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INCREASING UTILIZATION OF OCCUPATIONAL THERAPY AND PHYSICAL THERAPY SERVICES TO PROVIDE MOBILITY THERAPIES IN THE PICU: A QUALITY IMPROVEMENT PROJECT

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Increasing Utilization of Occupational Therapy and Physical Therapy Services to Provide Mobility Therapies in the PICU: A Quality Improvement Project

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Abstract

There is a growing body of evidence demonstrating early mobilization for critically ill children is safe and feasible**.** Occupational therapists and physical therapists have distinct skills and abilities which make them an integral part of an interdisciplinary early mobilization program in the pediatric intensive care unit (PICU). The incorporation of occupational therapy and physical therapy services in an early mobilization program assists in decreasing the negative effects of immobility and inactivity through the facilitation of active movement and participation in age appropriate functional activities. Despite consults being placed within 72 hours of admission in the PICU at Cincinnati Children's, barriers existed which impacted the ultimate delivery of OT and PT services to patients. The purpose of this study was to assess whether the desired improvement in the delivery of occupational therapy and physical therapy services in the PICU was achieved when interventions were applied using quality improvement methodology. A quality improvement approach, guided by Cincinnati Children's rapid cycle improvement collaborative roadmap, aimed to identify whether interventions applied during a 120 day quality improvement project were effective in transforming the care delivery processes for therapy services in the PICU at a single institution as measured by the ability to produce a 20% improvement in the percentage of scheduled occupational therapy and physical therapy treatments which were delivered. The PICU population included in this quality improvement project consisted of patients with (1) an occupational therapy and physical therapy consult, (2) a scheduled occupational therapy and/or physical therapy appointment, and (3) a bed on the PICU floor. The study period was from December 18, 2018 through April 16, 2019. Adoption of several interventions increased the median percentage of scheduled occupational therapy and physical therapy treatments which were delivered from 48.6% at baseline to 56%.

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Increasing Utilization of Occupational Therapy and Physical Therapy Services to Provide Mobility Therapies in the PICU: A Quality Improvement Initiative

In the United States, over 230,000 children were admitted to a pediatric intensive care unit (PICU) in 2001 (Randolph, Gonzales, Cortellini, & Yeh, 2004). The majority (98%) of children with a critical illness admitted to a PICU survive (Pollack, Holubkov, Funai, Clark, Berger, et al., 2014; Pollack, Holubkov, Funai, Clark, Moler, et al., 2014). Evidence indicates there is the potential to develop new morbidities associated with a PICU admission (Choong, Fraser, et al., 2018; Hopkins, Choong, Zebuhr, & Kudchadkar, 2015; Pollack, Holubkov, Funai, Clark, Berger, et al., 2014). Pollack, Holubkov, Funai, Clark, Berger, et al. (2014) found that at discharge from the PICU, the prevalence of new morbidities was 4.8% for children who survive their critical illness, which is twice the mortality rate of 2.0%. New morbidities may occur in mental status, sensory function, communication skills, motor function, feeding, and respiratory function (Pollack, Holubkov, Funai, Clark, Berger, et al., 2014). The highest proportion of new morbidities occurred in respiratory, motor, and feeding domains (Pollack, Holubkov, Funai, Clark, Berger, et al., 2014). Intensive care unit acquired weakness (ICUAW) is one such consequence of critical illness and prolonged immobility and inactivity (Kukreti, Shamim, & Khilnani, 2014). These sequelae have the potential to lead to persistent functional impairments in children who survive a critical illness (Ong, Lee, Leow, & Puthucheary, 2016).

Early rehabilitation and mobilization in the PICU is a newer treatment approach which typically includes active mobility interventions provided within 24-72 hours of hospitalization in order to maintain or restore strength and physical activity. (Choong, Canci, et al., 2018; Choong et al., 2015; Cui et al., 2017; Wieczorek et al., 2016; Wieczorek, Burke, Al-Harbi, &

Kudchadkar, 2015). Studies on early mobilization (EM) in the pediatric population are more recent and consist of observational studies and 2 randomized control trials, all with limited samples sizes (Abdulsatar, Walker, Timmons, & Choong, 2013; Betters et al., 2017; Choong et al., 2017; Choong et al., 2015; Fink et al., 2019; Tsuboi et al., 2019; Tsuboi et al., 2017; Wieczorek et al., 2016). Despite differences in EM protocols and variability of study populations, all studies found that EM in the PICU is a feasible and safe intervention (Abdulsatar et al., 2013; Betters et al., 2017; Choong et al., 2017; Choong et al., 2015; Cuello-Garcia, Mai, Simpson, Al-Harbi, & Choong, 2018; Fink et al., 2019; Piva, Ferrari, & Schaan, 2019; Tsuboi et al., 2019; Tsuboi et al., 2017; Wieczorek et al., 2016; Wieczorek et al., 2015).

Active mobility interventions are intended to help improve outcomes through mitigation of new morbidities associated with a PICU admission and maximization of functional mobility (Choong, Canci, et al., 2018). The primary objectives of EM are to reduce PICU and hospital length of stay and optimize functional recovery (Choong, Fraser, et al., 2018). Therefore, once a patient is stabilized, focus on early rehabilitation and mobilization may aid in maximizing functional outcomes (Choong, Canci, et al., 2018; Turner et al., 2011).

Although participation in EM is feasible and safe, readiness for participation in EM ought to take into consideration both contraindications and precautions to mobilization for children with a critical illness (Choong, Canci, et al., 2018). Children who are critically ill are a heterogeneous population with unique needs based upon their age, maturation, cognitive abilities, and baseline function. EM of children in the PICU should be developmentally appropriate, individualized, and serve to decrease the negative effects of immobility and inactivity such as muscle weakness and deconditioning. (Choong, Canci, et al., 2018). EM activities should be progressed in a step-wise fashion aimed at achieving functional mobility and increasing muscle strength (Choong, Canci, et al., 2018). Initiating rehabilitation services early may support a child's ability to maximize functional mobility during and after a PICU admission (Choong et al., 2017).

The ability to deliver occupational therapy (OT) and physical therapy (PT) services in the PICU may be impacted by patient-related barriers, structural barriers, PICU culture barriers, and process-related barriers. A survey of PICU healthcare providers found that 73% believed the amount of rehabilitation services provided by OT and PT to children who were critically ill was inadequate (Joyce et al., 2018). Despite a critically ill child's need for rehabilitation services, past studies have noted limitations in the availability of therapy resources to support those needs in some settings (Choong, Fraser, et al., 2018; Cremer, Leclerc, Lacroix, & Ploin, 2009; Cui et al., 2017; Zheng et al., 2018). Additionally, two studies reported that therapists' experienced frequent deferral of therapy sessions by nursing, impacting their ability to deliver care (Cui et al., 2017; Fink et al., 2019). Barriers to a therapist delivering care limits their ability to positively impact functional mobility outcomes.

Problem Statement

In May 2017, a multidisciplinary team engaged in a quality improvement (QI) project to decrease the negative effects of immobility and inactivity for critically ill patients in the PICU at Cincinnati Children's Hospital (CCHMC). The team followed the QI methodology developed at CCHMC. This resulted in the development and implementation of interventions which were successful, reliable, and sustainable to carrying out an EM program for patients with and without mechanical ventilation. CCHMC adapted the "PICU UP!™ Guidelines" (Wieczorek et al., 2016) to the local context and implemented this program for patients who would benefit from EM. Increasing the opportunity for OT and PT to deliver services to patients in the PICU was a key strategy and driver to the implementation of the EM program at CCHMC. During the first 90-day QI project the team identified that very few patients were receiving an OT/PT consult soon after admission to the PICU and recognized this as the problem their QI project would address. The QI project resulted in an increase in OT/PT consults being requested by physicians and nurse practitioners within 72 hours of admission from 8% to 22%. Despite improvements in consults being placed within 72 hours of admission in the PICU, barriers existed which impacted the ultimate delivery of OT and PT services to patients.

Beginning in October 2018, a subset of the multidisciplinary team from the first QI project participated in a second QI project. The QI project followed the Rapid Cycle Improvement Collaborative (RCIC) roadmap developed at CCHMC (Kaminski, Schoettker, Alessandrini, Luzader, & Kotagal, 2014) in order to affect an increase in the percentage of OT and PT sessions delivered to patients in the PICU who had a consult for such services. Applying this QI methodology, the team set out to identify and implement successful, reliable, and sustainable interventions with the goal to support increased OT and PT care delivery to patients in the PICU.

Purpose Statement

The purpose of this study was to assess whether the desired improvement in the delivery of OT and PT services in the PICU was achieved when interventions were applied using QI methodology.

Research Questions

The primary research aim was to identify if interventions applied during a 120 day QI project were effective in transforming the care delivery processes for therapy services in the PICU as measured by the ability to produce a 20% improvement in the percentage of scheduled

OT and PT treatments which were delivered. A secondary research question was to report the percentage of scheduled OT and PT appointments in the PICU which were deferred and the reasons consults were deferred in order to prioritize interventions on the problem which have the greatest potential to impact the delivery of OT and PT treatments.

Significance of the Study

Occupational therapists and physical therapists have distinct skills and abilities which make them an integral part of an interdisciplinary EM program in the PICU. The objective of EM programs is to decrease the negative effects of immobility and inactivity through the facilitation of active movement and participation in age appropriate functional activities. Minimizing the negative effects of immobility and inactivity and improving a patient's functional outcomes after hospitalization are beneficial to the patient, family, and society at large. The incorporation of OT and PT services in an EM program will support these objectives. This study reports the QI process followed to improve the consistent delivery of OT and PT services in the PICU and could have generalizability in other, similar settings and patient populations.

Definition of Terms

- **Early mobilization** typically includes active mobility interventions intended to maintain or restore strength, physical activity, and provided within 24-72 hours of hospitalization. (Choong, Canci, et al., 2018; Choong et al., 2015; Cui et al., 2017; Wieczorek et al., 2016; Wieczorek et al., 2015).
- **Function** involves all body functions (physical, cognitive, and psychosocial), activities of daily living, and participation in age appropriate life activities in the home, at school, and in the community (World Health Organization, 2007).

- **Intensive care unit acquired weakness** (ICUAW) is characterized by wide spread musculoskeletal weakness often due to critical illness polyneuropathy or critical illness myopathy (Kukreti et al., 2014).
- **Acquired morbidity** is a condition or disease that is the result of a complication or undesirable side effect following medical treatment. (Choong et al., 2015; Joyce et al., 2018))
- **Rehabilitation** includes treatment or treatments intended to "facilitate the process of recovery from injury, illness, or disease" (Choong et al., 2014, p. e271).
- **Session deferral** occurs when an occupational therapist or physical therapist attempts to provide services to a patient and the services are put off, delayed, or postponed.
- **Morbidity** refers to the impairment of functional health status (Odetola, 2014)
- **Chest PT** are "Physical methods to improve ventilation, ventilation/perfusion (V/Q) matching, breathing mechanics, and airway secretions clearance (e.g., percussion techniques, manual facilitation of chest wall movement, and deep breathing exercises [including blowing bubbles and incentive spirometry])" (Choong et al., 2013)
- **Passive range of motion (PROM)** includes "passive repositioning of patient or passive stretching of their limbs and joints. Passive means the patient does not voluntarily participate in the activity" (Choong et al., 2013)
- **Active range of motion (AROM)** "may include exercises and stretches that are taught to a patient to do independently and includes neurodevelopmental play"; "active" infers patient participation, no matter how little (Choong et al., 2013)
- **Mobility device** refers to "activities done with a device that facilitates limb movement (i.e., cycle ergometer)" (Choong et al., 2013)

- **Bed mobility** refers to "activities done while patient is recumbent—but requires active participation of the patient; for example, active or active-assisted repositioning in bed; rolling from side to side; and bridging (i.e., pelvic or hip lifts)" (Choong et al., 2013)
- **Transfers** refers to patient transferring "from one surface to the other (e.g., from bed to chair/commode, sitting or dangling on edge of bed…)" (Choong et al., 2013). "These activities may be active or passive, may occur with varying degrees of caregiver assistance and supervision, or may be performed independently" (Choong, Canci, et al., 2018).
- **Pre-gait activities** refer to "assisting the patient in exercises prior to ambulation" (Choong et al., 2013).
- **Ambulation** refers to "gait training of the patient, with or without assistance by therapist or device (e.g., walker)" (Choong et al., 2013).
- **Huddles** refers to a brief (i.e. 15-20 minute) meeting to share and discuss important information necessary to keep the work on track.
- **Reliability in healthcare** is the capability of a process, procedure or health service to perform its intended function in the required time under existing conditions (Nolan, Resar, Griffin, & Gordon, 2004).

Literature Review

A PICU is the unit in a hospital that delivers the highest level of medical care to children with severe illness (Odetola, 2014). Patients admitted to the PICU often include those with severe respiratory illnesses, serious infections, cardiopulmonary conditions, fluid and electrolyte imbalances, require post-surgical care, or those involved in a serious trauma (Edwards et al., 2012; Krmpotic & Lobos, 2013). The medical staff in the PICU provide intensive therapies that may not be available on other medical units within a hospital (Odetola, Clark, Freed, Bratton, &

Davis, 2005; Randolph et al., 2004). Some of these more intensive therapies include mechanical ventilation and certain medicines that can be given only under close medical supervision (Odetola et al., 2005; Randolph et al., 2004). As such, the focus of care in the PICU is complex management of some of the highest risk patients.

Patients admitted to the PICU often have complex chronic conditions (CCC). Childhood-onset chronic conditions, including congenital heart abnormalities, cerebral palsy, and chromosomal abnormities, have been reported in 53% of children admitted to PICUs in the United States (Edwards et al., 2012), 67% in France (Cremer et al., 2009), and 70% in Canada (Choong et al., 2017). Krmpotic and Lobos (2013) reported the most common preexisting medical conditions for children with an unplanned admission to the PICU were respiratory disease (26%) and neurologic/ neuromuscular (15%) conditions. Children with CCC represent a large percentage of the patient population admitted to the PICU, as indicated by multi-site and single-site studies (Choong et al., 2017; Cremer et al., 2009; Edwards et al., 2012; Krmpotic & Lobos, 2013).

