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Evaluating the effectiveness of a training program to support nurses to administer cryopreserved hematopoietic stem cells by intravenous push method

by Cheryl Page and Jessica Rebeiro

ABSTRACT

A training program was developed to prepare registered nurses (RNs) at one cellular therapy centre to administer cryopreserved cells by intravenous (IV) push method. There are two main methods of infusion for dimethyl sulfoxide (DMSO) cryopreserved hematopoietic stem cell (HSC) products, gravity drip and IV push. Administering DMSO by either route can cause hypersensitivity reactions. Administration of HSCs by gravity drip is slower, resulting in fewer DMSO reactions. However, prolonged exposure of DMSO once the cells are thawed increases the risk of cellular damage. The faster IV push method reduces cell damage and decreases staff time. An environmental review within Canadian transplant centres found that in most adult centres, nurses administer by gravity drip, and when IV push is required, cryopreserved hematopoietic stem cells are administered by physicians. Our centre's method was IV push by a physician or nurse practitioner (NP). As transplant numbers grew, capacity to perform this skill needed to expand. To maintain the current benefits of the IV push method and increase capacity in a hematopoietic transplant program, the role of infusing stem cells by the IV push method was transitioned from the NPs and physicians to RNs. A successful training program utilizing simulation to support these oncology nurses in learning the new skill was developed and evaluated.

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INTRODUCTION

An increase in hematopoietic stem cell (HSC) transplants in Ontario has led to an increased need for HSC transplant trained staff (CCO, 2017). Registered nurses (RNs) new to this oncology nurse sub-specialty require support and training specific to this area. Considering these human resource challenges to meet the increasing demand for the treatments, skill sets within disciplines were reviewed to determine if skills historically completed by one discipline could be shifted to other disciplines to enhance patient care flow. Arranging the infusion of cryopreserved hematopoietic stem cells was found to be especially challenging, as the prescriber medical practices expanded.

Understanding the management of adverse events related to the re-infusion of stem cells is a part of the competency of the specialized oncology nurse working in the field of cellular therapy (CANO, 2006). A critical step in transplantation is HSC infusion (Ezzone, 2020; Fairman, 2016). Dimethyl sulfoxide (DMSO) is a cryoprotectant that inhibits the formation of ice crystals, which would harm cells during the freezing process for cryopreservation of cellular therapy products (Wingard et al., 2015). There are two methods of infusion for DMSO cryopreserved products – gravity drip and IV (intravenous) push (Ezzone, 2020; Mulay et al., 2014), each of which offers benefits and drawbacks.

DMSO can cause hypersensitivity reactions (Ezzone, 2020; Fairman, 2016). Administration of HSCs by gravity drip is slower, resulting in fewer DMSO reactions (Ezzone, 2020), but prolonged exposure of DMSO once the cells are thawed increases the risk of cellular damage (Foreman, 2016; Lecchi et al., 2016; Sauer-Heilborn et al., 2004; Wingard et al., 2015). The faster intravenous (IV) push method reduces cell damage and is a faster process, thus decreasing time required for staff to perform this skill (Foreman, 2016; Wingard et al., 2015).

An environmental scan by the authors in 2020 regarding the administration of HSCs across Canada found that, in most adult cellular therapy centres, nurses administer cryopreserved HSCs to patients by gravity drip and, when IV push is required, HSCs are administered by physicians. At the time, our centre's method was IV push by physician or nurse practitioner (NP).

As transplant numbers grew, capacity to perform this skill needed to expand. Due to staffing pressures, priority was placed on decreasing staff time, thus the centre decided to continue with the IV push method. Additionally,

this centre historically had a comfort level with the IV push method, which allows direct control of the infusion rate by the participants performing the infusion. To maintain the current benefits of the IV push method while expanding capacity of staff available to perform these infusions, RNs at this centre were trained to perform this skill. This paper will describe our quality improvement project to evaluate the training program implemented for registered nurses to learn the IV push method for infusing DMSO.

METHOD

Education program design

The education program included a four-hour training session, including a didactic portion, simulated infusion, and case studies. The program was planned for specialized hematology RNs working in an outpatient area that delivers systemic therapy, as well as supportive care to hematology patients. Supports for the stem cell infusion education included a policy, procedure guide, and reaction management guide.

