DETERMINING IMMUNIZATION READINESS FOLLOWING HEMATOPOIETIC CELL TRANSPLANT

A DOCTOR OF NURSING PRACTICE PROJECT SUBMITTED TO THE GRADUATE DIVISION OF THE UNIVERSITY OF HAWAI`I AT MĀNOA IN THE PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF NURSING PRACTICE

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ABSTRACT

Hematopoietic cell transplant (HCT) following treatment for pediatric cancer has allowed for survivors to live longer, fuller lives. Infections following transplant can be life threatening, and for some, preventable. Re-immunization for vaccine preventable diseases are a vital post-transplant follow-up and should be administered to the pediatric patient. Previously, the only recommendations to determine re-immunization readiness was time since transplant, with many providers using various variables to determine readiness on their own, without a center specific guideline.

This project aimed to develop and implement a guideline to be utilized by providers, in a pediatric hematology and oncology department, to determine re-immunization readiness following hematopoietic cell transplant in the pediatric patient. A presentation was made at a hematology and oncology pediatric provider meeting. This presentation reviewed the current literature and outlined a plan to create and implement a flowsheet guideline for determining readiness to initiate immunizations post-transplant. A survey was conducted to assess provider practice for determining immunization eligibility. A second survey was distributed pre- and post-guideline implementation in order to determine provider acceptance of the change and utilization of the practice guideline.

A guideline was created, approved, and presented to the providers based on literature and current practice. This guideline may be used to assist Hematology and Oncology providers in determining immunization readiness following hematopoietic cell transplant. Utilization of the created guideline may prevent delays in re-immunization and ensure protection of pediatric post-HCT patients against vaccine-preventable diseases.

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Introduction to Problem, Background, and Significance

Along with chemotherapy and radiation, hematopoietic cell transplantation (HCT) has become a prominent and successful treatment for cancer, especially for those with the most aggressive forms of disease (Shimoni, Labopin & Savani, 2016 and Gooley, Chien, & Pergam, 2010). While survivors post-HCT are living longer, fuller lives, they risk long term effects of treatment related to chemotherapy, radiation, and transplant (Battiwalla, Tichelli, & Majihail, 2017 and Maijhail et al, 2012). Among these, infectious diseases that are preventable by vaccines are a major concern for the post- HCT patient as their specific antibody levels decrease significantly after hematopoietic stem cell transplant (Giebink, Warkentin, Ramsay, & Kersey, 1986). Recommendations are that once the patient is cleared by the transplant team, the immunizations for Pneumococcal conjugate, Tetanus, Diphtheria, acellular Pertussis (DTaP<7yo or Tdap >7yo), Haemophilus Influenzae, Inactivated Polio, and Recombinant Hepatitis B immunizations should be re-initiated in order to achieve immunity (Maijhail et al., 2012, Tomblyn et al., 2009, and Ljungman et al., 2009).

Post-hematopoietic cell transplant patients are at increased risk of acquiring these diseases due to their compromised immune systems and decreased production of antibodies post transplantation (Ballen et al., 2016, Gibink, Warkentin, Ramsay, & Kersey, 1986, Ljungman et al., 2009, and Hann Su et al., 2011). Due to the success of stem-cell transplant in eradicating the primary malignancy, patients have longer lifespans. Restoring immunity to infectious diseases through re-vaccination can play a major role in safeguarding these gains. However, a report from the Center for Disease Control and Prevention (CDC) in 2018 found that the completion rates for the combined 7-vaccine series in well children 19-35 months of age was only 70.4%. Diminishing herd immunity means this is not a reliable safeguard against vaccine preventable

disease spread, making patient immunization critical. It is therefore necessary to protect immunocompromised individuals from acquiring these potentially critical or life-threatening vaccine preventable diseases, as they can experience increased complications from infection (Ballen et al., 2016, Young et al., 2016, Hann Su et al., 2011).

There are no current standardized guidelines for determining readiness for initiation of re-immunizations after transplant (Top, et.al., 2016, Majhail, et.al., 2012, Mehta & Rezvani, 2016, Ogonek, et.al., 2016). Without standardized guidelines, patients may experience a delay in re-immunization, ultimately placing them at increased risk for these vaccine preventable diseases.

Needs Assessment

Kapiʻolani Medical Center for Women & Children (KMCWC) provides hematopoietic cell transplant and follow-up care for patients with various forms of pediatric cancer and blood disorders. Post-transplant follow-up care includes re-immunization against vaccine preventable diseases in addition to close follow up and monitoring for long-term side effects/toxicity from both the therapy received prior to transplant and the transplant itself. Through this quality improvement (QI) project, a guideline has been developed for pediatric hematology and oncology providers to determine patient readiness for re-immunization following hematopoietic cell transplant.