The rate of PICU growth over the past 2 decades is significant. In 1995, there were 306 PICUs in the United States (Randolph et al., 2004). By 2004, that number had grown to 337 hospitals with approximately 4,044 beds admitting 58 patients per PICU bed annually (Odetola et al., 2005). The average number of beds in a PICU in 2014 was 12 (interquartile range: 8–17 beds) (Odetola et al., 2005). The majority of intensive care units (ICUs) are either pediatric or adult and few mix care between these populations. In one survey, less than 6% of ICUs in the United States provided care to both adults and children suffering from a critical illness in the same area (Odetola et al., 2005). At CCHMC, one of the nation's larger ICUs caring for patients

0–21 years of age, more than 2,000 critically ill infants and children are admitted to the 35-bed PICU annually (Cincinnati Children's Hospital Medical Center, 2018).

Mortality has declined in areas where PICU services are accessible as a result of advances in intensive therapies and biomedical science (Odetola, 2014). While the majority of children survive a critical illness, studies suggest many are left with functional impairments and decreased quality of life (QOL) (Aspesberro, Mangione-Smith, & Zimmerman, 2015; Choong et al., 2013; Odetola, 2014; Ong et al., 2016). Following critical illness, evidence suggests children are at risk of acquiring new morbidities and experiencing functional deterioration (Choong, Fraser, et al., 2018; Choong et al., 2013; Pollack, Holubkov, Funai, Clark, Berger, et al., 2014; Wieczorek et al., 2015). PICU survivors are at risk of ICUAW, neurocognitive impairments, mental health sequelae, reduced QOL, caregiver burden, and functional impairments (Choong et al., 2014; Hopkins et al., 2015; Joyce et al., 2018). The highest proportion of acquired morbidities occur in respiratory, motor, and feeding domains (Pollack, Holubkov, Funai, Clark, Berger, et al., 2014). These sequelae may lead to persistent functional impairments in pediatric survivors of critical care (Odetola, 2014; Ong et al., 2016).

In two single-site studies, newly acquired functional deterioration following critical illness was found in at least 80% of patients admitted to the PICU (Choong et al., 2017; Choong, Canci, et al., 2018). Functional deterioration affected daily activities, mobility, social/cognitive, and responsibility domains, as measured by the Pediatric Evaluation of Disability Inventory-Computer Adaptive Test (PEDI-CAT) (Choong et al., 2017; Choong, Fraser, et al., 2018). Six months after discharge, 67.1% of patients demonstrated some functional recovery in one or more domains of function and 24% had not yet returned to baseline mobility function (Choong, Fraser, et al., 2018). Choong et al. (2017) found that mobility seemed to be the slowest to recover. This is important because functional decline has been shown to prolong hospital length of stay (Choong, Fraser, et al., 2018). While functional deterioration is common and can result in disability, functional deterioration and acquired impairments that result in disability are considered an undesired outcome of a PICU admission (Odetola, 2014).

Safety concerns and severity of illness often give rise to the perception that patients are too ill to be mobilized, resulting in prolonged periods of bed rest (Choong et al., 2014; Choong et al., 2013). Prolonged immobility is thought to increase the risk of critical illness-acquired morbidities such as ICUAW. ICUAW is characterized by polyneuropathy and myopathy-induced muscle weakness (Kukreti et al., 2014). Kukreti et al. (2014) found that ICUAW in children has a negative impact on morbidity, length of stay, and possibly mortality. Although this is a common ICU acquired morbidity in adults (Fan, 2012), Kukreti et al. (2014) concluded that future research was necessary to understand the prevalence of ICUAW in children.

Occupational Therapy and Physical Therapy Services in the PICU

In the PICU, occupational therapists and physical therapists treat patients with a variety of ages and conditions. Physical therapists work with children to improve their strength, endurance, and mobility while occupational therapists work with children to facilitate mobilization, maximize function, and integrate age appropriate occupational-based activities, Both OT and PT work to prevent the many complications of prolonged bedrest and immobility. Neuromuscular complications following a critical illness are common. In the absence of established pediatric clinical practice guidelines for these populations, therapists are required to use their clinical reasoning skills to integrate medical information with OT or PT knowledge to provide evidence based care.

OT and PT interventions in the PICU have often included both non-mobility and mobility therapies to address these complications. Non-mobility therapies are those which enhance respiratory function (chest PT), passive positioning, splinting, or passive range of motion (PROM) and stretching (Choong, Canci, et al., 2018; Choong et al., 2014; Choong et al., 2013; Wieczorek et al., 2016). Mobility therapies include active range of motion (AROM) or active strengthening exercises, mobilization devices, bed mobility, transfers, pre-gait activities, and ambulation (Choong, Canci, et al., 2018; Choong et al., 2015; Choong et al., 2014; Choong et al., 2013; Wieczorek et al., 2016). The role of OT and PT in the PICU at our institution is trending toward the delivery of more active interventions.

Physical therapists have long supported patients in the PICU through non-mobility therapies such as PROM, splinting, passive positioning, and respiratory PT (chest PT). Hawkins and Jones (2015) found that the primary intervention provided by PT in the PICU to mechanically ventilated patients was chest PT. Chest PT is for the management of secretion clearance and has been shown to be safe and effective (Hawkins & Jones, 2015). In addition, chest PT was the most frequent intervention requested by physicians (50.5%) in tertiary care pediatric critical care units across Canada (Choong et al., 2014). Consequently, interventions most often delivered by physiotherapists in the Pediatric Critical Care Unit (PCCU) in Canada were chest PT and PROM (77.8%) (Choong et al., 2013).

In a survey of Canadian practice with critically ill children, 70.4% of physiotherapists provided pre-gait and ambulation interventions sometimes or infrequently (Choong et al., 2013). Cui et al. (2017) reported that in 2011 only a third of children admitted to a single-site tertiary care PICU in the United States for ≥ 3 days participate in active mobility interventions. Mobility therapies include activities to maximize physical function and muscle strength. These may include both in-bed and out-of-bed activities (Wieczorek et al., 2016). Active mobility interventions are individualized to each patient and progress from in-bed activities to ambulating with or without an assistive device (Choong et al., 2014; Cui et al., 2017; Owens & Tapley, 2018; Wieczorek et al., 2016).

Early Mobilization in the PICU

EM in the PICU is a fairly new treatment option for the prevention and treatment of neuromuscular complications, such as ICUAW, following a critical illness (Choong, Canci, et al., 2018; Cuello-Garcia et al., 2018; Piva et al., 2019). The definition of EM in children who are critically ill typically includes developmentally age appropriate active mobility interventions intended to maintain or restore strength and function (Choong, Canci, et al., 2018; Cui et al., 2017; Parisien et al., 2016; Wieczorek et al., 2016) initiated within 24-72 hours of admission (Choong et al., 2015; Wieczorek et al., 2016). Although there is a paucity of research related to efficacy outcomes of EM in pediatrics (Choong, Canci, et al., 2018; Cuello-Garcia et al., 2018; Piva et al., 2019; Tsuboi et al., 2019), there is evidence that suggests prolonged immobility should be avoided in children (Kukreti et al., 2014).

Growing evidence demonstrates the benefits of EM in critically ill adults. In the adult population, EM has shown to reduce ICU and hospital length of stay, reduce length of time on the ventilator, and improve self-perception of function, and decrease sedation utilization and delirium (Adler & Malone, 2012; Cameron et al., 2015; Needham et al., 2010; Schweickert et al., 2009). Based upon encouraging adult findings, pediatric studies to date have demonstrated that implementation of early mobility activities is safe and feasible (Abdulsatar et al., 2013; Betters et al., 2017; Cameron et al., 2015; Choong et al., 2017; Choong et al., 2015; Fink et al., 2019; Hollander et al., 2014; Piva et al., 2019; Tsuboi et al., 2019; Turner et al., 2011; Wieczorek et al., 2016; Wieczorek et al., 2015). A recent retrospective before-after study of pediatric patients who underwent liver transplantation found that patients who received early mobility interventions were able to walk 5 days earlier and had shorter hospital lengths of stay compared to the pre-early mobilization period (Tsuboi et al., 2019). Although Tsuboi et al. (2019) findings will aid in understanding the impact of EM on liver transplantation patients, "the impact of early mobilization on the efficacy outcomes in critically ill children [as a whole] remains to be seen owing to the paucity of prospective trials and, therefore, the low certainty in the evidence to date" (Cuello-Garcia et al., 2018, p. 32). Early pediatric studies have investigated the implementation of EM programs which sets the foundation for future investigation of the efficacy of EM on functional outcomes, hospital length of stay or ICU length of stay in a younger population.

Recent pediatric studies have shown benefits of EM implementation including improved time to referral for OT and PT by PICU day 3 (Tsuboi et al., 2019; Wieczorek et al., 2016) and increases in EM activities (Abdulsatar et al., 2013; Choong et al., 2014; Choong et al., 2013; Hollander et al., 2014; Wieczorek et al., 2016). A survey assessing beliefs of PICU providers in regards to EM revealed that all respondents believed EM would be beneficial to patients, and 93% expressed interest in the implementation of EM (Joyce et al., 2018). Despite this interest, implementation of EM in the pediatric setting has been limited due to the heterogeneous nature of this patient population (Wieczorek et al., 2015) and lack of EM practice guidelines specific to pediatric populations (Choong, Canci, et al., 2018).

Barriers to Early Mobilization in the PICU

Infrastructure and process level barriers to EM in the pediatric PICU have been identified as a lack of protocols, time constraints, competing care priorities, lack of staffing, lack of training and education, lack of space, conflicting view of suitable patients, therapist's requirement for a physician's order prior to evaluation, lack of champions to promote EM, pediatric specific equipment, and safety concerns (Choong, Fraser, et al., 2018; Choong et al., 2013; Cui et al., 2017; Hopkins et al., 2015). Patient level barriers include medical instability, concern for device integrity or dislodgement, the presence of an endotracheal tube, and patient or parent refusal (Choong et al., 2017; Choong et al., 2013). The heterogeneity of the pediatric population, particularly with respect to age, cognitive maturity, and sedation needs is a barrier, which further complicates the implementation of EM (Joyce et al., 2018).

Barriers specific to the delivery of EM interventions by OT and PT also include structural barriers, patient-related barriers, PICU culture barriers, and process-related barriers. It has been suggested that structural barriers include knowledge gaps in this area by physicians who make referrals for OT and PT services (Choong et al., 2013), lack of clear practice guidelines (Choong et al., 2013; Wieczorek et al., 2016; Wieczorek et al., 2015), time constraints (Choong et al., 2013; Joyce et al., 2018), and excessive workload (Joyce et al., 2018; Zheng et al., 2018). Patient related barriers include parental stress (Choong et al., 2017; Colwell et al., 2019; Parisien et al., 2016) and safety concerns (Choong et al., 2013; Parisien et al., 2016; Wieczorek et al., 2015; Zheng et al., 2018). Cultural barriers impacting the ability of OT and PT to deliver EM interventions to appropriate patients include beliefs that patients are too sick to participate in therapy (Choong et al., 2014; Zheng et al., 2018). In addition, while it is encouraging that children with known baseline motor impairments were five times more likely to receive EM during periods of critical illness, there is also an opportunity to increase awareness of the rehabilitation needs of children with previously normal baseline function who become critically ill (Miura, Wieczorek, Lenker, & Kudchadkar, 2018).

Wieczorek et al. (2016) reported that OT and PT services support early rehabilitation for PICU patients and are felt to be a valuable personnel resource by nursing. In spite of this perceived value, deferment of OT and PT sessions is common in the PICU and was been reported to be 21.5% in one tertiary-level PICU (Cui et al., 2017), 25.8% in a single center, pilot, randomized controlled trial (Choong et al., 2017) and 19% for OT and 21% for PT in a randomized control trial of pediatric neurocritical care patients (Fink et al., 2019). The most common reason for deferral of OT and PT sessions was at the request of nursing (Choong et al., 2013; Cui et al., 2017). Reasons for nursing deferral included the necessity for nursing interventions or other diagnostics/procedure at the same time, difficulty calming a child after sedation interruption, sleeping patient, or at the family's request (Cui et al., 2017). Other reasons for deferral of OT and PT sessions included a sleeping patient (Cui et al., 2017), patient not in hospital room (Cui et al., 2017; Fink et al., 2019), patients' condition (Cui et al., 2017; Fink et al., 2019; Wieczorek et al., 2016), patient or family refusal (Fink et al., 2019; Wieczorek et al., 2016), and unavailable equipment (Wieczorek et al., 2016). Deferral of services may have contributed to 75% of PICU clinicians indicating they believe patients did not receive adequate OT and PT services (Joyce et al., 2018).

Successful implementation EM has taken into consideration many of these barriers. Mitigation strategies to address conflicting views of suitable patients have included parameters for inclusion in EM (Van Damme, Flori, & Owens, 2018; Wieczorek et al., 2016) and clinical recommendations which identify contraindications and precautions (Betters et al., 2017; Choong, Canci, et al., 2018; Tsuboi et al., 2019; Van Damme et al., 2018). Safety concerns have been addressed through a premobilization safety checklist (Betters et al., 2017; Wieczorek et al., 2016) and criteria for pausing EM activities and reassessing the patient before continuing has been created (Tsuboi et al., 2019; Van Damme et al., 2018; Wieczorek et al., 2016). Parents reported a decrease in anxiety following active participation in their child's care making them less likely to refuse care (Parisien et al., 2016). The identified lack of pediatric EM protocols has resulted in the creation of several institutional protocols (Betters et al., 2017; Van Damme et al., 2018; Wieczorek et al., 2016) as well as the creation of a practice recommendation for EM in children who are critically ill developed by a multidisciplinary panel of experts, using the Institute of Medicine framework (Choong, Canci, et al., 2018). The recent protocols and practice recommendation propose mobilizing in a step wise fashion, based on clinical variables and exclusion criteria, applying individualized developmentally appropriate goals which take into consideration the level of assistance required (Betters et al., 2017; Choong, Canci, et al., 2018; Van Damme et al., 2018; Wieczorek et al., 2016). EM activities may be provided in-bed or out of bed and often progress from in bed movement to sitting edge of bed, sit to stand, standing, transferring to a chair, and the highest level anticipated is ambulation and play (Betters et al., 2017; Cui et al., 2017; Wieczorek et al., 2016). Following implementation of an EM protocol in the PICU, Betters et al. (2017) found that 32% more staff believed mobilizing intubated patients was safe. Consideration of identified barriers and thoughtful planning of mitigation strategies has been shown to lead to successful implementation of EM for critically ill children.