The simulated infusions were accomplished with low-fidelity techniques, utilizing a demonstration of an infusion followed by participants practising the skill. Participants performed the procedure using all the supplies that would be used for a real infusion, except using a central vascular access device connected to a drainage bag. In this way, they practised the mechanical technique. Case studies covered patient scenarios, including adverse events, to allow participants to problem solve how they would deal with these situations when infusing stem cells into patients. At least three real infusions were completed in the clinical areas precepted by a transplant physician or NP with skill in this procedure. A competency record was used to document their technique. If an RN required additional infusions with a preceptor, these were accommodated until the RN felt comfortable performing the skill independently and safely. Stem cell infusions occurred either in the outpatient or inpatient settings.

Evaluation approach

The Kirkpatrick Evaluation Model was used as a guide for the evaluation. This model is a widely used, internationally recognized tool for evaluating the effectiveness of adult education and training programs (Reio, 2017). Our training program was evaluated with a Likert-type scale assessment, to collect data pre-training and post-training, and a follow-up post-post-training to assess independent skill performance. These data collection times allowed assessment of the first three levels of the Kirkpatrick Evaluation Model: reaction, knowledge, and behaviour (Kirkpatrick, 2006).

The first level of the Kirkpatrick Evaluation Model evaluates reaction (Kirkpatrick, 2006) or the degree that participants reacted favourably to the re-infusion education training. This was assessed immediately post-training. The second level of the Kirkpatrick Evaluation Model evaluates knowledge (Kirkpatrick, 2006) or the degree participants acquired the knowledge of how to re-infuse cryopreserved stem cells. Knowledge was assessed at baseline pre-intervention, immediately post-intervention to determine learning, and at three to six weeks of follow-up to assess retention. The third level of the Kirkpatrick Evaluation Model evaluates behaviour (Kirkpatrick, 2006) or the degree that participants applied what they learned regarding the re-infusion of cryopreserved stem cells. Application of knowledge was evaluated post-intervention, and at three to six weeks follow-up.

A non-parametric Friedman test (Halter, 2017) was conducted on the changes in knowledge and behaviour. Procedure evaluations were also completed, collecting additional information on infusion reactions during the procedures and how these reactions were handled by the registered nurses.

RESULTS

Eleven registered nurses attended the new training program. All RNs had previously completed a competency course for the administration of systemic therapy agents to oncology patients, including chemotherapy and biotherapy.

Many of the participants had experience in the RN monitoring role during infusions, when the physician or nurse practitioner administered the cryopreserved HSCs, prior to participating in this quality improvement project.

Procedure results

Our centre averages about 210 autologous cryopreserved stem cell re-infusions per year. Reviewing two months of internal data during the project implementation period, the average number of syringes of cryopreserved stem cell product per re-infusion was 5, with a range of 2 to 9 syringes. Infusion rates per syringe ranged from 3 to 12 minutes, with an average of 5 minutes. Syringe volume ranged from 34 to 58 mL with an average of 50 mL. Infusion rates ranged from 5 to 21 mL/min with an average of 10 mL/min.

During the training period, 82 re-infusions of cryopreserved stem cells took place. The most common symptoms experienced during the re-infusion process throughout the training period included flushing (41%), odour (29%), hypotension (22%), abdominal cramping (17%), chest tightness (17%), and nausea and/or vomiting (16%). Less common symptoms included throat tickling (6%), hypertension (5%), hypoxia (5%), tachycardia (5%), tingling (4%), chills and/or rigours (4%), oxygen desaturation (4%), dizziness (2%), pruritus (1%), and sustained tingling (1%), leg cramps (1%), and wheezing (1%; see Figure 1). For 22% of the re-infusions, no reactions were reported.

Adverse events during re-infusions for the duration of the training period were mostly managed by non-pharmaceutical interventions, as noted in the reaction management guide, including slowing the infusion rate, administering lemon candies, applying cool cloths to the patient's forehead, encouraging deep breathing, lowering the head of the bed, administering oxygen as needed, or applying a warm blanket to the abdomen. Dimenhydrinate was the most frequently required medication administered during reinfusion to manage nausea (16%), followed by lorazepam (2%), salbutamol (1%), famotidine (1%), and diphenhydramine (1%; see Figure 2).