Literature Synthesis

Search Criteria and Grading of Evidence

A search of the literature was completed using PubMed and the Cumulative Index to Nursing and Allied Health Literature (CINAHL) databases. Search criteria included “immune reconstitution,” “HCT,” “titer,” and “immunization.” The search criteria were limited to the past 5 years. A total of 76 articles were reviewed, and these were narrowed down to 22 relevant

articles. Additional pertinent articles were obtained from the reference lists of these relevant articles.

Grading criteria for the evidence and the number of articles per level is described in Table I. Of the 22 articles reviewed, 8 journal articles were systematic reviews, 10 articles were randomized trials or cohort studies, one reviewed a descriptive study, one was a qualitative study and one authority opinion article.

Table I: Levels of Evidence from Ackley, Ladwig, Swan, & Tucker (2008)

Mosby's Level of Evidence		# of Articles (Total 22)
Level I	Evidence from a systematic review or meta-analysis	8
Level II	Evidence obtained from at least one well-designed RCT	0
Level III	Evidence obtained from well-designed controlled trials without randomization	1
Level IV	Evidence obtained from well-designed case-control or cohort studies	10
Level V	Evidence from systematic reviews of descriptive and qualitative studies	1
Level VI	Evidence from a single descriptive or qualitative study	1
Level VII	Evidence from the opinion of authorities and/or reports of expert committees	1

Recommendations for Immunization Post Hematopoietic Cell Transplant

Following chemotherapy, radiation, and hematopoietic cell transplant, patients lose their previously developed protective antibodies. In the course of transplant, the patients' own immune cells are replaced with those from their donors, and this "re-booting" of the immune system after transplant renders patients with an immature immune system similar to that of a

newborn baby. Consequently, after transplant, levels of protective antibodies decline, and without intervention, their transplanted, naïve immune systems are not able to regenerate these antibodies. Re-immunization is necessary to help train the new immune system to develop appropriate defenses. The literature agrees that immunizations should be administered following hematopoietic cell transplant. The recommended vaccines, number of doses, and time of initiation post-transplant can be found in Table II (Cordonnier, et. al., 2019, Kennedy, et. al., 2017, Ljungman, et. al., 2009, Majhail, et. al., 2012, Tomblyn, et. al., 2009, Top, et.al., 2016).

Table II: Immunization Recommendations

Vaccine	Initiation Time Post- HCT	Number of doses
Pneumococcal Conjugate (PCV)	3-6 months	3-4
Tetanus, diphtheria, acellular pertussis	6-12 months	3
Haemophilus influenzae conjugate	6-12 months	3
Meningococcal conjugate	6-12 months	1
Inactivated polio	6-12 months	3
Recombinant hepatitis B	6-12 months	3
Inactivated influenza	4-6 months	1-2
Measles- Mumps- Rubella (live)	> 24 months	1-2
Varicella	>24 months	1-2
HPV	12 months- follow recommendations and dosing for general population	

The initiation of vaccines is recommended to begin at 3-6 months post-HCT with the pneumococcal conjugate vaccine, at 6-12 months post-HCT for inactivated vaccinations, and at

>24 months for live-attenuated vaccinations (Cordonnier, et. al., 2019, Kennedy, et. al., 2017, Ljungman, et. al., 2009, Majhail, et. al., 2012, Tomblyn, et. al., 2009, Top, et.al., 2016).

These time frames vary depending on both patient and transplant-related factors, and vaccinations are usually initiated once the patient is cleared by the transplant team. Once cleared for re-vaccination, the recommended immunization schedule is often provided to the primary care provider for completion.

Recommendations for Immunization Clearance Following Hematopoietic Cell Transplant.

Despite the recommendations in Table II, there are no clear guidelines on the determination of immune competence that would signal the appropriateness to begin re-vaccination. If vaccines are administered too early, the body may not mount the appropriate immune response, which would lead to ineffective antibody production and potential increased risk of infection (Ljungman et. al., 2009). On the contrary, delaying vaccinations may place vulnerable post-transplant patients at risk of developing vaccine preventable infections (Chemaly, Shah, Boeckh, 2014, Cordonnier et.al., 2015, Gibink, Warkentin, Ramsay, & Kersey, 1986, Gooley, Chien, & Pergam, 2010, and Hann Su et.al., 2011).

The means to determine readiness to commence re-immunizations remains unclear. Many of the vaccination schedule recommendations state the time since transplant as the sole initiation guideline (Cordonnier, et. al., 2019, Kennedy, et. al., 2017, Ljungman, et. al., 2009, Majhail, et. al., 2012, Tomblyn, et. al., 2009, Top, et.al., 2016). However, besides time post-transplant, various laboratory indicators have been utilized to follow the progress of immune reconstitution. These markers include CD4+ T-cell count, absolute lymphocyte count, CD19+ B-cell count and CD8+ T-cell count (Dorn, et.al., 2018, Majhail, et. al., 2012, Mehta and Rezani, 2016, Hudspeth, Hill, Lewis, Van Meter, & Ragucci, 2010, Ogonek, et.al., 2016). A post-transplant rise in the

level of CD4+ T-cells to >200 cells/uL may occur 3 to 9 months following the hematopoietic cell transplant for pediatric patients, and research suggests this numeric value indicates the immune system's ability to launch an adequate response following re-immunizations (Carpenter and Englund, 2015, Kennedy, Li, Savani, and Ljungman, 2017, Ljungman et. al., 2009, Ogonek et.al., 2016). CD8+ T-cell count reconstitution may occur earlier than CD4+ T-cell count, therefore, the latter response may be a more stringent marker to assess readiness (Ogonek et. al., 2016, Mehta and Revani, 2016).