Quality Improvement in Healthcare

QI is the "systematic, data-guided activities designed to bring about immediate, positive changes in the delivery of health care" (Baily, Bottrell, Lynn, Jennings, & Hastings, 2006, p. S5). Healthcare organizations may look to QI methodologies to accelerate improvements in processes of care and patient outcomes while decreasing variation in the care delivered to children and their families in collaboration with multiple institutions (Billett et al., 2013; Clauss et al., 2015;

Schouten, Hulscher, van Everdingen, Huijsman, & Grol, 2008). There are several QI methodologies developed which have been used in healthcare. Most QI methodologies used in healthcare define a goal, acquire and analyze data used to guide process changes, and they review the results to further refine future changes (Lee & Larson, 2014). A methodology commonly used in healthcare is the Model for Improvement (Langley et al., 2009) which is supported by the Institute for Healthcare Improvement. QI initiatives are a strategy used by many healthcare organizations, including CCHMC, to improve processes of care and patient outcomes.

Quality Improvement at CCHMC

CCHMC QI foundations are based in a *Conceptual Framework* using Deming's System of Profound Knowledge and *Core Methodology* using The Model for Improvement (Kaminski et al., 2014). Deming's system of profound knowledge is composed of interrelated components, namely appreciation of a system, theory of knowledge, psychology, and understanding variation, which together reinforce one another to accomplish the aim of the system (Deming, 2000). Transformation of systems occurs when improvement is made in all four components of profound knowledge (Deming, 2000), therefore, the components cannot be separated. Deming (2000) believed combining subject matter knowledge (professional knowledge) and profound knowledge (interaction of variation, knowledge, psychology, systems) in novel ways would lead to effective changes for improvement. The Improvement Model asks three basic questions as the framework for improvement:

- What are we trying to accomplish?
- How will we know that a change is an improvement?
- What changes can we make that will result in improvement? (Langley et al., 2009)

The comprehensive improvement capability model at CCHMC includes didactic and hands on learning through action oriented QI projects designed to achieve measurable improvements (Kaminski et al., 2014). There are several programs offered at CCHMC which begin with online modules to acquire knowledge about QI and progress from basic to advance programs designed to acquire broader QI skills which are applied to actionable projects. RCIC is a collaborative in CCHMC's QI educational offerings available to frontline staff to work in teams to deepen their knowledge and skills in improvement science methodology by applying QI methodology to a focused, narrow-scoped question or problem to achieve measurable improvement in 120 days (Kaminski et al., 2014). The RCIC roadmap translates the QI methodology into a sequence of activities and tools for teams as they apply QI methodology to a problem (Luzader, 2018). Use of the RCIC roadmap will allow team members to succinctly identify their current problem, document the current process, identify and analyze process failures, identify root causes, develop a SMART aim and measures, identify key drivers, identify potential interventions, design and execute plan-do-study-act (PDSA) cycles, scale-up successful interventions, and lastly plan for sustainability and spread (Luzader, 2018).

Teams have successfully demonstrated improvements in processes of care and patient outcomes through the use of CCHMC's QI methodology. Improvements have been reported for a variety of patient populations, including early identification and management of hospitalized pediatric patients who are at risk for medical deterioration (Parker et al., 2017), a reduction in time to antibiotic delivery in febrile immunocompromised children (Dandoy et al., 2016), and improved systems for identifying patients at risk for acute compartment syndrome (Schaffzin et al., 2013). Improved patient population outcomes following the application of QI methodology, such as for infants with congenital muscular torticollis, have also been reported (Strenk, Kiger, Hawke, Mischnick, & Quatman-Yates, 2017). In addition, QI projects guided by the RCIC roadmap (Figure 1) to accelerate improvements in processes of care while decreasing variation have successfully achieved the desired outcome set forth in the SMART Aim statement (Boyd, 2016). In light of the importance of OT and PT in the delivery of EM interventions to children, and the success of QI methodology in improving processes of care, using the RCIC roadmap is appropriate and meaningful.

Method

Study Design

The objective of this QI project was to apply QI methodology "to achieve measurable improvement in a focused, narrow-scoped project in 120 days" (Kaminski et al., 2014). The primary research aim was to identify whether interventions applied during a 120 day QI project were effective in transforming the care delivery processes for therapy services in the PICU as measured by the ability to produce a 20% improvement in the percentage of scheduled OT and PT treatments which were delivered. The Institutional Review Boards from CCHMC and from the University of Indianapolis were consulted and apprised of this project. This project did not meet the definition of "human subjects research" set forth in 45 CFR 46.102(f) since this project was designed and intended to apply improvement methodology to healthcare processes that would benefit the participants of the project. Therefore, informed consent was waived provided information collected did not allow for the identification of participants through the QI project.

Participants

The PICU at CCHMC is a multidisciplinary inpatient unit that serves critically ill children. The multidisciplinary practice includes physicians (MD/DO), nurse practitioners (APN), registered nurses (RN), patient care attendant (PCA), respiratory therapists (RT), occupational therapist, physical therapist, speech and language pathologists (SLP), dietician, child life specialist, and pharmacists. At CCHMC, there is one primary occupational therapist and one physical therapist who serve this unit along with support from other inpatient OT and PT staff members. All inpatient therapists at CCHMC have acute care training in order to serve patients in the PICU when needed, such as for extended time off or illness of the primary therapists or unexpected increases in census. The inpatient OT and PT services are supported by one program assistant and three unlicensed personnel (rehab tech). This support staff is responsible for scheduling patient appointments on a therapist's electronic schedule per therapist's instructions which are communicated electronically. Therapists are responsible to manage their own caseload and confirm availability of patients on a daily basis through chart review and care coordination with the patient's nurse. When appointments need to be changed or moved, the therapist either completes the task or sends an in-basket message to schedulers. Generally, the PICU population includes children with a critical illness from birth to 18 years of age. Patients in the PICU are referred for OT and/or PT services by a physician or nurse practitioner via an electronic medical record consult order. There is a single inpatient OT and PT consult referral, therefore a scheduler places patients on the appropriate discipline schedule by matching the patient's diagnoses and problems indicated by the referring provider against established criteria for distribution of OT/PT referrals at our institution. The PICU population included in this QI project consisted of patients with: an OT and PT consult, a scheduled OT and/or PT appointment, and a bed on the PICU floor. Exclusion criteria included: patients who do not have an OT and PT consult or the consult has been placed on hold.

Procedures

The primary investigator (PI) has participated in basic and intermediate improvement collaboratives designed to develop knowledge and expertise in the application of QI methodology. As an organizational leader, the PI has developed capability and is uniquely qualified to lead improvement work as evident by successful application of QI methodology as measured by statistically significant improvement of several RCIC projects, an intermediate improvement science series (I2S2) project, participation in advanced improvement leadership systems (AILS), and has served as a coach to other RCIC projects (Kaminski et al., 2014). The team included the PI who is the inpatient clinical manager, two physical therapists, one occupational therapist, one program assistant, and one PICU nurse.

The QI project was guided by the RCIC roadmap (Figure 1). The RCIC roadmap is designed to guide the team through the process of applying the CCHMC QI methodology to their specific problem or project (Luzader, 2018). Prior to the start of the QI project all team members completed online modules intended to introduce staff to basic QI concepts, terminology and measurement. The RCIC process included structured learning time one time every three to six weeks delivered by the PI in consultation with RCIC leadership, weekly team meetings for 45-60 minutes, monthly feedback from senior leadership within the Division of OT and PT at CCHMC, and frequent 15-20 minute huddles during testing of interventions.

The first step in the RCIC roadmap is to identify the problem. This is completed by identifying "what is the problem, who does it affect, how often does it occur, why is the problem relevant, and why do we care?" (Luzader, 2018). The problem identified in this project was the failure to deliver OT and PT services to patients in the PICU as determined through scheduling and service utilization data. The problem was vetted by the Division of OT and PT leadership and the staff directly involved in delivering OT and PT services in the PICU.

The next step in the RCIC roadmap is documenting the current process for the management of daily OT and PT service delivery in the PICU. This is completed by documenting the current process, beginning with determining the beginning (start) and ending boundaries (stop) of the process. The team also considers the customer of the process and what the desired output or outcome is of the process. This was accomplished by brainstorming all existing action steps and decisions as a team in a single meeting. The team documented the current process based on each member's personal experience with the process, placing action steps and decisions in chronological or sequential order. The team reviewed the action steps, combining those that were similar and expanding upon those that were not previously identified in sufficient detail. This resulted in a detailed process map that was expanded upon in subsequent weeks. This process map (Figure 2) was shared with other OT and PT staff who frequently provide services to the PICU for input and further modification in order to gain agreement on the existing process. This step took two to three weeks. By documenting the process in this manner, using consistent process map symbols (Figure A1), the team visually depicted the sequence of activities and decisions in the current process (Luzader, 2018).

After documenting the current process, the team observed the process. The purpose of physically observing the action steps and decisions was to ensure the team agreed that the process map was truly representative of the process (Luzader, 2018). Once the existing process map for management of daily OT and PT services in the PICU was complete, this was accomplished by four out of five team members involved in the QI project observing the process. Over the course of two to three weeks the individuals first silently observed the process and then actively observed the process again, this time asking questions to gain clarity. An observation tool was developed using the detailed process map that team members used to document discrepancies, make additions to the process, document failures, and denote unexpected findings. The focus of the observation was on how the process works prior to any assessment of opportunities for improvement (Luzader, 2018). Following observations, the team edited the process map based upon additional learnings.

The next step in the RCIC roadmap was to identify and analyze process failures. After confirming through observation that the current process map accurately captured the work and agreement was reached amongst those doing the work, the team identified, analyzed, and quantified failures. A high level process map with seven action steps was developed. This allowed the team to identify and analyze process failures using a simplified failures mode effect analysis (sFMEA) tool (Figure 3) over the course of two to three weeks. Any variation, inefficiencies, or rework were identified along with what was perceived to be working well (Luzader, 2018). The team engaged in a brainstorming process to identify actual and potential failures for each action step in the process (Luzader, 2018). The sFMEA tool helps illustrate both what has and what may go wrong at each action step along the process. Following creation of a sFMEA it was shared with other OT and PT staff who frequently provide services to the PICU for input and subsequent modification. The team chose a list of failures from the sFMEA to gather data on (Luzader, 2018). Lastly, the frequency of failures data or problems identified in the process were gathered and graphically represented on a Pareto chart (Figure 4). The data collected for each failure was summed and rank ordered in a Pareto chart from most frequent to least frequent (Langley et al., 2009; Luzader, 2018). These failures assisted in quantifying the relative importance of failures and was used to help guide the team in selecting which failure to focus on first (Langley et al., 2009; Luzader, 2018).

The next step in the RCIC roadmap is to identify root causes for the most prevalent process failures previously identified. Starting with the failures with the highest frequency the team used the root cause analysis tool (Figure 5) by asking “Why?” at least 5 times (Langley et al., 2009; Luzader, 2018). Over several weeks the team answered why the failures occurred, the answers were written below the failure and the question repeated at least five times until the root cause of the failure was identified (Luzader, 2018). If the sequence of answers provided did not identify the root cause of the failure or problem, then the team started over. To verify if a root cause was identified the team started with the root cause and read in reverse order from the bottom to the top of the tool adding ‘therefore’ to the end of the answer listed. If a root cause was appropriately identified, there should be a logical sequence when reading from the bottom up. This process was repeated for the top 4 failure modes until the root cause of the failures were identified. Determining the root-cause helped ensure that future interventions were directed at achieving the SMART Aim.

After identifying the problem, documenting the current process, identifying and analyzing process failures, and identifying root causes, a SMART Aim including a measure was developed. A SMART Aim is specific, measurable, actionable, relevant, time bound, and population-specific (Luzader, 2018). The SMART Aim included the measure, a baseline and goal for which the QI team wanted to achieve, and a timeframe for achievement (Langley et al., 2009; Luzader, 2018). An operational definition is used to connect meaning to a concept in order to reduce variation in communication and measurement (Langley et al., 2009). The operational definition for this QI project defined the measure in the SMART Aim statement and ensured there was clarity & agreement on how data was being collected. This ensured the team had clarity and agreement on how to operationalize the measure and ensures repeatability of measures (Luzader, 2018). The SMART Aim measure was tracked daily during the weekday (Monday through Friday), with the exception of holidays. Data was tracked daily since the number of patients scheduled each day varies. Furthermore, data was tracked as a percentage in order to gain a better understanding of how many opportunities there were to deliver care (denominator) versus how many were actually provided (numerator). Data was tracked for at least four weeks prior to testing potential interventions in order to establish a baseline measure and set the goal for which the QI team wanted to achieve. Data was plotted on a run chart to graphical display the data over time (Langley et al., 2009). By establishing a baseline prior to testing interventions, the team would also be able to determine if the interventions tested were having the desired impact. The SMART Aim described the focus of the QI project (Luzader, 2018) and took approximately 4 weeks to complete.

In the next step, the team identified key drivers which needed to be in place and working well in order to achieve the SMART Aim (Luzader, 2018). Key drivers were identified over two weeks of brainstorming all potential drivers. Ideas may come from examining failures listed on the sFMEA tool and turning them into positives (Luzader, 2018). The team clarified and combined drivers as appropriate. Key drivers were added or removed during the project based upon learnings. Key drivers were written as specific affirmative statements that include a noun and descriptor that serve to explain what is necessary to drive improvement (Luzader, 2018). All key drivers were assessed using the RCIC Assessment Tool to ensure all the components were present (Figure 6) (Luzader, 2018).

The next step in the RCIC roadmap was to identify potential interventions that had a strong potential to eliminate root causes. Potential interventions to address process failure(s) that occurred most often were identified by reviewing key drivers, failures, root causes, and change concepts (Langley et al., 2009; Luzader, 2018). The team took approximately three weeks to generate ideas. The team began by reviewing key drivers, along with process failures listed on the sFMEA tool, the Pareto chart, and root cause tool, followed by brainstorming a list of possible interventions. Lastly the team reviewed a list of change concepts (Figure 7), considering which seem appropriate within the context of this project and identified additional possible interventions (Luzader, 2018). Once brainstorming was concluded the team confirmed potential interventions relate to one or more key drivers. Potential interventions were listed in the sFMEA tool (Figure 8) and prioritized based upon the predicted impact to the SMART Aim in order to choose which intervention to test first (Luzader, 2018). A key driver diagram (KDD) is used to schematically organize and display the SMART Aim, key drivers, and potential intentions, which combined represent our theory for improvement (Figure 9).