Figure 1

Infusion Reactions Seen During 82 Re-Infusions Post Intervention

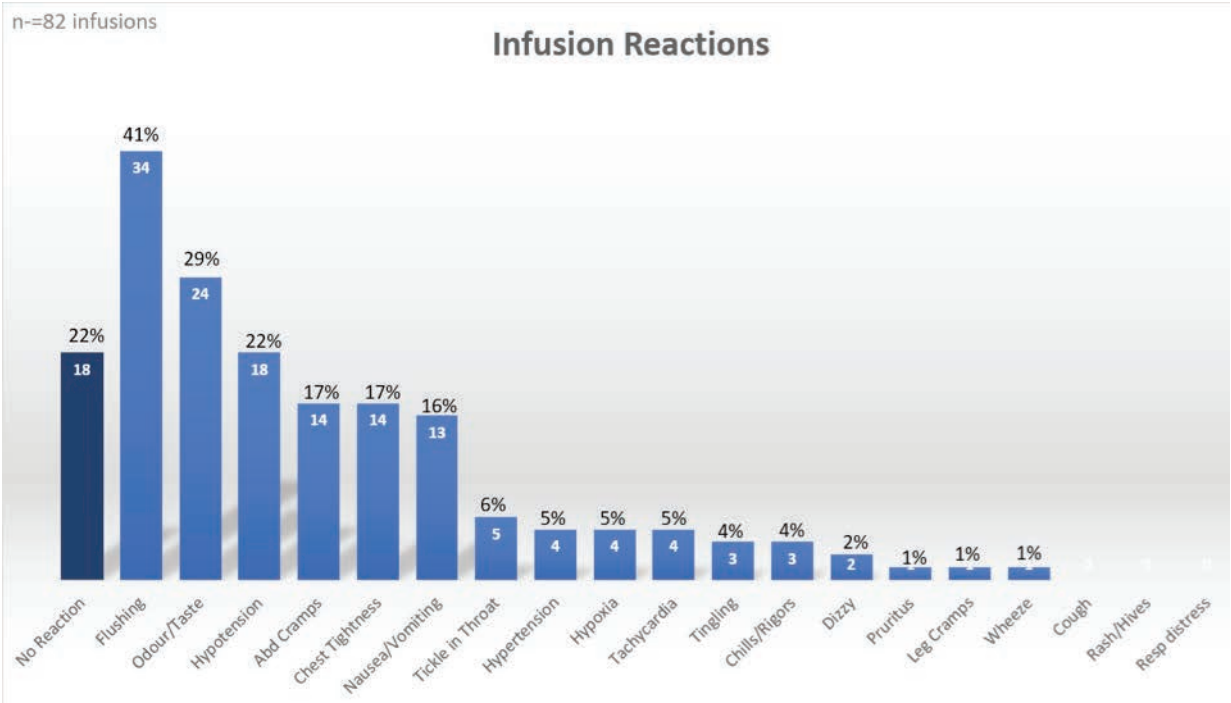
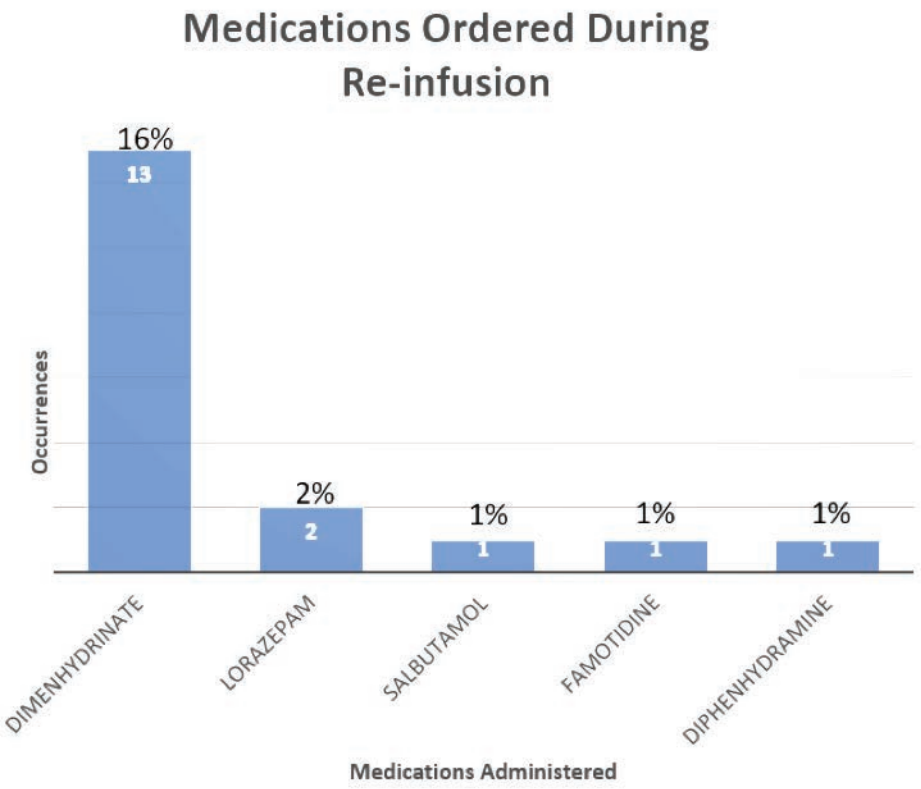


