Individual QI projects from single institutions

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The Nationwide Children's Hospital Blood and Marrow Transplant Index: A Quality Improvement Approach to Assess the Performance of a Pediatric Blood and Marrow Transplant Program

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ABSTRACT

Introduction: To design and test a metric that reflects the overall quality and safety performance of our blood and marrow transplant program (BMT) and use this metric to enhance the quality of care provided to patients. **Methods:** The BMT index (BMTI) aggregates safety events and missed opportunities for best practices into a composite score that reflects the overall clinical performance of the BMT program, irrespective of the type of transplant or patient outcome. We selected 13 domains and divided them based on the time in the transplant continuum. The BMT journey has 3 general spheres: (1) the pretransplant, (2) the transplant admission, and (3) the posttransplant follow-up and long-term care. The BMTI represents the total count of adverse safety events or missed opportunities to deliver quality care within a given period within these domains. In this regard, lower aggregate BMTI scores reflect higher quality care and improved overall systems performance. **Results:** The BMTI was easy to calculate and monitor. The annual BMTI aggregate score progressively decreased from a baseline of 133 in year 1 to 35 in year 3 (73.68% reduction), leading to a follow-up version of the BMTI that addressed new domain measures and achieved sustained mode. **Conclusions:** The BMTI is a valuable metric for monitoring the efficiency of the BMT service quality improvement initiatives. This concept applies to other programs. Specifically, the index documented the ability to improve the quality of patient care and provide consistent, evidence-based care. *(Pediatr Qual Saf 2025;10:e811; doi: 10.1097/pq9.0000000000000811; Published online April 30, 2025.)*

INTRODUCTION

Blood and bone marrow transplant (BMT) outcomes are commonly assessed in terms of survival, encompassing overall and disease-free survival rates. BMT, a procedure fraught with high risk, demands a multidisciplinary approach to cater to the diverse and medically complex patient population it serves. Risks associated with BMT vary depending on individual patient factors, underlying disease, donor source, and transplant regimen. Hospital mortality rates can reach up to 11%, particularly for patients undergoing allogeneic transplantation. Approximately 30% of patients require intensive care unit support, 33% develop graft-versus-host disease, and infectious complications occur in 26% of patients.[1] During the past 2 decades, external quality review organizations in the United States and internationally have established benchmarking standards for BMT centers to improve patient outcomes.[2] Meeting national benchmarks necessitates efforts at the institutional level to enhance patient outcomes. In 2009, our hospital initiated the zero hero patient safety/high-reliability program, which provided our oncology-BMT programs with a framework and unit-level data to develop and perform quality improvement (QI) initiatives driven by safety performance data.[3] Although endeavors to diminish patient harm are crucial, they may not comprehensively address the performance of the BMT program across the continuum of services provided over time.

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We designed the BMT index (BMTI) along the lines of a multiple metric QI dashboard.[4–6] BMTI is a dynamic metric that combines multiple BMT-specific QI projects to reflect the BMT program's overall quality and safety performance. The index can facilitate overall program QI. A comprehensive review of adverse events and patient care processes within the BMT program identified gaps in care that required attention. The specific aim of this project was to reduce the BMTI score by 10% from baseline within 12 months and sustain it for 6 months.

METHODS

As a QI initiative, this study did not involve human subjects research, exempting it from institutional review board approval at Nationwide Children's Hospital.

First, we identified an initial list consisting of 17 domains. A team of multidisciplinary experts, including physicians, advanced practice providers, nursing staff, and quality teams, evaluated each domain's potential for maximum impact, support, and agreement among relevant teams, ensuring alignment with the institutional strategic plan. The group agreed to include 13 domains in the BMTI, comprising 11 process measures and 2 outcome measures. The domains were organized according to the various stages of care within the transplant continuum: pretransplant, transplant admission, posttransplant follow-up, and long-term care. A lower BMTI score signified enhanced overall care processes. We tracked and audited the BMTI monthly over 3 years. During this timeframe, the team revised the BMTI by integrating new domains to address emerging QI measures. The principal objective of this iterative methodology was to identify avenues for enhancement and accurately reflect how the program met the needs of patients and regulatory requirements.

Domain Definitions and Metrics

The first version of the BMTI includes the 13 domains (Table 1).