The next step in the RCIC roadmap was to test the chosen interventions. PDSAs are the method used to test potential interventions. Interventions should be tested on a small scale, often starting with one patient, one therapist, or one day (Luzader, 2018). A PDSA ramp planning tool (Figure 10) was used to clearly depict the plan for a series of tests. PDSA ramps sequentially building on the knowledge gained from PDSAs (Luzader, 2018). Each test of change was designed using PDSA methodology and documented on a PDSA worksheet (Figure 11). The PDSA worksheet was used to record the plan, document what happened during the test, to record what was learned and what the team would do next based on the results of each test. The plan included the intervention being tested, the start and end date, what the objective of the particular test is, the test population, and which key driver it was intended to impact. Most importantly, it included how success was measured, a quantitative prediction, and a data collection plan (Luzader, 2018). After the test was executed the team huddled to discuss what occurred during the test and to decide next steps. Included in discussion of what occurred during the test was whether the test was carried out as planned, recording of data and observations, and identifying what occurred that was not part of the plan. The team studied whether the results matched the prediction, compared results to previous performance, and analyzed the results and document what the team learned. Following analysis of the results the team determined whether to adapt, adopt, or abandon the intervention and documented next steps for the intervention strategy (Luzader, 2018). Refinements and adjustments were made as needed in subsequent PDSA cycles (Luzader, 2018). PDSA cycles continued for at least 8 weeks or up until 120 days. After 60 days of PDSA cycles the Pareto was updated to determine whether there had been changes in previously identified failures. Lastly, as the interventions were tested through PDSA cycles, successful changes were strategically scaled across the target population as defined in the operational definition in a logical, well-thought-out manner (Langley et al., 2009; Luzader, 2018).

Data Collection, Management, and Analysis

The specific measure in the SMART Aim addressed in this RCIC project was tracked over time using a run chart (Figure 12). “A *run chart* is a graphical display of data plotted in some type of order” (Langley et al., 2009). Data was collected from the electronic medical record used at CCHMC which is EPIC (Verona, WI) as well as manual data collection when desired data could not be obtained via the electronic medical record. Data was plotted daily on the run chart and analyzed for special cause variation signaling a statistically significant change. Once a baseline median was established via the run chart, testing of interventions to achieve the SMART Aim began. The median was moved when a statistically significant change in the data occurred using the CCHMC Rules for Finding Special Causes (Figure 13). CCHMC Rules for Finding Special Causes are a set of rules that show patterns in the data that determine if the interventions led to the desired improvement. Once enough data had been collected the RCIC project was transitioned from a Run Chart to a Control Chart which is probability distribution based. Failure data were analyzed using a Pareto chart at the beginning of the QI project to quantify failures and after 60 days of testing to see if the frequencies & rank ordering on the Pareto Chart had changed signaling the elimination of a root cause.

Results

Data

Baseline data were extracted over time from October 30, 2018 to December 6, 2018. The baseline data collection established the median percentage of scheduled OT and PT treatments delivered were 48.6% (Figure 12). The testing time period was 120 days during the time period of December 18, 2018 through April 16, 2019 and is presented in a run chart (Figure 12). Figure 12 shows the daily data collection results relative to the SMART Aim that occurred from October 30, 2018 to April 16, 2019. Once the baseline was established, the goal rate of OT and PT treatments which were delivered was set to be 58%, which was a 20% improvement. The SMART Aim therefore was to increase percent of scheduled OT and PT sessions which are delivered to patients in the PICU from 48% to 58% by April 16, 2019.

Baseline data for OT and PT appointments in the PICU which were deferred were identified from October 24, 2018 to October 30, 2018. Deferrals occurred when a patient was scheduled for a therapy session, but the session was not initiated. Fifty-six deferred appointments were grouped into thirteen categories using a Pareto chart (Figure 4). The baseline data collection established that prior to the start of interventions, therapy was most frequency deferred because OT and PT were on hold for medical reasons, the patient was with another service when OT or PT attempted, the patient did not have an acute therapy need and for inappropriate timing of the OT/PT consult.

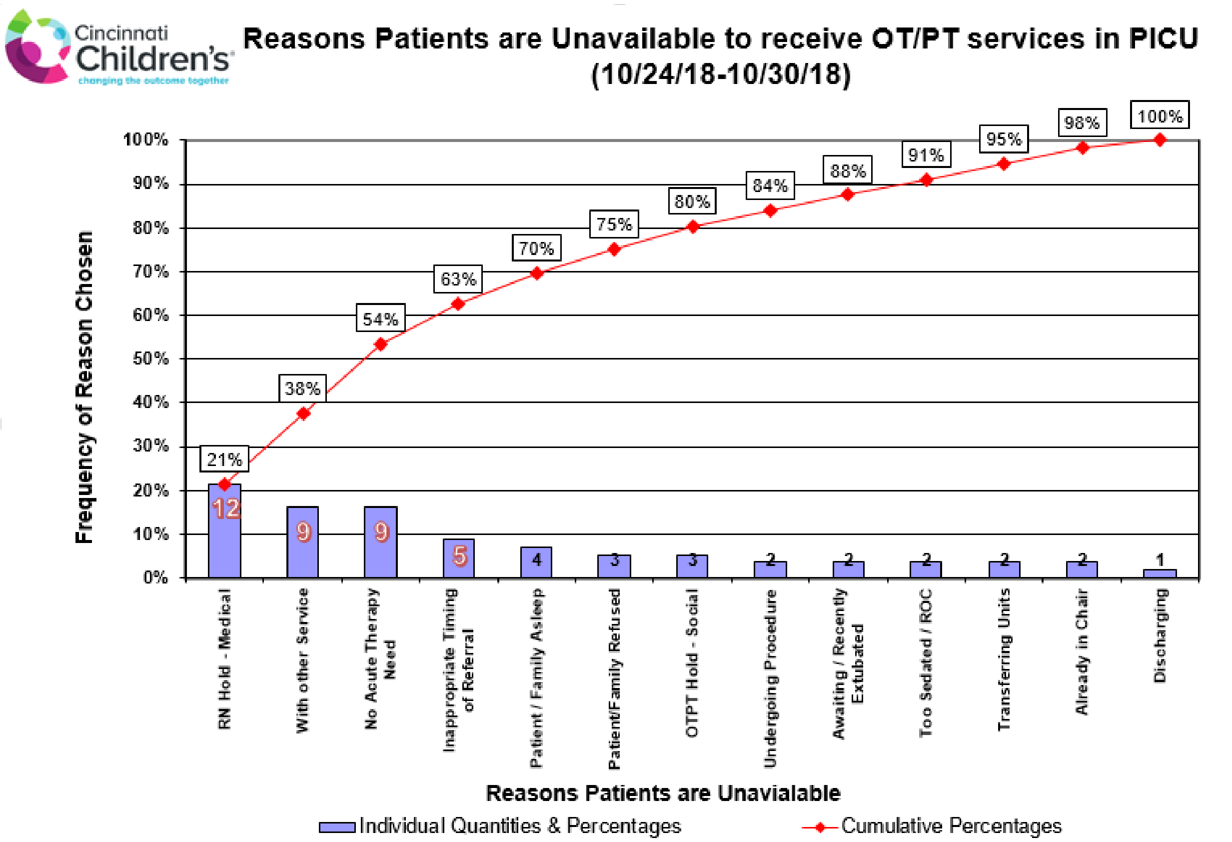

Figure 4. Frequency & rank ordering of reasons patients were unavailable to receive OT/PT services in PICU from 10/24/18 to 10/30/18.

Repeat data for OT and PT appointments in the PICU which were deferred were identified from March 11, 2019 to March 15, 2019. Sixty-three deferred appointments were grouped into the same thirteen categories using a Pareto chart (Figure 15). The repeat data collection established that following 60 days of interventions therapy was most frequency deferred because the patient was with another service when OT or PT attempted, the patient or family refused, the patient was undergoing a procedure when OT or PT attempted and because OT and PT was on hold for medical reasons.

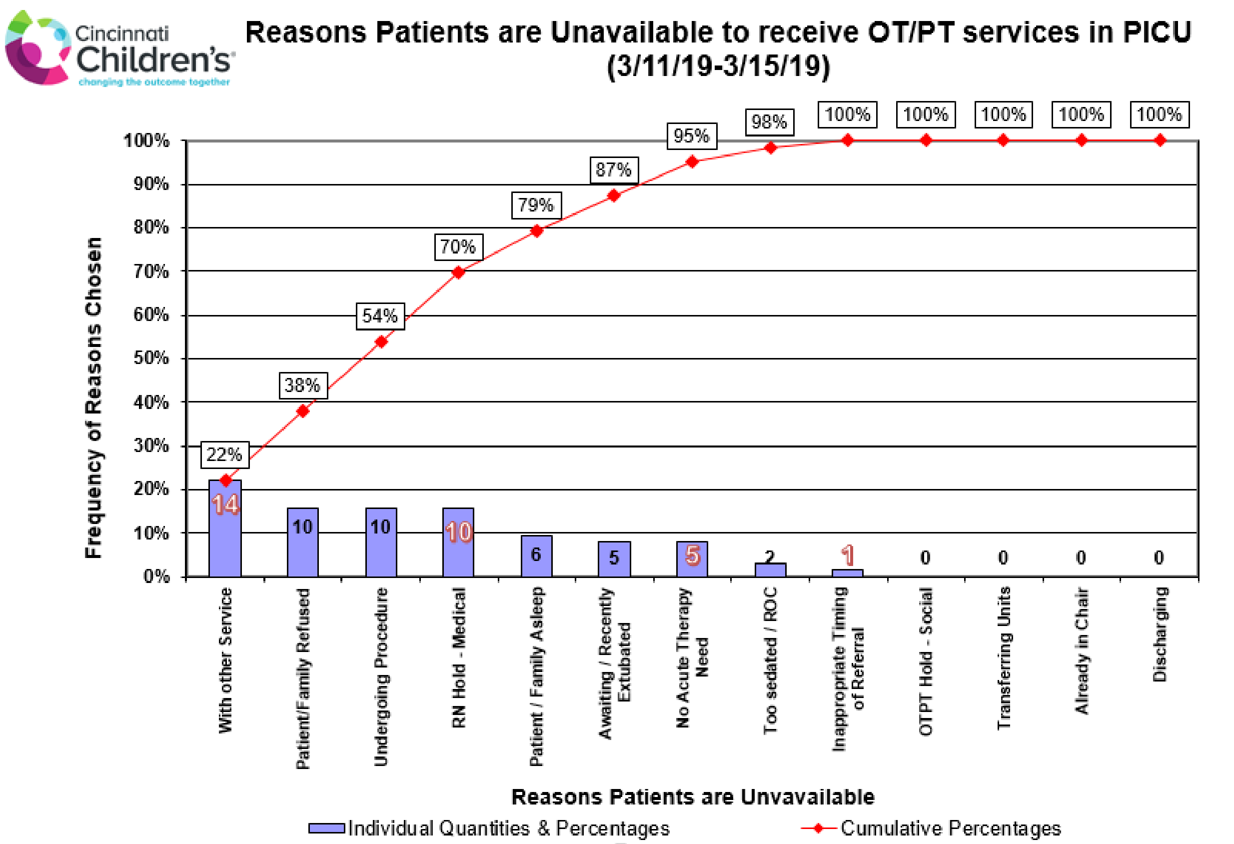

Figure 15. Frequency & rank ordering of reasons patients were unavailable to receive OT/PT services in PICU from 3/11/19 to 3/15/19.

Statistical Analysis

After the baseline median of 48.6% (Figure 12) was established and testing began, special cause rules (Figure 13 and Figure 14) were utilized to determine if the interventions led to the desired improvement. Run chart data plotted daily were analyzed for special cause variation signaling a statistically significant change.

Failure data were analyzed using a Pareto chart at the beginning of the QI project to quantify failures (Figure 4) and after 60 days of testing (Figure 15) to see if the frequencies & rank ordering on the Pareto Chart had changed signaling the elimination of a root cause.

PDSA Cycles

During testing, 5 different interventions were tested, with a varying number of PDSA cycles (e.g., 3–6). One of these was ultimately abandoned, while 4 were adopted as useful intervention (Figure 16).

Intervention	Plan-Do-Study-Act Intervention	Summary of Outcomes	PDSA Cycles	Impact to Which Key Driver(s)
1	Communication with bedside nurse following initial attempt to request contact when patient is available for therapy.	Adopted. Therapist schedules do not support physically checking back on patients numerous times. Therapists collaborated with nursing to identify preferred mode of communication. A standard message was sent via internal messaging system. Communication was quick for therapist and allowed nurse to efficiently reply when patient was available.	4	Coordination with other providers and appropriate scheduling
2	Engage residents in identifying appropriate patients for consult to OT/PT.	Adopted: Identified that therapists were unnecessarily over-processing orders sent for inappropriate patients. Multipronged approach included 1) statement in email sent to residents immediately prior to their PICU rotation along with a handout that includes indicators for appropriate consults; 2) Brief (15 min) learning session with OT/PT as part of resident onboarding during 1st week of rotation; 3) Handout including indicators for appropriate consults in resident call room.	5	Appropriate ID of patients for therapy consult
3	Schedule new consults for evaluation after medical team has completed their intake and history and physical (H&P).	Adopted: Identified that OT/PT consult is part of the admission order set, therefore therapists were receiving consults and attempting to see patients before the medical team had finished their H&P. Referral management staff were provided criteria for which PICU consults should be scheduled for evaluation the following day for patient safety. Scheduler messaged therapist on Day 0 for awareness only.	6	Appropriate scheduling
4	Engage nursing in identifying a patient's readiness for OT/PT interventions.	Adopted: Identified that there was not agreement amongst nursing staff and therapists regarding when it was appropriate to involve OT/PT in rehabilitative interventions. To increase the ability for nursing to identify patients appropriateness for OT/PT services a presentation was delivered to nurse orientee's which included case-based scenarios .	3	Nursing identifies patient readiness and Buy-In of Unit staff regarding value of OT & PT services

5	Determine number of patient on daily caseload that would allow therapist adequate time to see scheduled patients	Abandoned: Unable to automate or efficiently adjust for fluctuations in available work hours per therapist therefore it continued to be a manual process.	5	Appropriate scheduling and adequate time for OT & PT to see scheduled patients

Figure 16: PDSA Interventions and Outcomes are listed the twenty-three specific PDSAs that were tested are described.

Analyzing the Run Chart/Control Chart

Improvement in the primary outcome measure was demonstrated when special cause variation signaled a statistically significant change. After thirty-two days of testing the center line shifted upward. The new median rate of OT and PT treatments delivered was calculated (February 4, 2019-February 13, 2019), for a value of 66%. This represents a 37.5% increase in the number of scheduled OT and PT treatments which were delivered. This increase was not sustained and after eight more days of testing the center line shifted down. The new median rate of scheduled OT and PT treatments delivered was calculated (February 14 – February 25), for a value of 56%. This represented a subsequent 15.2% decrease in the number of scheduled OT and PT treatments which were delivered. The percentage of scheduled OT and PT treatments delivered fluctuated over the course of this QI project (December 18, 2018 – April 16, 2019). From a baseline of 48%, there were two shifts before stabilizing at 56% of scheduled OT and PT treatments being delivered on the day scheduled, representing an overall increase of 16.7%. Data was transferred to a statistical process control chart to identify whether changes in processes were making a difference in the outcomes over time using a P-chart, which is an attribute control chart (Figure 17). The P-chart indicated that the mean improved from 48.6% to 56% at the end of the time period. Since the processes had clearly changed, new control limits reflected a desired decrease in day-to-day variation (Figure 17).