While a CD 4+ T-cell count is thought to be a marker for immunization readiness following transplant for pediatric hematologic malignancy (Forlenza, and Small 2013, Dorn et.al, 2018, Kennedy et. al., 2017, Ljungman et. al., 2009, Ogonek, et.al., 2016, Top et. al., 2016, Bate, Patel, Chisholm, & Heath, 2010, Carpenter & Englund, 2015, Hudspeth et. al., 2010, & Ariza-Heredia et.al., 2014), a survey of stem cell transplant centers revealed the use of multiple different standards to determine readiness for clearance (listed in Table III).

Table III: Variables Considered for Determining Timing of Vaccine Administration.

Age	Immunological Markers
Type of transplant	CD4+ >200/uL
aGVHD or cGVHD	CD19>20/uL
Immunosuppression medications	Absolute lymphocyte count >1000ul
Treatment with monoclonal antibodies Anti-CD20mAB< 6 months ago	CD4+ & CD8+ count
Time since transplant	T cell antigen proliferation
Current Steroids use	
Treatment with IVIG >2 months ago	

Depending on transplant center practices, different factors have been used to determine vaccine readiness (Forlenza, and Small 2013, Dorn et.al, 2018, Kennedy et. al., 2017, Ljungman et. al., 2009, Ogonek, et.al., 2016, Top et. al., 2016, Bate, Patel, Chisholm, & Heath, 2010, Carpenter & Englund, 2015, Hudspeth et. al., 2010, & Ariza-Heredia et. Al., 2014). Top et. al., (2016) determined there was no significant difference in timing between centers that tested serologic responses prior to immunization initiation and those that did not do complete serologic testing. Regardless of which factors are used to determine vaccine readiness, each transplant center should remain consistent in the means by which this is accomplished. Without a defined practice policy, there may be a delay in vaccination, or incomplete re-vaccinations that put the patients at increased risk of infection (Ariza-Heredia et. al., 2014).

Gaps and Limitations in the Literature

Gaps in the literature demonstrate the lack of a consistent guideline for determining immunization readiness other than time since transplant. Gaps also exist in best practices for tracking of re-immunizations following HCT, and the role oncologists play in re-immunization. There is limited literature regarding re-immunization barriers for the post-HCT patient and family.

PICO Statement

Compared to the current baseline, does initiating a center-specific guideline improve provider understanding of the criteria recommended for determining immunization readiness in the pediatric Stem Cell Transplant program at Kapiʻolani Medical Center for Women & Children (KMCWC)?

Purpose Statement Goals and Objectives

The purpose of this DNP quality improvement project was to develop and deploy an institutional guideline for providers treating pediatric and adolescent hematopoietic cell transplant recipients seen by KMCWC's Pediatric Hematology, Oncology and Stem Cell Transplantation program. This guideline may be utilized when determining eligibility and readiness to initiate re-immunization following hematopoietic cell transplant. The goals of this QI project were to determine provider readiness for change, to assess their understanding of re-immunization readiness guidelines, and to initiate a consistent practice guideline within the department.

Theoretical Framework

The Plan, Do, Study, Act theoretical model was used to guide this practice change. The steps of the model included developing a plan to carry out the objective, carrying out that plan, analyzing the data, and determining what was learned and what changes should be made prior to the next implementation cycle. (Institute for Healthcare Improvement, n.d.)

The plan began with the selection of the topic, which occurred with the recognition by the Hematology and Oncology providers at KMCWC that there was a need for immunization readiness guideline development and implementation. The team and stakeholders included oncology providers the from KMCWC pediatric Stem Cell Transplantation program and the nurse practitioner (DNP) student. After performing a thorough review of the literature, the DNP student discussed the current data regarding determining immunization readiness following hematopoietic cell transplant with the oncology providers. The Do aspect included a pre-implementation survey that assessed provider readiness to undertake practice change. A second survey was used to assess current re-immunization practice in the Stem Cell Transplantation

program. The Study aspect involved the recommendation of a practice guideline based on provider responses and current literature. A flowsheet was created to assist the provider group with completion of the clinical and laboratory components of the evaluation process. This guideline was approved by the pediatric Hematology and Oncology providers at KMCWC. A letter to be distributed to primary care providers was developed that includes the vaccination schedule, appropriate number of doses, and a start date. In the Act phase, the guideline was modified based on provider input, and then deployed for use. A post implementation survey was used to assess provider acceptance of the change and utilization of the practice guideline.

