follow-up appointment, with some requiring as many as five off-site visits. Structured care coordination is essential to ensure that patients return for follow-up appointments while still meeting the IRF regulatory requirement of 3 hours of therapy per day [20]. Coordinating these visits involves logistical challenges, including scheduling, arranging transportation, and adjusting therapy sessions to compensate for missed time and patient endurance. To address these complexities, rehabilitation teams should implement standardized workflows and communication protocols that proactively plan for off-site medical needs without compromising therapy intensity.

Additionally, this study found full adherence with immunosuppressant medication reconciliation at admission, supporting safe care transitions and therapeutic continuity for patients in the BRTP. Medication management and adherence are critical aspects of care for transplant recipients, as immunosuppressive therapies are essential to prevent graft rejection by suppressing the immune response [21, 22]. Even minor deviations from prescribed orders can result in serious complications, including organ rejection. Effective management of these high-risk medications requires strict adherence to institutional protocols and close coordination among the rehabilitation team, pharmacy, laboratory services, and the transplant team. Regular lab monitoring is necessary due to the narrow therapeutic window of these drugs. Subtherapeutic levels can lead to rejection, while supratherapeutic levels increase the risk of nephrotoxicity, neurotoxicity, and infection [22, 23]. Given these risks, it is essential that inpatient rehabilitation teams are well-trained and consistently follow

TABLE 3 | Outcomes of patients in the Brooks Rehabilitation Transplant Program (2019–2023), $n = 202$.

Rehabilitation quality outcomes	Heart $N = 36$	Kidney $N = 25$	Liver $N = 106$	Lung $N = 35$	p value	All patients $N = 202$
Mobility score discharge: median (IQR)[a]	66 (52.5–73)	56 (48–62)	60 (48–69)	63 (56–66)	NS	61 (49–69)
Mobility score change: median (IQR)[a]	32 (26.5–41.5)	31 (17–34)	33.5 (23–41)	35 (26–38)	NS	33 (23–40)
Self-care score discharge, median (IQR)[a]	33 (29–40)	31 (29–32)	32 (30–36.5)	33 (31–36)	NS	32 (30–36)
Self-care score change: median (IQR)[a]	11 (7.5–18.5)	11 (9–14)	14 (11–18.5)	13 (10–16)	*	14 (10–17)
IRF length of stay (days): median (IQR)	11.5 (8–20.5)	11 (7–16)	13 (9–15)	11 (9–14)	NS	12 (9–16)
Acute readmission during index IRF stay					NS	
No acute readmission	28 (77.8)	17 (68)	84 (79.2)	25 (71.4)		154 (76.2)
Acute readmission	8 (22.8)	8 (32)	22 (20.8)	10 (28.6)		48 (23.8)
Discharge location index IRF stay: n (%)					—	
Community	27 (75.0)	14 (56.0)	82 (77.3)	25 (71.4)		148 (73.3)
Skilled nursing	1 (2.8)	3 (12.0)	2 (1.9)	0 (0.0)		6 (3.0)
Acute hospital	8 (22.2)	8 (32.0)	22 (20.8)	10 (28.6)		48 (23.7)
Discharge location final IRF stay: n (%)					—	
Community	30 (83.3)	17 (68.0)	91 (85.9)	27 (77.1)		165 (81.7)
Skilled nursing	1 (2.8)	3 (12.0)	3 (2.8)	2 (5.7)		9 (4.4)
Acute hospital	5 (13.9)	5 (20.0)	12 (11.3)	6 (17.1)		28 (13.9)
Fall during IRF stay: n (%)					NS	
No fall	35 (97.2)	23 (92.0)	98 (92.5)	32 (91.4)		188 (93.1)
Fall	1 (2.8)	2 (8.0)	8 (7.5)	3 (8.6)		14 (6.9)
IRF acquired pressure injury					—	
No acquired pressure injury	36 (100)	25 (100)	106 (100)	35 (100)		202 (0)
Acquired pressure injury	0 (0)	0 (0)	0 (0)	0 (0)		0 (0)
Feeding tube at discharge ($n = 50$): n (%)					—	
No tube	4 (80.0)	0 (0)	30 (69.8)	1 (100)		35 (70.0)
Tube	1 (20.0)	1 (100)	13 (30.2)	0 (0)		15 (30.0)

Abbreviation: NS, not significant.

[a]IRF index stay including patients with score on discharge ($n = 154$).

*$p < 0.05$.

established protocols to ensure safe and effective medication management.