Improvement in the secondary measures was demonstrated through change in the frequency & rank ordering of reasons patients were unavailable for scheduled OT and PT appointments in the PICU. Changes in frequencies & rank ordering on the Pareto Chart signal a decrease in frequency of the following root causes (Figure 18):

- Therapy placed on hold
- Patient did not have any acute therapy needs
- Inappropriate timing of consult
- Therapy placed on hold for social reasons
- Patient too sedated to participate in OT or PT
- Patient transferring units
- Patient already in chair
- Patient discharging

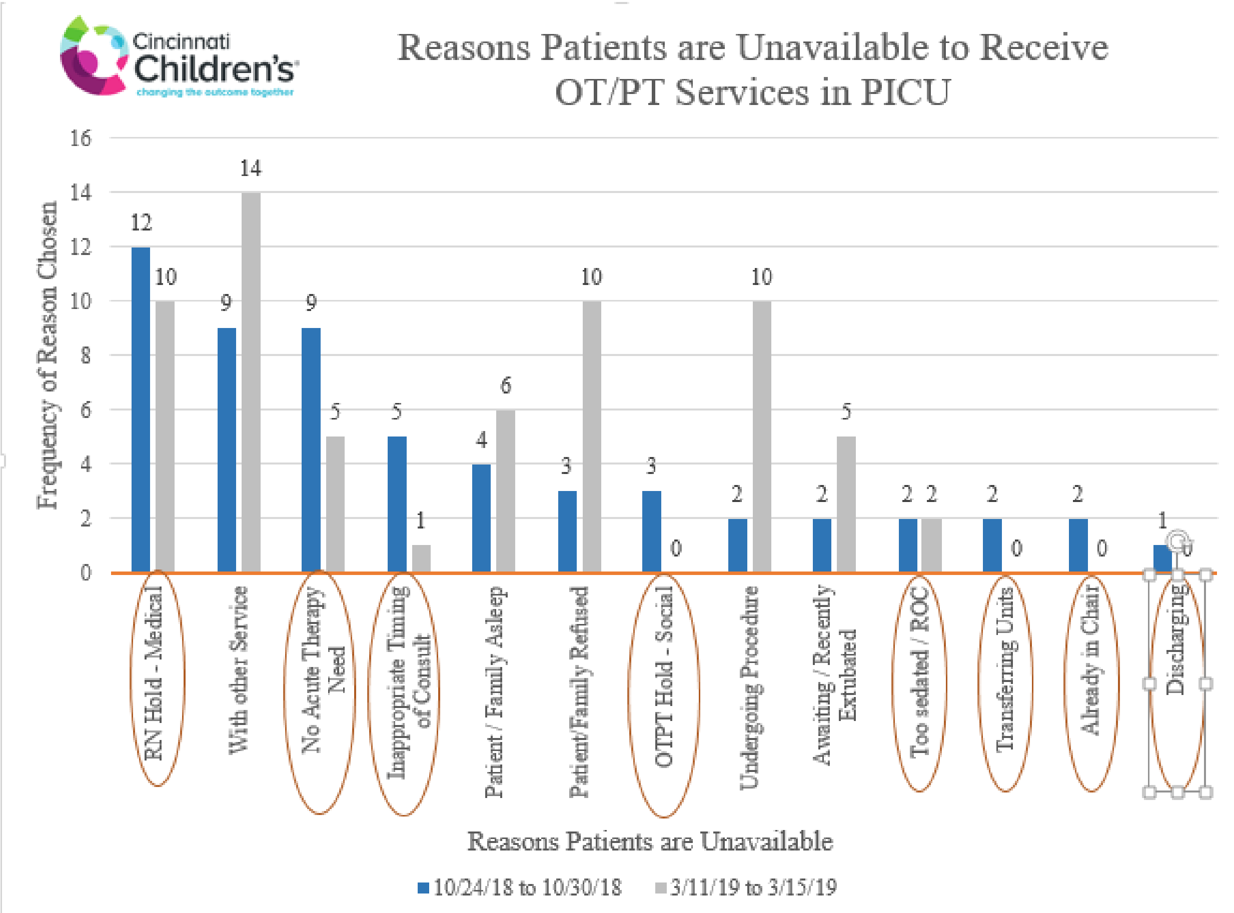

Figure 18. Comparison of frequency & rank ordering of reasons patients were unavailable to receive OT/PT services in PICU. October 24, 2018 to October 30, 2018 compared to March 11, 2019 to March 15, 2019. The change in frequency of reasons patients were unavailable signaled a decrease in root causes.

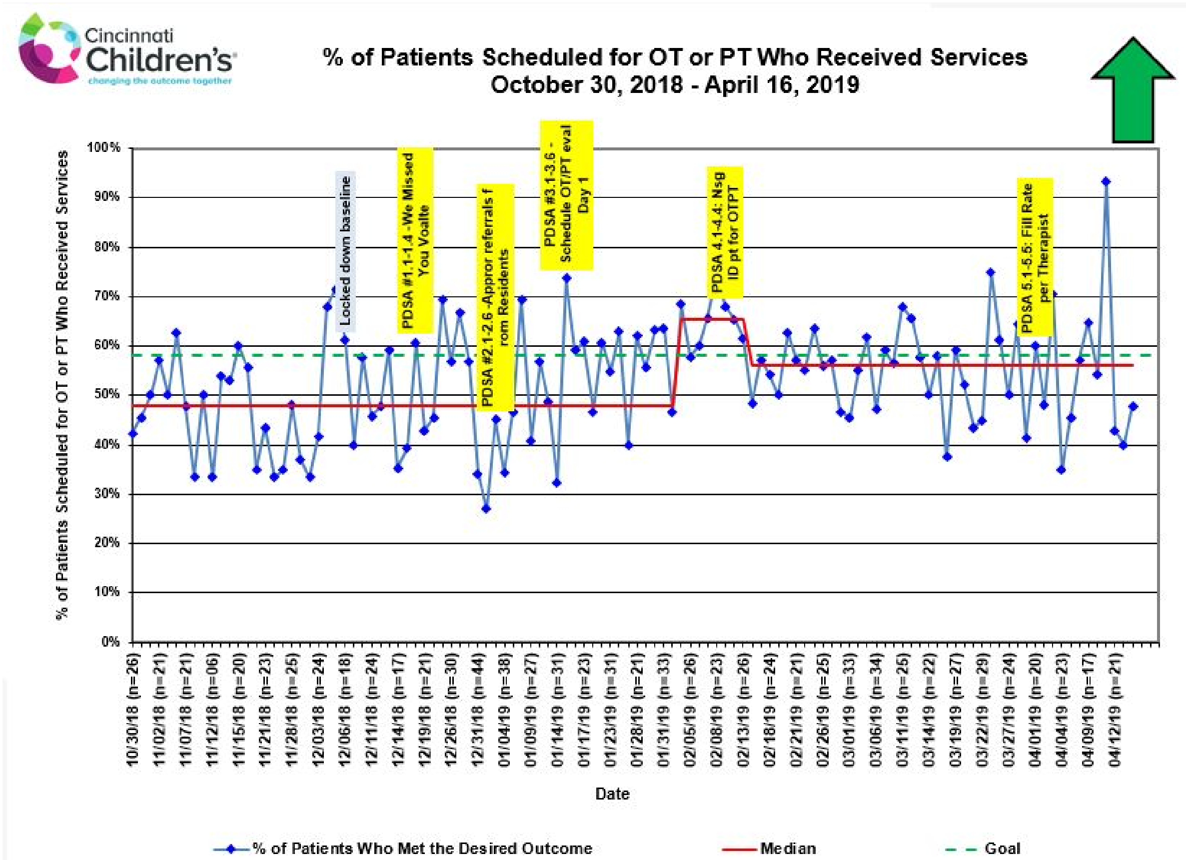

Figure 12. Run chart indicating the percentage of Patients Scheduled for OT or PT Who Received Services in the PICU from October 30, 2018 - April 16, 2019. The center line shifted from 48.6% to 66% on the run chart, then shifted to 56% and remained there at the end of the QI project. With a 16.7% improvement the center line did not reach the 20% improvement goal. The observed data are indicated by the blue line with markers. The green arrow in the upper right-hand corner represents the desired direction of change. The center line is indicated by the solid red line and represents the overall median score for a specified period of time. This percent change is calculated using the formula (V2 − V1)/V1 * 100, where V1 is equal to the initial value and V2 is equal to the final value.

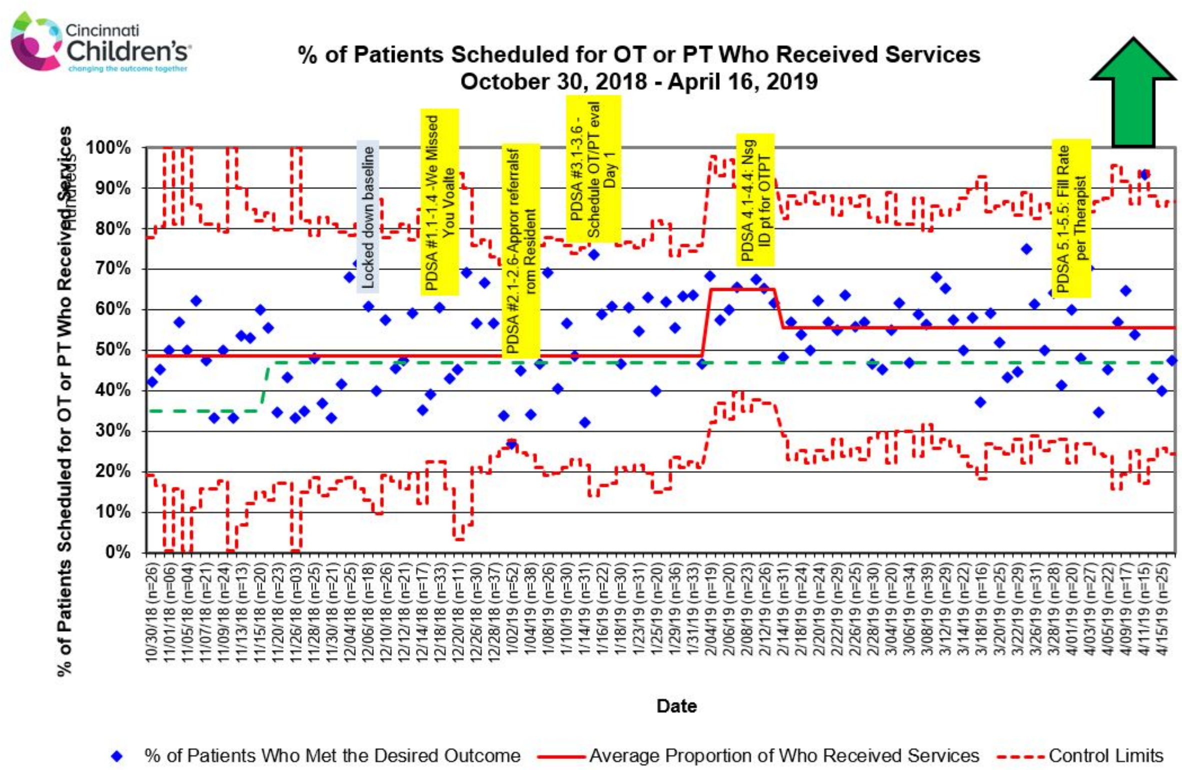

Figure 17. P-chart indicating by day the percent of patients Scheduled for OT or PT Who Received Services in the PICU from October 30, 2018 - April 16, 2019. The mean shifted from 48.6% to 66% on the p-chart, then shifted to 56% and remained there at the end of the QI project. With a 16.7% improvement the mean did not reach the 20% improvement goal. The observed data are indicated by the blue markers. The green arrow in the upper right-hand corner represents the desired direction of change. The mean is indicated by the solid red line and represents the overall average score for a specified period of time. The control limits, indicated by the dashed red lines, set at ±3SD, are used to determine when the process is out of control.

Discussion

Current barriers negatively impacted the delivery OT and PT services to patients in the PICU at our institution. The purpose of this study was to assess whether the desired improvement in the delivery of OT and PT services in the PICU was achieved when interventions were applied using QI methodology. Data collected by comparing how many opportunities there were to deliver care versus how many were provided were analyzed to inform whether interventions applied during a 120 day QI project were effective in transforming the care. Using QI methods, we increased the percentage of scheduled OT and PT treatments which were delivered in the PICU by 16.7%, which was short of our 20% improvement goal. Additionally, the study provided insights into the reasons appointments were deferred at our institution in order to prioritize interventions on the problems which have the greatest potential to impact the delivery of OT and PT treatments.

Our project built on previous work that developed a proactive system to increase consults for OT and PT services within 72 hours of admission. Because we wanted to improve the ability to deliver OT and PT services in our institution, we did not predetermine what interventions to test based upon findings in the literature. Rather, we collected data on the root causes for why OT and PT services were deferred at our institution and rank ordered them by highest to lowest frequency to effectively prioritize interventions. We observed the most frequent reasons appointments were deferred at the start of the project were when nursing declined OT and PT services for medical reasons (21.4%); when another provider was with the patient (16.1%); when patients did not have any acute therapy needs, such as an admission for bronchiolitis with an expected length of stay < 72 hrs, as determined during chart review (16.1%); and when the timing of consult was inappropriate (8.9%), for example submitted by a PICU resident before surgical restrictions affecting mobility were discontinued. Patient level barriers such as medical instability were perceived by 90.9% of providers to be a barrier to EM (Choong et al., 2013). Although 90.9% of provider's surveyed perceived medical instability was a barrier, Choong et al. (2013) did not assess the frequency at which this barrier occurred as was done in our study and Wieczorek et al. (2016). Our results agree with the findings of Wieczorek et al. (2016) who reported frequent reasons for deferral were due to medical instability (16% and 22% respectively) and procedures (16% and 20% respectively). In addition, we experienced a high frequency of deferrals at the request of nursing (21%). These results are similar to the findings of Fink et al. (2019) and Cui et al. (2017) who reported a frequent reason for deferral of therapies was at the request of nursing (18% for PT and 16% for OT and 50% for OT and PT combined respectively).