Project Design and Evaluation

Setting

Kapiʻolani Medical Center for Women & Children is a 253 bed, accredited not-for-profit tertiary care hospital for the care of women, infants, and children (Hawaii Pacific Health, n.d). Specialty services include intensive care for infants and children, 24-hour emergency pediatric care, maternal-fetal medicine, and the Kapiʻolani Children's Cancer Center (Hawaii Pacific Health, n.d). The Kapiʻolani Children's Cancer Center provides specialized care to Hawai'i's children including hematopoietic cell transplantation and follow-up care for children and adolescents with hematologic or oncologic malignancies.

Participants

The participants were 7 Pediatric Hematology, Oncology and Stem Cell Transplantation providers from KMCWC. All providers that treat pediatric and adolescent hematopoietic cell transplant recipients were included in the survey.

Implementation Strategies and Data Collection Methods

A Power Point presentation was made at one of the KMCWC Hematology and Oncology pediatric provider meetings. This presentation reviewed the current literature and outlined a plan to create and implement a flowsheet guideline for determining readiness to initiate immunizations post-transplant. A paper survey (Appendix A) was given to the providers to assess the current practice for immunizations and determining eligibility following HCT. A second survey (Appendix B) was distributed pre- and post-guideline implementation in order to determine provider acceptance of the change and utilization of the practice guideline.

A guideline flowsheet was developed through provider consensus, based on their current practice, relevant literature, and review of other pediatric transplant center guidelines. Providers were presented with the draft version and given the opportunity to ask questions and give feedback on the proposed guideline. Edits were considered and discussed with the division. The guideline was reviewed by administration, and upon approval, the flowsheet guideline and vaccination schedule were presented to the pediatric Hematology, Oncology and Stem Cell Transplantation providers during one of their program meetings.

The guideline starts as soon as six months post-transplant and takes the last dose of IVIG, current levels of IgG, IgA, and IgM, and the absence of graft vs. host disease into account. CD4 count and CD19 count are the last variables checked prior to clearance for inactivated immunizations. This clearance will trigger the immunization process with the vaccination letter (Appendix E) and schedule being sent to the primary care provider. Once all doses of the inactivated immunizations are completed, the hematology, oncology provider can utilize the Process to Begin LIVE Immunizations Following Hematopoietic Stem Cell Transplant (Appendix C) guideline to determine readiness for live immunizations. It should be at least a year after the cessation of IVIG and immunotherapy treatment prior to commencing

immunization with LIVE vaccines. The final guideline (Appendix C) and vaccination schedule (Appendix D) was approved and distributed to the pediatric Hematology, Oncology and Stem Cell Transplantation providers at KMCWC.

Ethical Aspects

The author has completed the Collaborative Institutional Training Initiative (CITI) training Good Clinical Practice for research ethics, Human Subjects Research for research with human subjects, and Health Insurance Portability and Accountability Act (HIPAA) training to protect the privacy of every patient. This project did not involve patient contact, nor any patient information. Participants were healthcare providers and data obtained came from a paper survey that eliminated respondent identifiers. Demographics that would identify respondents were excluded from the survey. This QI project was intended to evaluate and improve upon current practice. The clinical practices involved are considered a part of the usual patient care and does not include any additional risk over what is already involved in the current plan of care. Thus, this project did not require IRB approval.

Data Analysis

Pre and post survey data were analyzed using the mean for each question. A comparison of the means from pre-survey to post-survey was performed to determine any differences in provider readiness to change and adoption and implementation of a new practice guideline.

Results

Out of the seven Pediatric Hematology, Oncology and Stem Cell Transplantation providers, all completed two pre-implementation surveys and one post-survey following the introduction of the flowsheet guideline. There was no change in pre-survey and post-survey mean. Of note, lack of guideline was listed as the biggest barrier when assessing re-

immunization readiness. When questioned if re-immunization readiness following hematopoietic cell transplant is adequately addressed, the average score was 2.7 out of 5. The average was 4.7 out of 5 for the question asking if the provider would implement a practice guideline for determining re-immunization readiness. The pre and post survey means for each question are given in Table IV.

Table IV: Pre and Post Readiness for Change Survey Mean

	Pre-Survey- Mean	Post- Survey Mean
I adequately address re-immunization readiness following hematopoietic cell transplant.	2.7	2.7
A current practice guideline is followed to determine re-immunization readiness following hematopoietic cell transplant.	2.7	2.9
Using a practice guideline for re-immunization readiness is important	5.0	4.9
There are barriers to assessing re-immunization readiness.	3.7	4.0
The following could be barriers to assessing re-immunization readiness. Rank in order from 1-5 the barriers faced when assessing re-immunization readiness. (1 is the biggest barrier, 5 smallest barrier)		
Time	4.0	4.2
Lack of guideline	1.0	1.0
Experience with HCT patients	3.2	3.4
Patient complications	4.0	3.8
Inconsistency in the literature	2.6	2.2
I will implement a practice guideline for re-immunization readiness.	4.8	4.7