The patients in the BRTP demonstrated substantial improvements in overall function and across all Section GG Self-care and Mobility items on the IRF-PAI. Functional gains were observed across all solid organ transplant categories. At admission, functional tasks reflected levels of dependence ranging from complete dependence to partial assistance, with a need for supervised assistance to independence at discharge. Our findings are consistent with prior studies using the Functional Independence Measure (FIM) to assess functional status [3, 6, 24–26]. FIM, however, has been replaced by Section GG as the standardized functional outcome measures for the post-acute continuum, in response to the IMPACT Act of 2014 [27]. To our knowledge, this study is the largest to date examining functional improvement using Section GG for inpatient rehabilitation patients with a solid organ transplant. Goodman et al. reported functional improvement of 14 patients with bilateral lung transplantation due to long COVID pulmonary disease in a freestanding urban IRF [28]. The mean score increases of 14.7 for Self-care and 38.6 for Mobility closely align with the results for patients with lung transplant in our study (13 and 35, respectively). Although our retrospective chart review spans the COVID-19 pandemic period, COVID-related transplantation was beyond the scope of this research.

Although discharge to community was the most common (73%) discharge disposition from inpatient rehabilitation in this study, 24% of patients were readmitted to acute care during their index IRF stay. These results are not unexpected, as 30-day readmission rates consistently exceed 30% across solid organ transplant patients [29–31]. Despite these readmission rates, inpatient rehabilitation has been shown to decrease the risk and severity of 30-day readmissions when compared to discharge to home from the acute hospital following transplantation [7]. In our study, nearly 60% of patients with an acute readmission returned to the IRF to continue rehabilitation care, which ultimately led to 82% of patients discharging to community. Similar results for discharge to community (83%) were reported for patients with liver transplants [24]. Findings from these studies suggest that although patients at times require additional interventions at acute care, they can return to IRF to successfully complete rehabilitation and discharge home.

Common reasons for return to acute for patients include infection and organ rejection [32]. In our study, the two primary reasons for acute readmission were infection related to the transplanted organ and, interestingly, admission to the acute hospital after a scheduled follow-up appointment with the acute transplant team due to various medical reasons. These findings, when shared between the BRTP and acute transplant teams through enhanced collaboration and outcomes evaluation, allowed the acute transplant teams to appreciate the higher level of care that can be provided through the BRTP, thereby increasing their confidence to return patients to IRF where complicated care needs can be managed successfully. This shared improvement strategy provides an opportunity to reduce preventable readmissions for patients with transplantation moving forward.

Our study has several limitations, primarily due to the pragmatic nature of the investigation. This review of practice is not a study of the efficacy of the transplant program. This distinction is important, as the findings should be interpreted in the context of routine practice. Furthermore, this retrospective study lacks a comparator group, as all patients with a solid organ transplant were enrolled in the BRTP as a standard of care. A pre-post implementation study design was not appropriate for examining changes in function, as the BRTP implementation coincided with the CMS transition from using FIM to Section GG in 2019 [33]. Change in function analyses were restricted to only those patients discharging to community or SNF since Section GG items were not collected for those discharging to acute care. Although this is a large study of patients with solid organ transplants, the sample was heavily weighted toward liver transplantation, accounting for over one-half of the patients in this cohort. Small group sizes for heart, kidney, and lung transplantation made between-group comparisons difficult across patient characteristics and outcomes. Reported findings are from two IRFs with transplant patients from a homogeneous acute care referral source, limiting the generalizability of the findings.

This study included data from IRFs only. Future investigations should include the pre- and post-transplantation data from acute care hospitals in combination with data from IRFs to further evaluate health services and patient outcomes across healthcare organizations. In addition, further investigation into the impact of time since transplant to IRF admission and admitting to IRF from an intermediary location on rehabilitation quality outcomes would be beneficial.

5 | Conclusions

Postoperative rehabilitation is essential for post-transplantation recovery and comprehensive transplant programs. Inpatient rehabilitation helps support this process. The BRTP offers a structured, evidence-based model of care that promotes recovery and optimizes functional outcomes for transplant recipients.

Acknowledgments

The authors thank the Brooks Rehabilitation leadership and staff involved in the development, implementation, and sustainment of the transplant program. No research funding was received to support the development of the program or the conduct of this analysis.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.

Supporting File 1: ctr70324-sup-0001-AppendixA.docx **Supporting File 2:** ctr70324-sup-0002-AppendixB.jpg