A key driver to increase the percentage of scheduled OT and PT sessions which were delivered to patients in the PICU was efficient coordination with other providers. In a survey of provider beliefs, Joyce et al. (2018) found that therapists report time constraints and increased workload as barriers to the delivery of EM in the PICU. Although Joyce et al. (2018) did not specify the type of time constraints nor propose solutions, we observed that therapist were unable to physically return to the patient's room numerous times a day when the patient was unavailable on the first attempt. Therefore, we tested novel methods for coordination with the bedside nurse that would alert OT or PT when the patient was available after the first attempt. We used both low reliability methods such as patient specific reminder cards and posting reminders on patient doors and higher reliability methods such as standardized text messaging. Collaboratively, nursing and therapy staff determined that a text message was the preferred method of communication. Therapists created a standard message that was efficiently inserted into a text, individualized to the patient, and then sent to the bedside nurse. Nursing reported it was simple and efficient to reply back to that message once the patient was available for OT or PT.

Another key driver was appropriate identification of patients who would benefit from OT and PT services. A failure we observed was therapists engaging in unnecessary chart reviews and communication with nursing as a result of new consult orders received for patients who did not have an acute therapy need. Educational methods were tested to assist residents in appropriate identifications of patients who would benefit from OT and PT services. One challenge we faced was maintaining a system during turnover of resident providers. To overcome this obstacle, we used both low reliability methods such as education and training and higher reliability methods such as decision aids. We learned that integrating information about OT and PT services via existing communication paths when onboarding residents was beneficial. This multipronged approach included a statement in a newsletter sent immediately preceding the PICU rotation along with an attached PDF that included indicators for appropriate consults. The same PDF was posted in the resident call room, and a brief (15 min) interactive learning session with OT and/or PT was integrated into the first week of a PICU rotation. We also discovered that repeating the set of 4 interventions with each change in team composition improved the reliability that consult orders placed were for patients who had an acute therapy need. By anticipating when new residents would arrive and implementing our set of interventions at the start of their rotation, we improved and maintained appropriate OT/PT consult orders through multiple changes in staff. We observed that the education bundle reduced the number of consults received for patients who did not have an acute therapy need (Figure 18).

We observed that this challenge with inappropriate OT/PT consult orders was the result of orders being placed at the time of admission. This resulted in therapists arriving to see patients prior to the medical team ascertaining if the patient was clinically safe to participate in therapy interventions. Other studies have found that consults were received 2 or more days after admission to the PICU or considered delayed (Choong et al., 2013; Cui et al., 2017; Wieczorek et al., 2016), thus this was a unique challenge to our institution. We tested methods to schedule patients appropriately, which has previously been identified as another key driver to success in this QI project. Scheduling staff were provided criteria for which PICU consult orders should be scheduled for evaluation the following day. Schedulers were instructed to message the therapist on Day 0 for awareness, but therapies would not be initiated until Day 1 of admission to the PICU. Obtaining orders within 24 hours of admission as recommended by Choong, Canci, et al. (2018) was typical at our institution following previous QI initiatives.

Additional key drivers we focused on were nursing identification of patient readiness and buy-in of unit staff regarding the value of OT & PT services. Similar to other studies, we observed lack of agreement amongst staff regarding patient suitability to participate in rehabilitative interventions (Choong et al., 2013; Wieczorek et al., 2015). In addition, studies have suggested that PICU nursing frequently deferred OT and PT sessions (Choong et al., 2013; Cui et al., 2017; Fink et al., 2019). We discovered that knowledge regarding which patients may benefit from OT or PT services and what interventions OT and PT provide to critically ill children varied amongst nursing staff at our intuition. A recently published practice recommendation proposes that the decision to provide mobility interventions should involve an interprofessional team, including occupational therapists and physical therapists who have expertise in mobilizing patients (Choong, Canci, et al., 2018). Therefore, we focused on educational methods that would emphasize the breadth of therapy interventions available to critically ill patients. Initial PDSAs focused on establishing agreement between novice nurses and a therapist or an experienced nurse using current patients to determine readiness for OT and PT. Following several PDSA cycles to establish agreement, case-based education was developed by the QI team. Lastly, it was delivered during an interactive nursing orientation session in order to facilitate dialog around accurate identification of patients ready to participate in OT and PT interventions. A 6% decrease in the frequency of nursing staff deferring therapy was observed (Figure 18).

Lastly, adequate time for OT and PT to see scheduled patients was identified as a key driver to success in this QI project. It was reported that therapists workload at our institution may limit their ability to serve patients who were receiving care from another provider at the time they attempted to provide OT or PT services. Other studies have also found therapists report time constraints, increased staff workload (Joyce et al., 2018) and staffing limitations (Choong et al., 2013) as barriers to providing OT and PT services. We learned that determining a reasonable number of scheduled patients based on hours available was achievable. Despite some initial success this intervention involved a labor intensive process that requires therapists to remember to manually denote available hours in an unused field within the electronic scheduling system weekly. After a few PDSA cycles therapists reported this manual process was not sustainable within their current workload, therefore, this intervention was abandoned.

Leveraging the existing QI culture associated with increasing OT and PT services for the purposes of early mobilization at our institution, we found the interprofessional team to be receptive to PDSA cycles. We tested several methods of communication with bedside nurses, educated residents on appropriate identification of patients who would benefit from therapy, proactively scheduled initial evaluations when patients were most likely to be available, educated nurses to identify patients' readiness for OT and PT services, and determined the number of patients a therapist could manage on a daily basis. Although we fell short of our 20% improvement goal, the QI team reported that engaging in a series of PDSAs to address and mitigate many system issues linked to therapist's workload and collaborative relationships amongst therapists, nurses and residents was valuable.

We hypothesized that the high acuity of patients in the PICU made it difficult to predict their course of care and was a barrier to achieving our goal. In addition, we hypothesized that the lack of routine modes of communication for interprofessional collaboration made it challenging to anticipate when patients were most likely to be available for therapy or when other procedures or services were anticipated on the same day. Furthermore, order entry using an order set combined with resident turnover were barriers to achieving our goal. Based on a number of observations, residents tended to choose a generic order set that included OT and PT even when a patient's presentation did not indicate a need for therapy services. This added to a therapist's workload and adversely affected the time therapists had available to provide interventions to patients in need of OT or PT services. Lastly, the 37.5% increase followed by a subsequent 15.2% decrease in the measure is believed to be the result of interventions to reduce the number of consults received for patients who did not have an acute therapy needs in addition to successful interventions to schedule patients starting the day after admission. It is not uncommon for a team to see a significant 'bump' in their measure as a result of increased effort and persistence by early adopters only to have it stabilize at a lower level.

Limitations

This study is subject to a number of limitations. First, the study was conducted at a single health care institution by a small QI team consisting of the PI, two physical therapists, one occupational therapist, one program assistant, and one PICU nurse. As such, the results may not be generalizable to other institutions. Second, our project relied heavily on a combination of EMR and manual end of day self-reporting to assist in data collection to identify which scheduled OT and PT treatments were delivered. We believe that an automated system for inclusion of eligible appointments is likely more effective and objective than self-reporting, and implementation in a system without an EMR or dedicated PICU staff may require significant effort. Finally, the goal of our project was to drive rapid change in practice. The QI methodology was determined to be the best method to achieve this goal. As such, the specific mechanism that resulted in change could not be identified.

Implications for Practice and Future Research

Although we sustained our improvement for 2 months, we did not reach our goal of a 20% improvement in the percentage of scheduled OT and PT treatments which were delivered in the PICU. Although the results may not be generalizable, the experiences of therapist workload challenges, systems and processes which result in processing inappropriate consult orders, frequent resident turnover, and lack of agreement amongst staff regarding patient suitability to participate in rehabilitative interventions exists in many pediatric health care institutions. Given the generic nature of these interventions, they could likely be replicated in other care environments. For those who chose to replicate these interventions in other health care institutions, spread concepts should be used to ensure success (Langley et al., 2009). Our work was not able to address the issues regarding inefficient coordination with other providers or the availability of appropriate staff and equipment. In addition, despite several PDSAs, we were unable to automate our scheduling system to support scheduling a reasonable number of patients based upon available work hours per therapist. Future work may look to better address these challenge to determine their potential effect on further improvement. In addition, the interventions applied in this QI project are being spread to other occupational therapy and physical therapy staff at our institution who are most likely to provide coverage in the PICU.

Conclusion

This study described how QI methodologies and tools facilitated in a structured, organized manner at our institution promoted the improvement of care delivery processes. We successfully identified and applied interventions during a focused, narrow-scoped 120 day QI project that were effective in improving the care delivery processes for therapy services in the PICU as measured by an improvement in the percentage of scheduled OT and PT treatments which are delivered. Key drivers of success for our QI project included (a) appropriate identification of patients for OT/PT consult orders, (b) nursing identification of patient readiness, (c) appropriate scheduling, (d) buy-in of unit staff regarding the value of OT and PT services, and (e) efficient coordination with other providers. Many of the key drivers and interventions that were used in this project are generalizable to other units within our institution and given their generic nature, may be replicated elsewhere.

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Figures

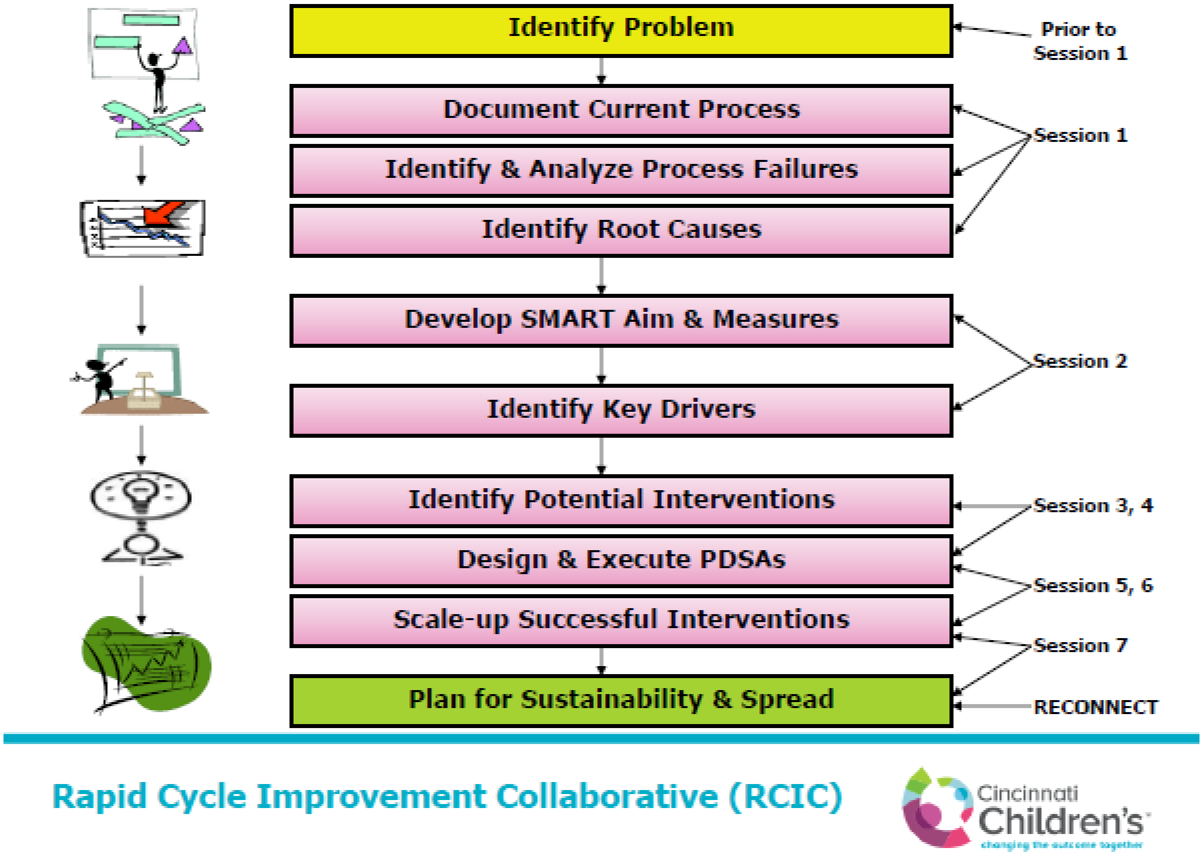

Figure 1: RCIC Roadmap to Guide Teams through Application of Improvement Methodology (Luzader, 2018)

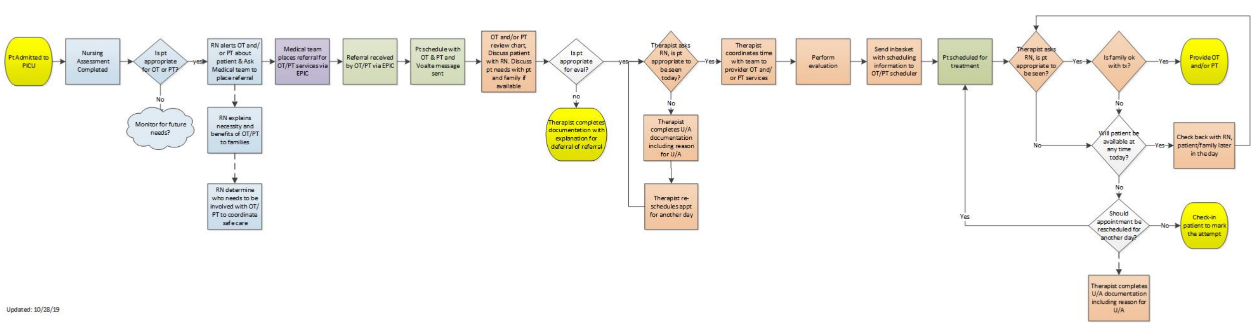

Figure 2. Process Map which visually depicted the sequence of activities and decisions in the current process.