1: Strongly disagree, 2: disagree, 3: neutral, 4: agree, 5: strongly agree

Discussion and Implications

There was no change between pre- and post-survey results when assessing provider acceptance of the change and willingness to use a practice guideline. In both the pre-and post-surveys, providers disagreed with the statement that they adequately addressed the re-immunization process, and they strongly agreed that they would implement a practice guideline for re-immunization readiness. This indicates the providers may have been ready for the

implementation of a practice guideline and will likely implement the created guideline. The "Process to Begin Re-Immunization Following Hematopoietic Stem Cell Transplant" guideline (Appendix C) and the vaccination schedule (Appendix D) were approved and deployed for implementation at KMCWC.

Strengths, Limitations and Sustainability

Strengths of this project include the implementation of a practice guideline where there previously was not a standard practice guideline. The lack of literature resulted in variability amongst the providers in the re-immunization process. The addition of a guideline will allow the providers to refer to the flowsheet and utilize the recommendations when determining re-immunization readiness for their patients. This may result in decreased variability in timing of re-immunizations and increase patient protection from these vaccine preventable infections following stem cell transplant.

The flowsheet guideline will be made readily available to the providers to access when determining readiness for immunization for their patients. Once a patient is deemed ready for immunization, the provider letter (Appendix E) and vaccination schedule (Appendix D) will be provided to the patient's primary care provider. This process may prevent delays in re-immunization and ensure all providers are informed of the timeline regarding their mutual patient.

The major limitation of this project is the lack of time to implement the guideline with patients and determine its effectiveness. Future projects could assess the status of re-immunizations for the pediatric post-HCT patients and time from transplant for re-immunizations to be initiated before and after implementation of the guideline. This would help determine the effectiveness of the guideline and whether it facilitates more timely re-

immunization of post-transplant patients, thus decreasing the risks of potential infection by these vaccine preventable diseases. The effectiveness of the guideline will speak to the sustainability of the project. If the guideline effectively assists providers with determining readiness for re-immunizations, then they will be more likely to refer to it for subsequent HCT patients.

DNP Essentials

There are eight Doctor of Nursing Practice essentials provided by the American Association of Colleges of Nursing (2006). These essentials describe core competencies that should be completed by the Doctor of Nursing Practice candidate. These essentials and how they were met are described in Appendix F.

Conclusion

This evidence-based quality improvement project was successful in creating and implementing a guideline to be utilized by providers when determining immunization readiness following hematopoietic cell transplant. The guideline may prevent unnecessary delays in re-immunization, potentially protecting immunocompromised individuals from acquiring vaccine preventable disease.

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Appendix A

Re-Immunization after Hematopoietic Cell Transplant

1. What is your position?
    a. Hospitalist
    b. Oncologist
    c. Nurse Practitioner
    d. Other_____
2. Does your center have practice guidelines for immunizing pediatric patients or determining readiness for re-immunization initiation after hematopoietic cell transplant?
    a) Yes
    If yes, which guideline is utilized
        i) National Marrow Donor Program (NMDP)
        ii) Be the Match
        iii) Red Book
        iv) Other_____
    b) No

3. What criteria do you use to determine when to begin initiation of INACTIVATED vaccines? Please rank order of use.
    a. Time since hematopoietic cell transplant
    b. Date of discontinuation of immunosuppressive drugs and/or monoclonal antibodies
    c. Patient's pre-transplant immunization status
    d. Immunologic Markers (e.g., CD4+ T cells, absolute lymphocyte count)
    e. Other, please specify_____

4. What immunologic markers are used to determine readiness for re- immunization of INACTIVATED vaccines?
    a. Absolute lymphocyte count: Level used:_____
    b. CD4+ T cell count: Level used:_____
    c. CD8+ T cell count: Level used: _____
    d. T cell proliferation responses
    e. Antibody titers to vaccines received pre-transplant: Please Specify which titers:_____
    f. Other/none Please Specify: _____

5. What criteria is used to determine when to begin initiation of LIVE-attenuated vaccines? Please rank order of use.
    a. Time since HCT
    b. Date of discontinuation of immunosuppressive drugs and/or monoclonal antibodies
    c. Patient's pre-transplant immunization status
    d. Immunologic Markers (e.g., CD4+ T cells, absolute lymphocyte count)
    e. Other, please specify

6. What immunologic markers are used to determine readiness for re- immunization of LIVE-attenuated vaccines?
    a. Absolute lymphocyte count: Level used:_____

b. CD4+ T cell count: Level used:_____
c. CD8+ T cell count: Level used: _____
d. T cell proliferation responses
e. Antibody titers to vaccines received pre-transplant. Please specify which titers:_____
f. Other: Please specify: _____