Domains Related to the Pretransplant Period

The Informed Consent Documentation in EMR

BMT is a complex and high-risk intervention often offered to patients with no other curative treatment options. Informed consent is essential for shared decision-making and compliance with ethical and legal standards.[7] Required elements of consent include (1) the nature of the procedure, that is, BMT; (2) risks and benefits of BMT; (3) discussing other treatment options, when applicable; (4) risks and benefits of alternatives; and (5) assessment of the patient's and parent's understanding. Incorporating consent documentation in the EMR facilitates tracking and auditing by administrative staff to ensure compliance. Failure to perform and document these consent elements in the electronic medical record (EMR) counts as a BMTI event.

Fertility Preservation Counseling

Preserving reproductive potential has long-range implications for each patient.[8,9] All patients undergoing BMT must have a consultation with the fertility and reproductive health team to discuss the impacts of transplant on fertility and available options for fertility preservation, including Lupron/Aygestin, ovarian tissue cryopreservation, testicular tissue cryopreservation, and sperm banking. This consultation must be documented in the EMR. Lack of documentation is a BMTI event.

Pretransplant Donor Eligibility Documentation

Determining allogeneic donor eligibility for stem cell collections performed at a collection center is a Foundation for the Accreditation of Cellular Therapy (https://factglobal.org/) requirement. It ensures recipient safety by assessing the risk of transmitting infections to the recipient.[10,11] The lack of physicians' eligibility documentation can lead to unforeseen delays in insurance approval of stem cell collection through downstream delays in documentation by coordinators. NCH (Nationwide Children's Hospital) requires a donor eligibility note in the EMR before the donor undergoes a bone marrow harvest or stem cell collection. The absence of documentation at the time of donation is a BMTI event.

Order Entry and Verification ≥48 hours Preadmission

Pretransplant conditioning orders require attention to detail. The BMT physician or advanced practice provider should enter orders cosigned by a second provider before admission.[12–14] To ensure adequate time for pharmacy review and ordering agents not routinely stocked, we established a target of having orders entered in the electronic medical record treatment plan at least 48 hours before admission to reduce errors. This practice also facilitates the timely initiation of conditioning chemotherapy for patients beginning treatment on the same day of admission.[15–17] Failure to place orders at least 48 hours before admission becomes a BMTI event.

The Transplant admission

Advanced Illness Management Consult on Admission <1 Business Day

Patients experience a high symptom burden in the first month after transplantation and value care focusing on quality of life.[18] The Advanced Illness Management (AIM) team, formerly the palliative care team, plays a crucial role in improving the quality of life in BMT.[19,20] The team evaluates the patient and the family in person to determine how to help families cope with the admission. Introducing palliative care early during treatment improves the quality of life and lessens depression and posttraumatic stress disorder post–stem cell transplantation by improving symptom burden and anxiety.[21,22] Hence, our goal was to provide these services to the patients within 24 hours of admission. Failure of the AIM

Table 1. BMTI Measures*

Pretransplant	Description	Rationale	Relevant References
Consent documentation in EMR	Notes should be documented in the EMR describing the informed consent discussion for BMT	Improve workflow for administrative staff to ensure compliance with legal and ethical standards	
Fertility preservation counseling	Consultation with the fertility and reproductive team regarding the impact of BMT on fertility and available fertility preservation options should be documented in the EMR	Improve utilization of fertility preservation strategies	6,7
Pretransplant donor eligibility documentation	Note should be documented in the EMR describing whether an allogeneic stem cell donor is eligible based on the screening donor history questionnaire. If the donor is ineligible, the reason for should be mentioned in the note	Decrease the risk of communicable infection in transplant recipients from stem cell products. Ensure compliance with regulatory standards	8,9
Order entry and verification ≥48 h before transplant admission	Orders for the chemotherapy regimen to be given before stem cell infusion should be entered in the EMR at least 48 h before the patient is admitted for BMT	Decrease the risk of chemotherapy errors and ensure timely initiation of conditioning chemotherapy on the day of admission	10–15
The transplant admission			
Advanced illness management consult on admission <1 business day	The AIM team should be consulted within 1 d of admission	Improve patient symptom burden	16–20
Medication reconciliation on admission	The admitting provider should reconcile home medications on admission to the BMT unit and document in the EMR	Decrease the risk of medication errors	21
Psychology/social worker consult placed upon admission	Psychology, social work and other psychosocial services (therapeutic recreation, music therapy) should be consulted on admission	Improve mental health-related quality of life and coping skills	22–26
PHI (CLABSI, adverse drug events, hospital-acquired infections)	Hospital metric to track real-time harm events	Decrease preventable harm events	3,27,28
Time to antibiotics <60 min	Antibiotics should be administered within 60 min of documented fever in a patient admitted for BMT	Decrease sepsis-related morbidity and mortality	29–31
Standardized treatment regimen followed	Conditioning regimens for common indications should follow standardized institutional roadmaps and order sets in EHR	Decrease the risk of errors and standardize care	
Tacrolimus infusion through dedicated lumen on central line	Tacrolimus should be infused through a dedicated lumen on the central line	Decrease the need for venipuncture to determine accurate tacrolimus levels	
Posttransplant			
Influenza vaccination	All patients >6 mo of age should receive inactivated influenza vaccine if they are at least 4 mo post-BMT	Decrease influenza-related morbidity post-BMT	32,33
Initiation of revaccinations at 6 mo	All patients should start revaccination post-BMT at 6 mo	Increase revaccination rates post-BMT and decrease risk of morbidity due to vaccine-preventable diseases in BMT recipients	32,33