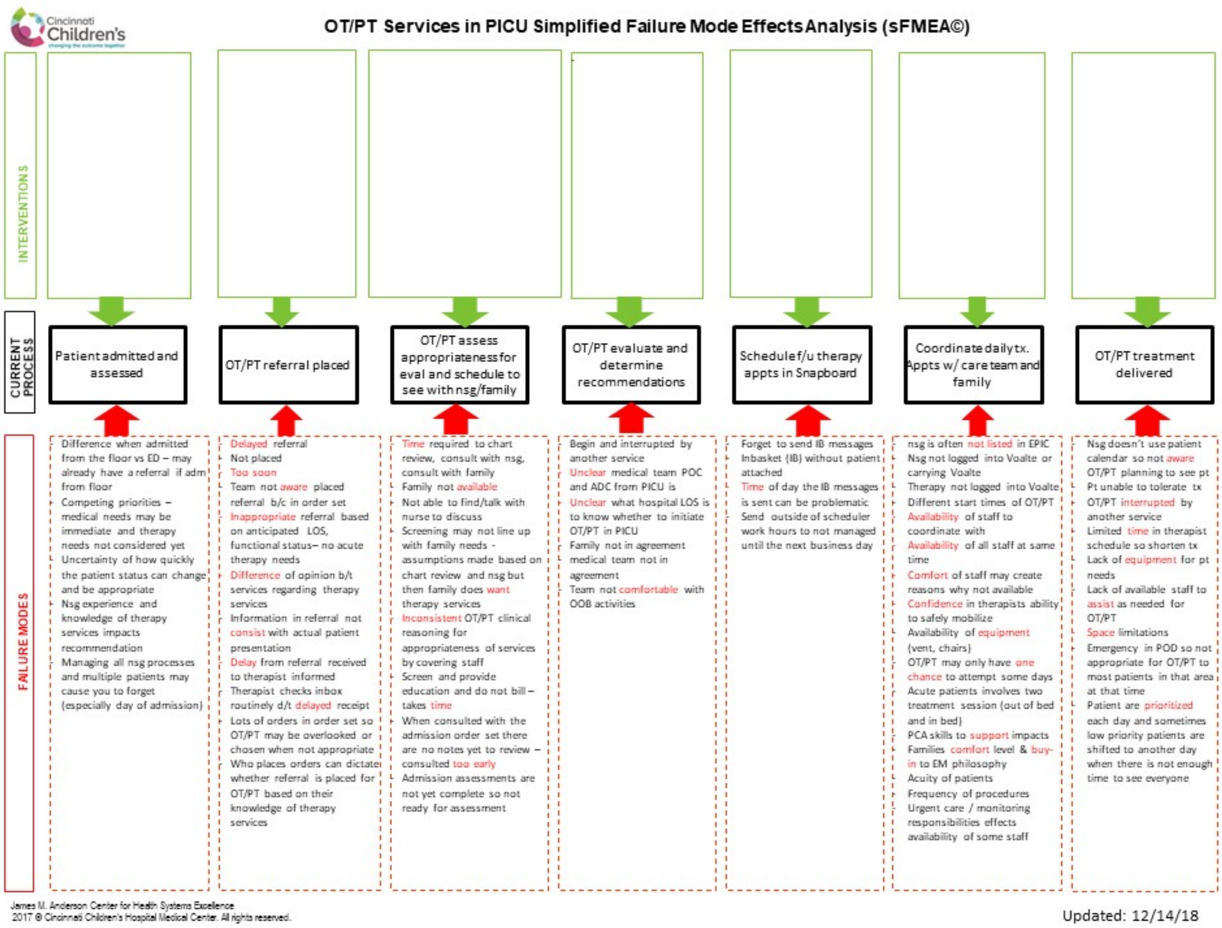

Figure 3. Simplified FMEA Diagram used to Identify Current Failures

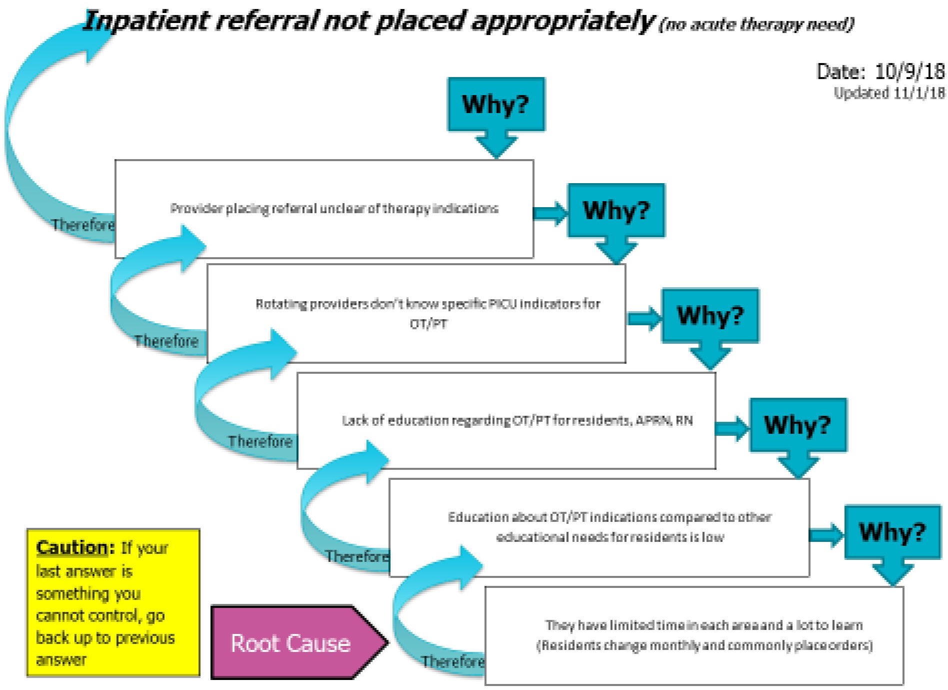

Figure 5. Root Cause Analysis Worksheet used To Identify Future Interventions

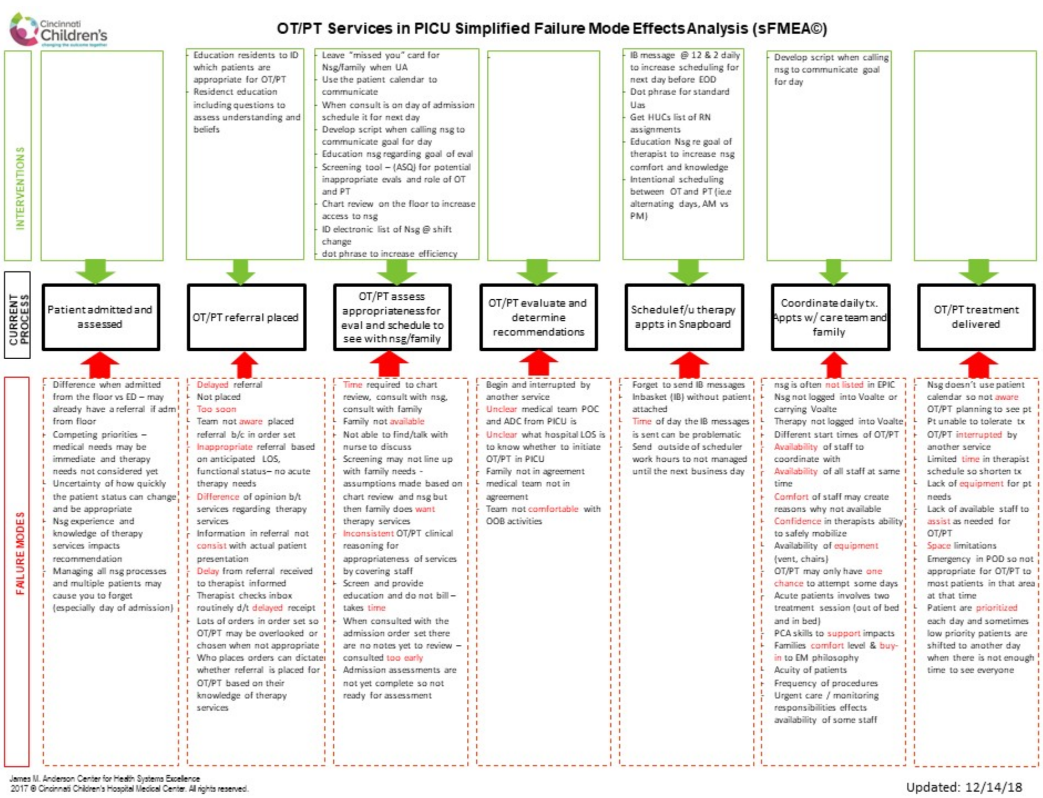

Figure 8. Simplified FMEA Diagram used to Identify Potential Interventions

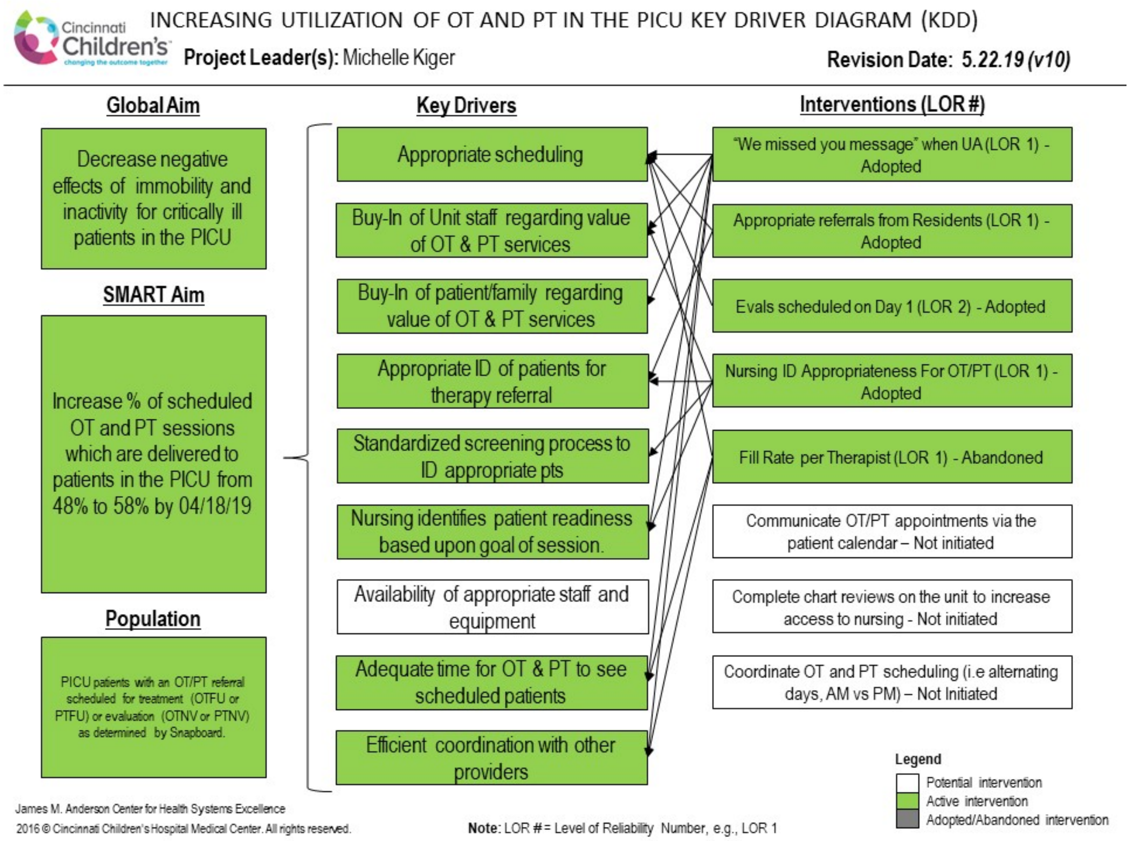

Figure 9. Key Driver Diagram Relating SMART Aim to Key Drivers and Interventions

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SMART Aim, Key Driver & Run Chart Assessment Tools

Is it a SMART Aim?

S - Specific	
M - Measureable	
A - Actionable	
R - Relevant	
T - Time Bound	

Components of a SMART Aim

Increase/Decrease... (Measure)	
From... (Baseline)	
To... (Goal)	
By When... (End Date)	

Is it a Key Driver?

Stated in the affirmative	
Stated as a WHAT	
Specific not vague	
Linked to the Aim	
Written as nouns with descriptors	
Followed template standards	

Key Elements of a Run Chart

1st title is measure in SMART Aim; 2nd title is time period	
Well defined X & Y axes	
Time on x-Axis	
Sample size noted on x-Axis	
Goal line (dotted/dashed green)	
Median line (solid red)	
Arrow indicating "good"	
Interventions annotated (with data labels & arrows)	
Unexpected events annotated (different color shading than interventions)	

Figure 6. RCIC Assessment tool to ensure SMART Aim, Key Drivers, Run Charts, PDSAs & Ramps meet all criteria (Luzader, 2018)

List of Change Concepts

A. Eliminate Waste

1. Eliminate Things That Are Not Used
2. Eliminate Multiple Entry
3. Reduce or Eliminate Overkill
4. Reduce Controls on the System
5. Recycle or Reuse
6. Use Substitution
7. Reduce Classifications
8. Remove Intermediaries
9. Match the Amount to the Need
10. Use Sampling
11. Change Targets or Set Points

B. Improve Work Flow

12. Synchronize
13. Schedule into Multiple Processes
14. Minimize Handoffs
15. Move Steps in the Process Close Together
16. Find and Remove Bottlenecks
17. Use Automation
18. Smooth Work Flow
19. Do Tasks in Parallel
20. Consider People as in the Same System
21. Use Multiple Processing Units
22. Adjust to Peak Demand

C. Optimize Inventory

23. Match Inventory to Predicted Demand
24. Use Pull Systems
25. Reduce Choice of Features
26. Reduce Multiple Brands of Same Item

D. Change the Work Environment

27. Give People Access to Information
28. Use Proper Measurements
29. Take Care of Basics
30. Reduce Demotivating Aspects of Pay System
31. Conduct Training
32. Implement Cross-Training
33. Invest More Resources in Improvement
34. Focus on Core Processes and Purpose
35. Share Risks
36. Emphasize Natural and Logical Consequences
37. Develop Alliance/Cooperative Relationships

E. Enhance the Producer/Customer Relationship

38. Listen to Customers
39. Coach Customers to Use Product/Service
40. Focus on the Outcome to a Customer
41. Use a Coordinator
42. Reach Agreement on Expectations
43. Outsource for "Free"
44. Optimize Level of Inspection
45. Work with Suppliers

F. Manage Time

46. Reduce Setup or Startup Time
47. Set up Timing to Use Discounts
48. Optimized Maintenance
49. Extend Specialist's Time
50. Reduce Wait Time

G. Manage Variation

51. Standardization (Create a Formal Process)
52. Stop Tampering
53. Develop Operational Definitions
54. Improve Predictions
55. Develop Contingency Plans
56. Sort Product into Grades
57. Desensitize
58. Exploit Variation