7. How is re-immunization initiated (Please select all that apply)
   a. Hematology/Oncology clinic administers the immunizations
   b. Immunization schedule is given directly to the patients Primary Care provider for administration
      i) Letter is sent to the Primary care provider
      ii) Phone call from office to primary care provider
      iii) Provider to provider communication
      iv) Coordinator to PC office/provider communication
   c. Other: Please specify

8. How is the completion of immunization confirmed?
   a. Center administers vaccines and updates electronic medical record
   b. Primary care providers fax vaccination records to office/center
   c. Patient communicates completion to office/center
   d. Online documentation per electronic medical record
   e. No regular follow-up
   f. Other, please specify

9. Which antibody titers are routinely measured following re-immunization?
   a. Diphtheria
   b. Tetanus
   c. S. pneumoniae
   d. Hepatitis B
   e. Measles
   f. Mumps
   g. Rubella
   h. Varicella
   i. Other, please specify

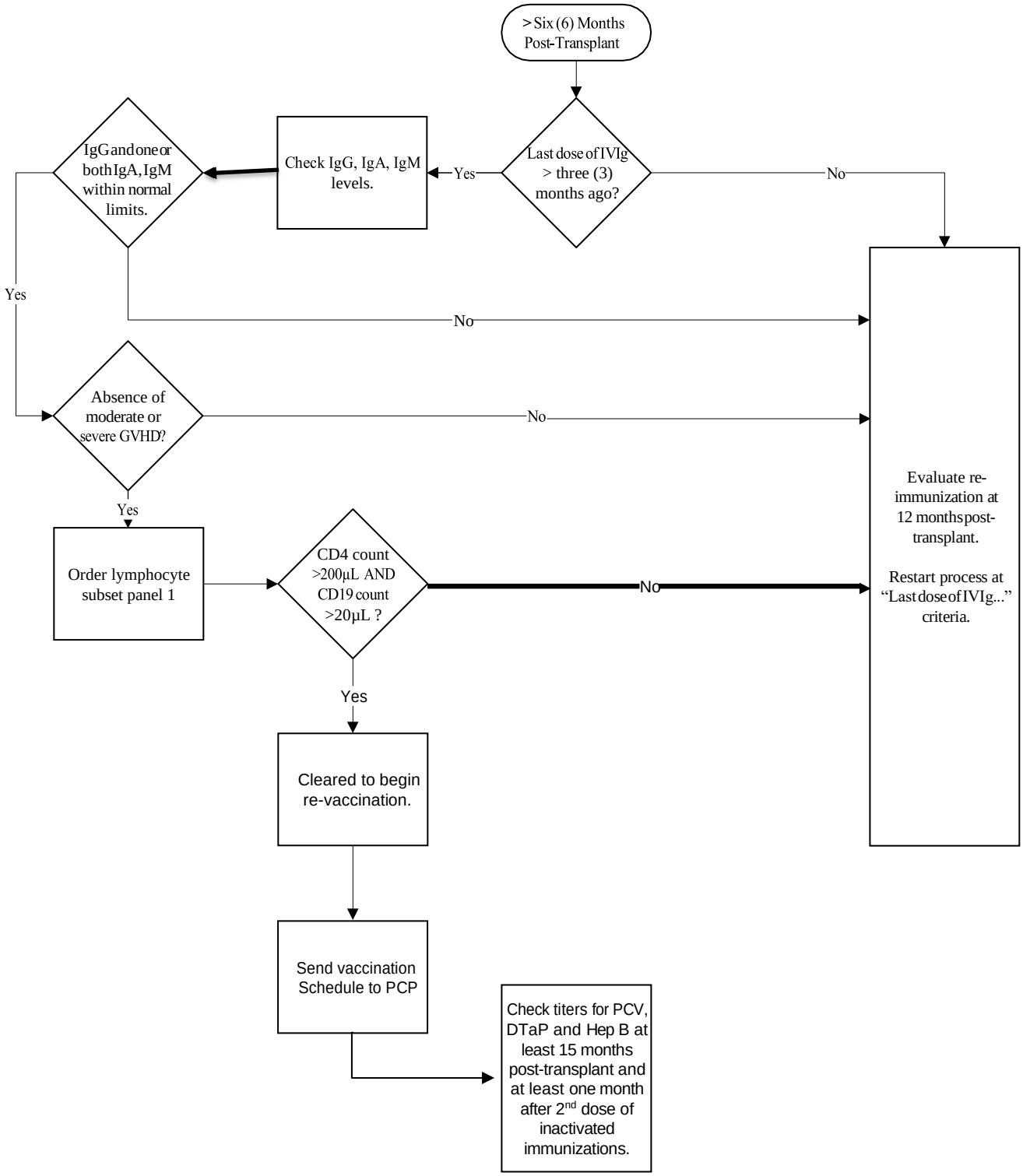
Appendix B

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
The physician adequately addresses re-immunization readiness following hematopoietic cell transplant.	1	2	3	4	5
A current practice guideline is followed to determine re-immunization readiness following hematopoietic cell transplant.	1	2	3	4	5
Using a practice guideline for re-immunization readiness is important.	1	2	3	4	5
There are barriers to assessing re-immunization readiness.	1	2	3	4	5
The following could be barriers to assessing re-immunization readiness. Rank in order from 1-5 the barriers faced when assessing re-immunization readiness. (1 is the biggest barrier, 5 being the smallest barrier) _____Time _____Lack of guideline _____ Experience with hematopoietic cell transplant patients _____ Patient complications _____ Inconsistency in the literature					
I will implement a practice guideline for re-immunization readiness.	1	2	3	4	5