Domains selected for the inclusion in the first version of the BMTI.
*Other domains that were initially considered included documentation of patient weight on admission in the admission history and physical note, documentation of chemotherapy orders reviewed by 2 providers, and patient room cleaning and treatment errors. These domains were not included in the final list due to a combination of factors, including lack of buy-in from all stakeholders and lack of alignment in the institutional strategic plan or low potential of impact.
EHR, Electronic Health Record.

team to initiate a referral and consultation within that timeframe, or if a family refuses a consultation with an AIM team physician, counts as a BMTI event. The literature indicates that patients generally accept the early integration of palliative care.[18] In the event of inadequate staffing, the teams work collaboratively to determine a different day to meet with the family, which is not counted as a BMTI event.

Medication Reconciliation on Admission

On admission, the treating team should thoroughly review the home medication list and check for accuracy and redundancy before starting treatment. Inadequate review can lead to medication errors and confusion among caregivers.[13,23] Documenting medical reconciliation in EMR is an objective gauge of completing reconciliation. Failure to document reconciling the patient's medication list in the EMR during admission counts as a BMTI event.

Psychology/Social Worker Consult Placed Upon Admission

Psychosocial needs are essential and well-documented in this population.[24–28] To reach all BMT patients, the psychology team at our center has created a psychosocial

assessment bundle. This collection comprises a set of assessments with related interventions intended to address all relevant issues. Each patient should be referred to psychology, social work, recreational therapeutics, and an education specialist, when age-appropriate, who performs a needs assessment. Failure to consult psychology/social work on admission constitutes a BMTI event.

Healthcare-Associated Infections and Preventable Harm

Any infection is dangerous to children with compromised immune systems. Specific teams within the hospital epidemiology department identify and investigate infections with input from the BMT providers involved in the patient's care. The hospital-wide safety group captures catheter-associated bloodstream infections (CLABSI), catheter-associated urinary tract infections, surgical site infections, and ventilator-associated pneumonia as part of the hospital's preventable harm index (PHI).[3] They are counted in the BMTI through the same mechanism. Although fungal infections and upper respiratory tract viral infections are usually not problematic for healthy children, they can be a significant hazard for BMT patients, so they are tracked and included in the BMTI if hospital-acquired.[29,30]

The hospital uses PHI as an essential metric to track and address real-time safety events. In addition to previously described healthcare-associated infections, the PHI tracks other harm categories, including adverse drug events, pressure ulcers, non–intensive care unit cardiac arrests, significant surgical complications, serious falls, and other serious safety events. The sum of these safety events, documented monthly in the BMT population, is added to the cumulative BMTI.

Standardized Treatment Regimen Followed

Due to significant variations observed in conditioning regimens ordered by different physicians, our program developed standard operating procedures and standard treatment plans for common diagnoses and donor sources. Multidisciplinary input from pharmacists, physicians, advanced practice providers, and nurses finalized the regimens. These regimens were built into order sets within the oncology medication ordering module of the EMR. The clinical team reviewed the treatment regimens for all upcoming patients planned to be admitted for transplantation; at this time, the team determined if the variation was clinically justified. Any variation requires deviation reporting and comprises a BMTI event unless clinically indicated.