H. Design Systems to Avoid Mistakes

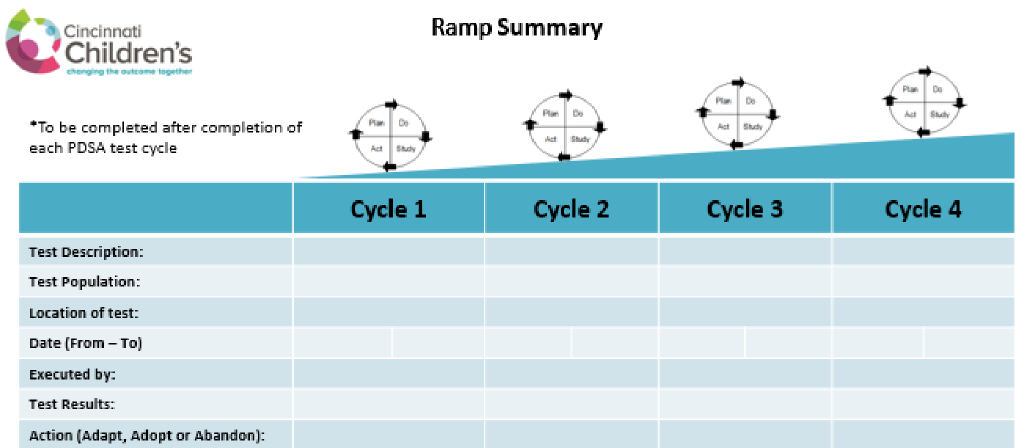
59. Use Reminders
60. Use Differentiation
61. Use Constraints
62. Use Affordances

I. Focus on the Product or Service

63. Mass Customize
64. Offer Product/Service Anytime
65. Offer Product/Service Anyplace
66. Emphasize Intangibles
67. Influence or Take Advantage of Fashion Trends
68. Reduce the Number of Components
69. Disguise Defects or Problems
70. Differentiate Product Using Quality Dimensions
71. Change the order of process steps
72. Manage uncertainty, not tasks

Source: Adapted from The Improvement Guide: A Practical Approach to Enhancing Organizational Performance, 2nd Edition; G. Langley, K. Nolan, T. Nolan, C. Norman, & L. Provost, 2009 page 132
Provided by: The James M. Anderson Center for Health System Excellence – July 2018

Figure 7. Change concepts to consider when designing interventions in Luzader (2018), adapted from Langley et al. (2009)



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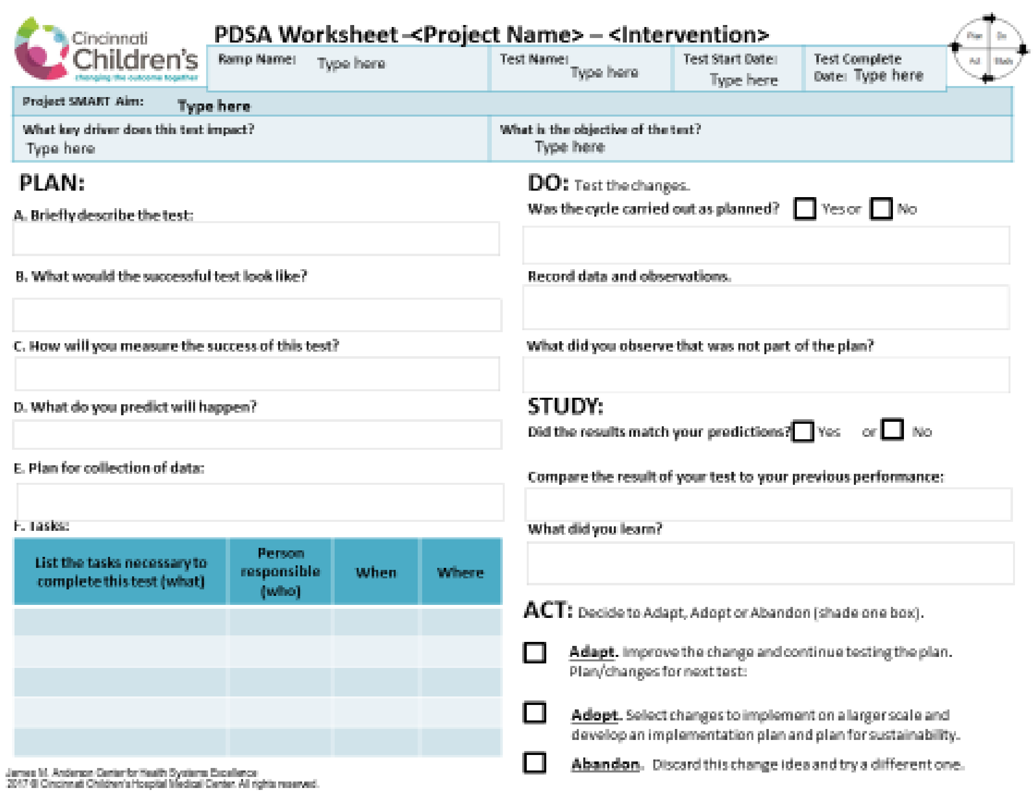
Ramp Summary

*To be completed after completion of each PDSA test cycle

	Cycle 1	Cycle 2	Cycle 3	Cycle 4
Test Description:				
Test Population:				
Location of test:				
Date (From – To)				
Executed by:				
Test Results:				
Action (Adapt, Adopt or Abandon):				

Figure 10. PDSA Ramp Planning Tool Which will Combine Change Common to a Single Theme (Luzader, 2018).



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PDSA Worksheet –<Project Name> – <Intervention>

Ramp Name: Type here | Test Name: Type here | Test Start Date: Type here | Test Complete Date: Type here

Project SMART Aim: **Type here**

What key driver does this test impact? Type here

What is the objective of the test? Type here

PLAN:

A. Briefly describe the test:

B. What would the successful test look like?

C. How will you measure the success of this test?

D. What do you predict will happen?

E. Plan for collection of data:

F. Tasks:

List the tasks necessary to complete this test (what)	Person responsible (who)	When	Where

DO: Test the changes.

Was the cycle carried out as planned? ☐ Yes or ☐ No

Record data and observations.

What did you observe that was not part of the plan?

STUDY:

Did the results match your predictions? ☐ Yes or ☐ No

Compare the result of your test to your previous performance:

What did you learn?

ACT: Decide to Adapt, Adopt or Abandon (shade one box).

☐ **Adapt.** Improve the change and continue testing the plan. Plan/changes for next test:

☐ **Adopt.** Select changes to implement on a larger scale and develop an implementation plan and plan for sustainability.

☐ **Abandon.** Discard this change idea and try a different one.

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Figure 11. PDSA Worksheet That Will be Used for Each Test (Luzader, 2018).

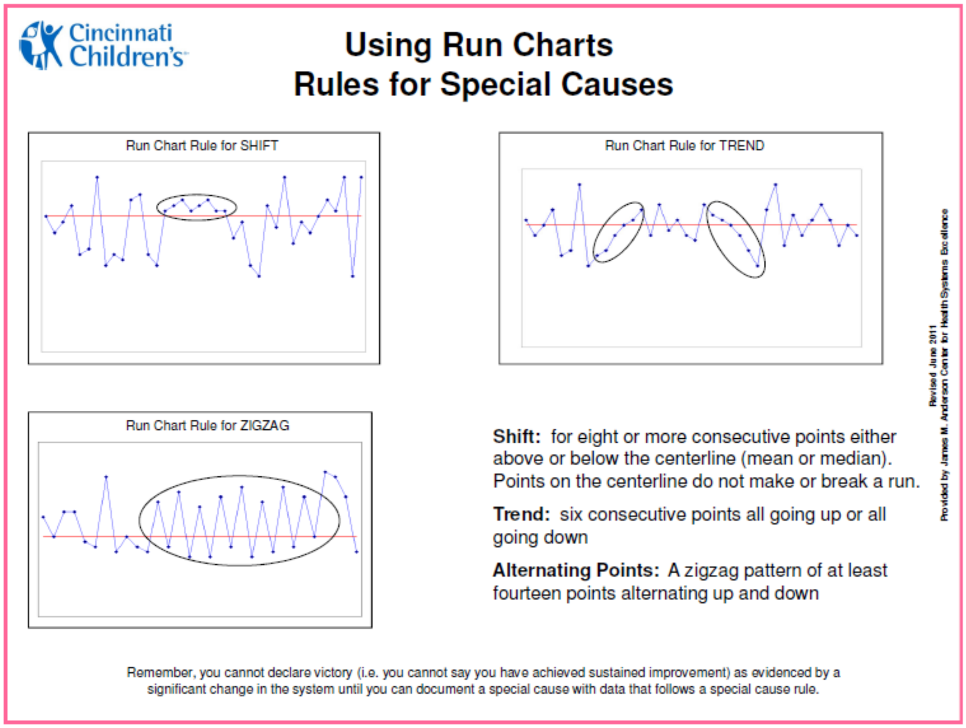

Figure 13. Special Cause Rules Applied to a Run Chart (Luzader, 2018)

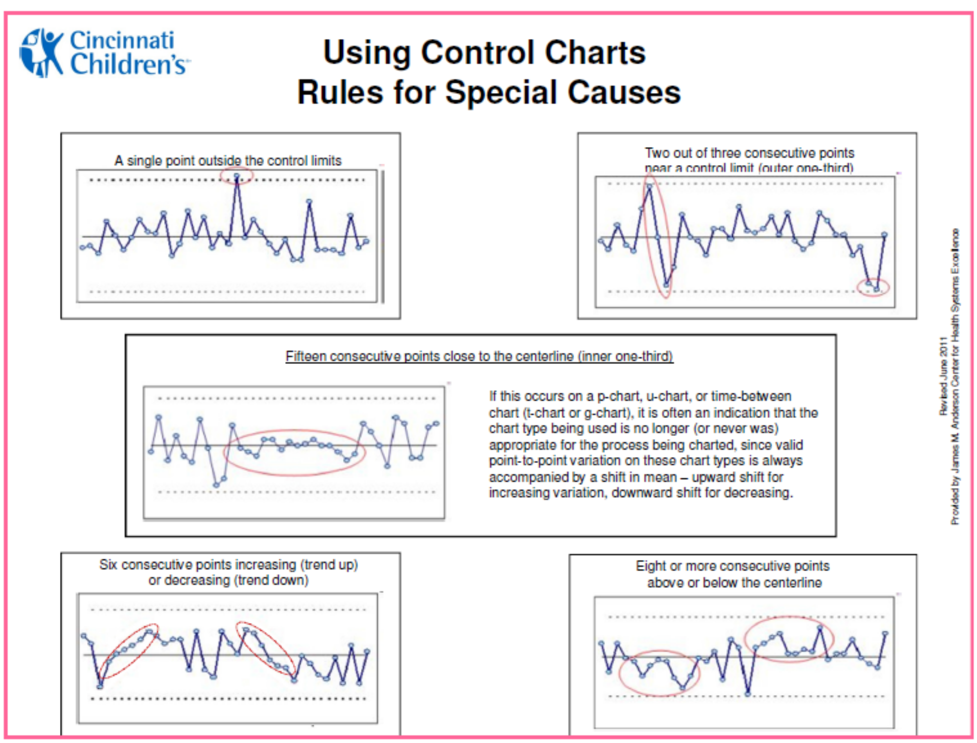

Figure 14. Special Cause Rules Applied to a Control Chart (Luzader, 2018).

Appendices

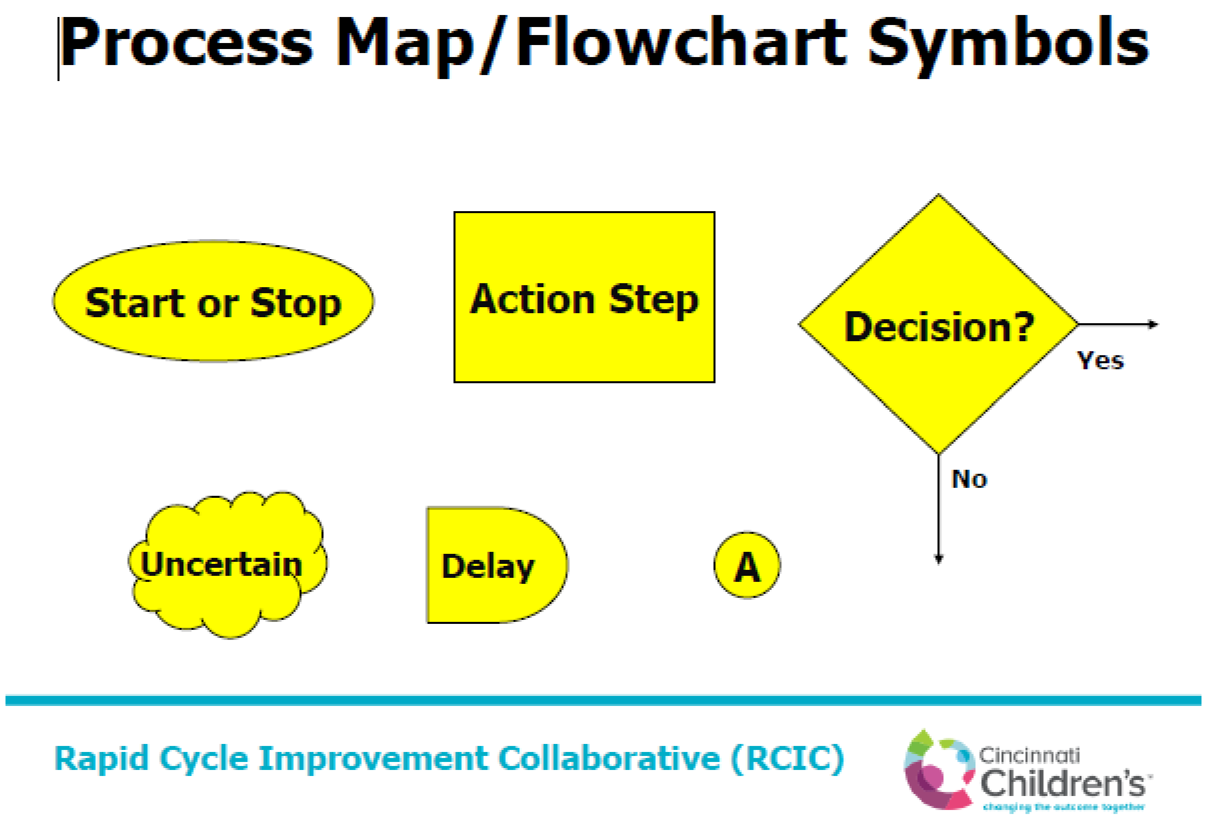

Figure A1. Process map symbols used to visually depict the sequence of activities and decisions in a process (Luzader, 2018).