Appendix C

HAWAIʻI PACIFIC HEALTH | KAPIʻOLANI MEDICAL CENTER FOR WOMEN & CHILDREN

Process to Begin Re-Immunization Following Hematopoietic Stem Cell Transplant (HPCT)



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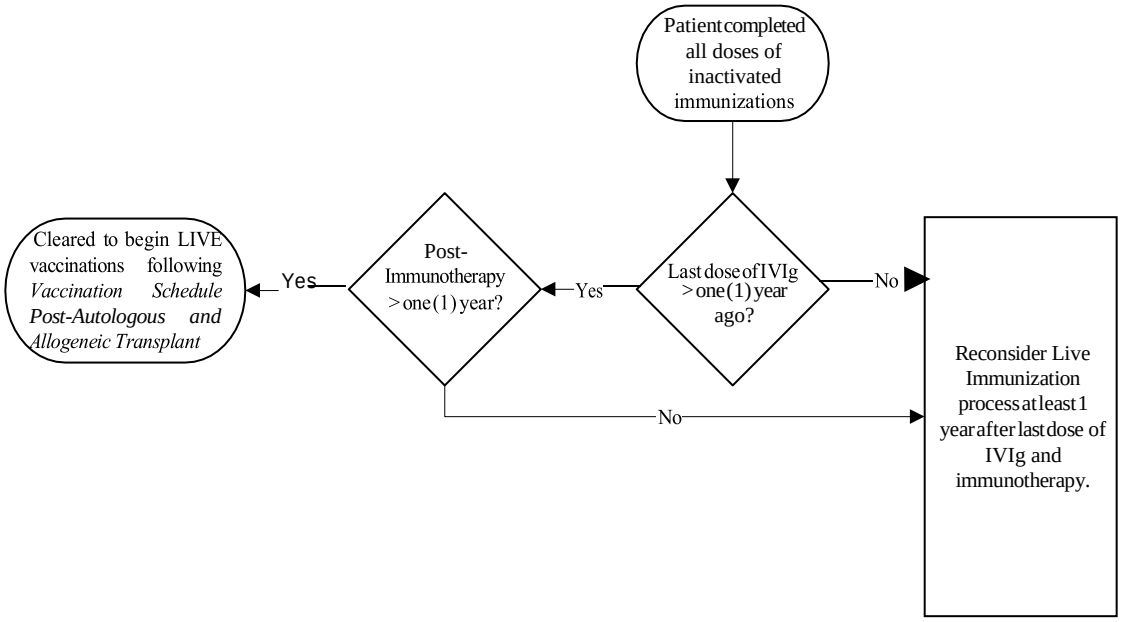
Process to Begin LIVE Immunizations
Following Hematopoietic Stem Cell Transplant (HPCT)



Appendix D

HAWAIʻI PACIFIC HEALTH | KAPIʻOLANI MEDICAL CENTER FOR WOMEN & CHILDREN

VACCINATION SCHEDULE

POST-AUTOLOGUS AND ALLOGENEIC TRANSPLANT[a]

Name:		**Date of Diagnosis:**	
Date of Birth:		**Date of Transplant:**	
Diagnosis:		**Type of Transplant:**	

Time Frame (Post-Transplant)	Date Eligible	Immunization	Date Given
6 months		Inactivated Influenza – Seasonal[e]	
6-9 months		Pneumococcal Conjugate (PCV) #1[b]	
12 months		Tetanus, Diphtheria, Acellular Pertussis DTaP[c] (<7yo); Tdap[c] (>7 yo) #1	
		Haemophilus Influenze Conjugate #1	
		Inactivated Polio (IPV) #1	
		Recombinant Hepatitis B (Hep B) #1	
		Pneumococcal Conjugate (PCV) #2 [b]	
14 months (+2 months after initial set of immunizations)		Tetanus, Diphtheria, Acellular Pertussis DTaP[c] (<7yo); Tdap[c] (>7 yo) #2	
		Haemophilus Influenza Conjugate (Hib) #2	
		Inactivated Polio (IPV) #2	
		Recombinant Hepatitis B (Hep B) #2	
		Pneumococcal Conjugate (PCV) #3 [b]	
15 months		**Titers for PCV, DTaP, Hep B** Done at Pediatric Ambulatory Unit (PAU)	
24 months (+12 months after initial set of immunizations)		Tetanus, Diphtheria, Acellular Pertussis DTaP[c] (<7yo); Tdap[c] (>7 yo) #3	
		Haemophilus Influenza Conjugate (Hib) #3	
		Inactivated Polio (IPV) #3	
		PPSV23[b] (pneumococcal)	
		Recombinant Hepatitis B (Hep B) #3	
>24 months (patients with active GVHD, and on Immune suppression)		MMR[fgh]	
		Varicella (Varivax only)	