Tacrolimus Infusion through Dedicated Lumen of Central Line

Tacrolimus, an immunosuppressive drug commonly used for graft-versus-host disease prophylaxis, is usually administered via a dedicated central venous line (CVL), and trough levels are drawn from the unexposed lumen. Being an oil-based medication, tacrolimus may be adsorbed to the inner lumen of the CVL and result in falsely high levels drawn from an inadvertently exposed lumen. Not infusing tacrolimus in the dedicated line may contaminate both lumens and require peripheral venipuncture for level monitoring. Each incorrect line usage for tacrolimus administration initiates an incident report, which we tracked as BMTI events.

Time to Antibiotics <60 Minutes

Best practice requires prompt antibiotic administration to feverish patients post-BMT regardless of their neutropenia status—within 60 minutes after emergency department (ED) or hospital arrival or when they become febrile on the inpatient unit.[31–33] If that time exceeds 60 minutes, it is a BMTI event.

Posttransplant

Influenza Vaccination

In collaboration with the infectious disease team, we established institutional guidelines for reimmunization posttransplantation. These guidelines included seasonal influenza vaccination as well. All patients >6 months should receive inactivated influenza vaccine annually beginning 4 months after transplant during influenza season. If given early in the season, patients may require a second dose in the first year (determined by the infectious disease team).[34,35] Patients with a life expectancy measured in months and under hospice care are excluded. Otherwise, failure to administer the influenza vaccine is a safety event that should be added to the BMTI. Vaccine refusal also constitutes a safety event.

Initiation of Revaccinations at 6 Months

Antibody titers to vaccine-preventable diseases decline after autologous or allogeneic BMT, irrespective of prior vaccination status. Such diseases pose increased risks for BMT recipients until immunity is fully restored. Therefore, except for viruses exhibiting latency outside the hematopoietic system (eg, varicella), BMT recipients should be revaccinated against pathogens contained in childhood primary immunization schedules starting at 6 months.[34,35] Our institutional guideline requires all patients to start reimmunization at 4–6 months after transplantation. We excluded patients with immune deficiency who were still receiving immunoglobulins and patients within six months post-anti-CD20 monoclonal antibody. Otherwise, failure to initiate vaccines at six months (±1 mo) becomes a BMTI event. Vaccine refusal also constitutes a safety event.

Data Acquisition and Auditing

All charts were audited monthly by the BMT program quality manager to ensure compliance with expectations in each domain. Initially, baseline data were collected for

a year, followed by a monthly prospective data collection. The BMT program, QI teams, and division leadership received monthly updates on cumulative year-to-date BMTI data. The entire division received overall results quarterly. We plan to repeat the same process every 3 years with some domain modifications to address new areas of potential improvement and remove some domains without further evaluation due to the positive sustainability of outcome or process measures.

Statistical Analysis

Data were summarized with frequency and percentage. Fisher exact tests were utilized to compare the components of the BMTI between baseline and year 2. No formal statistical hypotheses were planned a priori. However, due to the relatively small sample size, we decided to test the hypothesis that the proportion of transplants in which components of the BMTI were observed was statistically different after implementing the QI initiative.

RESULTS

The BMT quality meeting received monthly data reports, discussed trends, and developed action plans for noted patterns. The annual BMTI aggregate score progressively decreased from the baseline of 133 in year 1 to 35 in year 3 (73% reduction). The number of BMT patients per year was similar (n = 46 patients for years 1 and 2 and n = 43 for 3). The number of safety events across all domains of the BMTI each month is graphed over 3 years on a statistical process control C-chart (Fig. 1). The first 12 months serve as the baseline. After the launch of BMTI, the process mean shifted from 11.3 to 3.9 within 3 months. This change was sustained over the next 20 months.

The breakdown of the annual BMTI by the number of missed opportunities or safety events per domain (pretransplant, transplant, and posttransplant) is illustrated in Table 2. Some missed opportunities were zero at baseline as the BMT team consistently demonstrated 100% performance with fertility counseling, pretransplant donor eligibility documentation, medication reconciliation on admission, psychology/social worker consult placed upon admission, and influenza vaccinations during the evaluation period. The areas demonstrating a significant improvement over time were order entry and verification ≥48 hours preadmission, advanced illness management consult upon admission, and standardized treatment regimen followed ($P < 0.0001$).

PHI (CLABSI, adverse drug events, hospital-acquired infections) and time to antibiotics <60 minutes did not show improvement over the study period. CLABSIs drew most of the safety events related to the PHI (Table 2). We implemented further interventions to address these events.