Additional Vaccinations[5]:

- **Meningococcal Conjugate** – Follow country recommendations for general population one (1) dose, six to 12 months post-transplant.
- **Hepatitis A** (Inactivated) – Recommended for individual cases or travelers. Three (3) doses, six to 12 months post-transplant.
- **HPV** – Follow recommendations for the general population after 12 months post-transplant.

Vaccination Schedule: Post Autologous and Allogeneic Transplant

Notes[4]:

a) A uniform specific interval between doses cannot be recommended, as various intervals have been used in studies. As a general guideline, a minimum of 1 month between doses may be reasonable.
b) Following the primary series of three PCV doses, a dose of the 23-valent polysaccharide pneumococcal vaccine (PPSV23) to broaden the immune response might be given. For patients with chronic GVHD who are likely to respond poorly to PPSV23, a fourth dose of the PCV should be considered instead of PPSV23.
c) DTaP (diphtheria tetanus pertussis vaccine) is preferred, however, if only Tdap (tetanus toxoid-reduced diphtheria-toxoid reduced acellular pertussis vaccine) is available (for example, because DTaP is not licensed for adults), administer Tdap. Acellular pertussis vaccine is preferred, but the whole-cell pertussis vaccine should be used if it is the only pertussis vaccine available.
d) See references for consideration of an additional dose(s) of Tdap for older children and adults.
e) For children <9 years of age, two doses are recommended yearly between transplant and 9 years of age.
f) Measles, mumps and rubella vaccines are usually given together as a combination vaccine. In females with pregnancy potential, vaccination with rubella vaccine either as a single or a combination vaccine is indicated.
g) Not recommended <24 months post-HCT, in patients with active GVHD, and in patients on immune suppression.
h) In children, two doses are favored.

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Appendix E

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[Publish Date]

Dear Dr.

xxx had a matched sibling allogeneic bone marrow transplant on xxx for Chronic Myelogenous Leukemia (CML). The transplant process went well and we have been following xxx closely for infections, toxicities from the high dose chemotherapy, inflammatory markers, and signs of Graft Versus Host Disease.

xxx is now off all medication other than monthly pentamadine and PRN lorazepam and ondansetron. He is doing very well and does not require the same level of transplant follow-up as previously. We would like to refer xxx back to you for routine pediatric care.

Part of this routine care is re-immunization. The intense chemotherapy/radiation therapy that is required to condition the body for the stem cell infusion also severely damages the lymphocytes and the entire immune system. It effectively erases the "immune memory." Complete re-immunization is necessary.

A re-immunization schedule, recommended for transplant patients, is attached. Please follow this schedule.

We will continue to follow xxx. If you have any questions or concerns about symptoms that may arise, please do not hesitate to call me at 808-983-8551.

Sincerely,

Pediatric Hematologist / Oncologist

Appendix F

DNP Essential	DNP Student's Activities
Scientific Underpinnings for Practice	This DNP Essential was met as this project utilized science-based investigation and analytics through a thorough search and critique of the literature in order to improve knowledge and streamline process for determining readiness for re-immunization following hematopoietic cell transplant (HCT).
Organizational and System Leadership for Quality Improvement and Systems Thinking	This DNP Essential was met as this project evaluated current practice and developed a guideline based on scientific findings that will enhance care delivery.
Clinical Scholarship and Analytical Methods for Evidence-Based Practice	This DNP Essential was met through the systematic review and literature critique. This QI project required a review of the literature as well as evaluating current practice in order to make appropriate recommendations.
Information Systems/ Technology and Patient Care Technology for the Improvement and Transformation of Health Care	This DNP Essential was met by designing a flowsheet guideline that was used to determine immunization readiness following post hematopoietic cell transplant.
Health Care Policy for Advocacy in Health Care	The DNP Essential was met by critically analyzing current practice and evidence-based practice in order to encourage practice change.
Interprofessional Collaboration for Improving Patient and Population Health Outcome	The DNP Essential was met through two interprofessional educational sessions with the Hematology and Oncology providers.
Clinical Prevention and Population Health for Improving the Nation's Health	The DNP Essential by analyzing statistics for immunizations completed in the community in order to determine the presence of herd immunity and understand the necessity of re-immunization following hematopoietic cell transplant.
Advanced Nursing Practice	The DNP Essential was met by designing and deploying a guideline that will assist providers in determining readiness for re-immunization following hematopoietic cell transplant. This guideline may prevent delays in re-immunization and prevent infection by vaccine preventable diseases.

1/