DISCUSSION

Healthcare systems often utilize composite measures, such as the PHI and the serious harm event index, to consolidate data from various preventable patient harm events and provide a comprehensive evaluation of patient safety initiatives.[36] In 2009, NCH introduced PHI to quantify patient safety events within specified timeframes. A lower PHI value signifies fewer events, correlating with improved outcomes and performance. Its simplicity and ease of understanding have facilitated its utility as a driving force in eliminating preventable harm.[3,37,38] Developing the cancer care index (CCI) extended this concept to the cancer program by encompassing 15 domains across the cancer care continuum. A lower CCI reflects enhanced overall care processes.[4]

We devised the BMTI, building upon the foundational framework of the PHI and CCI. The BMT journey has 3 general spheres: (1) pretransplant, (2) transplant admission, and (3) posttransplant follow-up and long-term care. Optimal outcomes necessitate comprehensive attention to all 3 areas. Metrics pertinent to transplant diagnosis and treatment must gauge the program's proficiency to accurately deliver treatment protocols and assess the adequacy of patient evaluation and education regarding treatment options.

Like the PHI, the BMTI and its metrics are not directly comparable across different institutions. Moreover, the BMTI lacks standardized definitions and fails to normalize the frequency of missed opportunities or safety events based on population size and the severity of underlying diagnoses (eg, BMT for relapse disease versus bone marrow failure syndrome). Nonetheless, the BMTI encompasses distinct safety events or missed opportunities deemed crucial by the team, aiming to achieve zero value through QI interventions. Each mitigated missed opportunity contributes to the overall performance of the BMT group, translating into optimal patient care.

Areas exhibiting statistically significant improvement include order entry and verification within two days before BMT admission and advanced illness management consultations. Because admission orders for BMT are intricate and detailed, having these orders available for pharmacy review can prevent medication errors that jeopardize patient safety. Advanced illness management, synonymous with palliative care, is pivotal in delivering holistic care to this patient population, offering end-of-life care and symptom control during BMT.[19–22]

The reasons for the lack of statistically significant change in some domains are likely multifactorial. The number of safety events for some domains was too low. At the same time, adequate data were not collected/available for statistical calculations in certain other domains (eg, PHI and tacrolimus administration through a dedicated line). However, we speculate that interventions targeting changes in the system or electronic medical record are more likely to result in sustained improvement

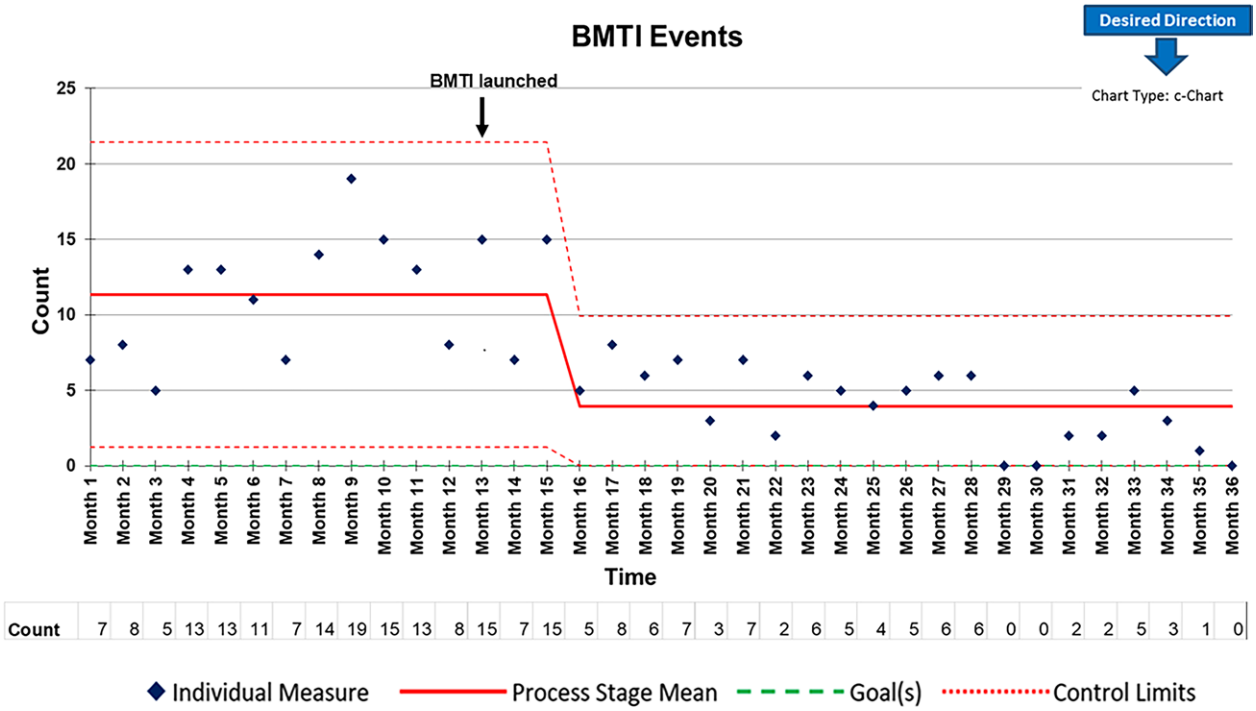

Fig. 1. Number of safety events across all domains of the BMTI each month over 3 years.

than interventions that require altering individual practice. Significant challenges persist in areas like time to antibiotics and PHI, where no improvement has been observed. Despite the nursing staff's compliance with CVL-associated care protocols, CLABSIs primarily drove up the PHI. Various interventions, including prophylactic antibiotics during neutropenia, have been implemented to mitigate CLABSIs. Efforts to reduce the time to antibiotics administration (<60 min) for febrile patients with CVLs are ongoing, encompassing strategies such as proactive communication with families and expedited evaluation in the ED with enhanced ED nursing staff education. Moreover, in cases of fever onset in the inpatient setting, prompt notification to pharmacy and bedside nurses is prioritized to facilitate urgent antibiotic administration.

Of note, 11 BMTI measures were process-related, and the measures with significant improvements belonged to this category. This observation suggests that although process improvements are often a prerequisite for better outcomes, they do not always lead to improved outcomes. A high-performing program with standardized, consistently followed practices is better positioned to improve outcomes. Thus, this work provides a strong foundation for continued process improvement and better outcomes in the future.

Detecting safety events can gauge the efficacy of harm prevention, whereas the frequency of specialized

Table 2. Breakdown of the Annual BMTI by Number of Missed Opportunities in Each Domain

Year	Baseline (n = 46)	Year 1 (n = 46)	Year 2 (n = 43)	Baseline vs Year 2, *P*
Pretransplant				
Informed consent documentation	5	0	0	0.0554
Fertility preservation counseling	1	0	0	0.99
Pretransplant donor eligibility documentation	0	0	0	N/A
Order entry and verification ≥ 2 d preadmission	34	20	8	<0.0001
Transplant Admission				
Advanced illness management consult on admission <1 business day	25	9	1	<0.0001
Medication reconciliation on admission	0	0	0	N/A
Psychology/social worker consult placed upon admission	0	0	0	N/A
PHI (CLABSI, adverse drug events, hospital-acquired infections)	19	16	21	N/A*
Standardized treatment regimen followed	37	36	0	<0.0001
Time to antibiotics < 60 min	5	3	4	N/A*
Tacrolimus administration in dedicated lumen	3	0	0	N/A*
Posttransplant				
Influenza vaccine	0	0	0	N/A
Revaccinations at 6 mo posttransplant	4	0	1	0.36

**P* value unable to be calculated due to inadequate data. (There were multiple line entries and drug administration events associated with each patient. This information was not available.)
N/A, Not applicable.

support services such as psychology and social work can evaluate psychosocial support provision. The BMTI is a comprehensive metric representing the total safety events or missed opportunities in BMT care across 13 domains. Multidisciplinary teams have been instrumental in driving metrics for each BMTI domain toward zero. We hypothesize that leveraging the BMTI alongside targeted QI initiatives will continue to enhance overall care.

CONCLUSIONS

In conclusion, the BMTI is a valuable metric in monitoring the efficacy of QI initiatives within the BMT service. In addition to preventing avoidable harm, BMTI highlights the consistent delivery of evidence-based care and psychosocial support. Leveraging the BMTI as an outcome metric, alongside other QI endeavors, has yielded significant improvements in BMT program performance.

Moreover, the adaptable nature of the BMTI framework presents a broader application across various healthcare programs. The ability to customize domains based on program-specific needs renders it a versatile tool for enhancing performance and patient outcomes. As such, the BMTI is a model for other healthcare programs seeking to implement systematic QI measures. BMTI's success underscores its potential as a valuable resource in promoting excellence in patient care across diverse medical specialties.

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