Figure 2

Medications Ordered in Response to Symptoms During Re-Infusions



After participants transitioned to independent skill performance, a prescriber needed to be on the inpatient or outpatient hematology unit during the infusions, but not in the patient room. The prescribers were notified, per the parameters in the reaction guide, when the patient had a serious reaction during infusion or did not respond to interventions ordered per parameters. The prescriber was notified in 9 cases during the 82 infusions, which is 1% of the cases. The notification rationale included: oxygen requirements over 35% by venti-mask to maintain oxygen saturation levels over 92%, systolic blood pressure over 180 mm Hg, systolic blood pressure under 85 mm HG, puritis, and a case of sustained tingling. The calls to the prescriber were all appropriate, per the reaction guidelines. There was only one instance in which criteria to notify a prescriber as per the reaction guide was met, but the prescriber was not notified until post-reinfusion related to hypotension. Follow-up with the participants was completed and no further instances occurred (see Figure 3).

Participant results

The nurse participants completed a Likert-type scale assessment before and after training, and an independent skill performance assessment following the training. The survey evaluated the three levels based on the Kirkpatrick Evaluation Model: reaction, knowledge, and behaviour.

First level of evaluation: Reaction

The post-intervention survey, capturing the degree to which the participant reacted favourably to the training session, was completed by all 11 participants. The results indicate that 100% of the participants reacted favourably to the training program. All participants strongly agreed or agreed that the following content was covered effectively in the training session: autologous transplant indications, autologous transplant process, re-infusion of cryopreserved stem cells, DMSO reactions, and management of adverse events during cryopreserved stem cell infusion.

The survey found that 73% (8/11) of the participants agreed and 27% (3/11) of the participants strongly agreed that the education covered the topic of autologous transplant indications effectively, 45% (5/11) of the participants agreed and 55% (6/11) of the participants strongly agreed that the education covered the topic of autologous transplant process effectively, and 64% (7/11) of the participants agreed and 36% (4/11) of the participants strongly agreed that the education covered the topic of re-infusion of cryopreserved stem cells effectively. Additionally, 73% (8/11) of the participants agreed and 27% (3/11) of the participants strongly agreed that the education covered the topic of re-infusion of cryopreserved stem cells effectively (see Figure 4).

Comfort level of the RN was assessed for each infusion during the training period. Following each infusion, the RN completed a self-assessment form rating their comfort level for infusing the cryopreserved HSCs on a Likert scale. The participants rated their infusion comfort level as moderate for 21% of the infusions, high for 38% of the infusions, and very high for 42% of the infusions. They never rated their comfort level as low or very low. Moderate ratings were reported within the first three infusions. Participants were expected to complete a minimum of three competency assessments with a preceptor or continue until the learner felt confident with the skill. Learners completed between three and four competency assessments, averaging four (see Figure 5). One RN did not complete training due to an approved leave.

Figure 3

Reasons the RN Infusing HSC Notified the Physician or Nurse Practitioner

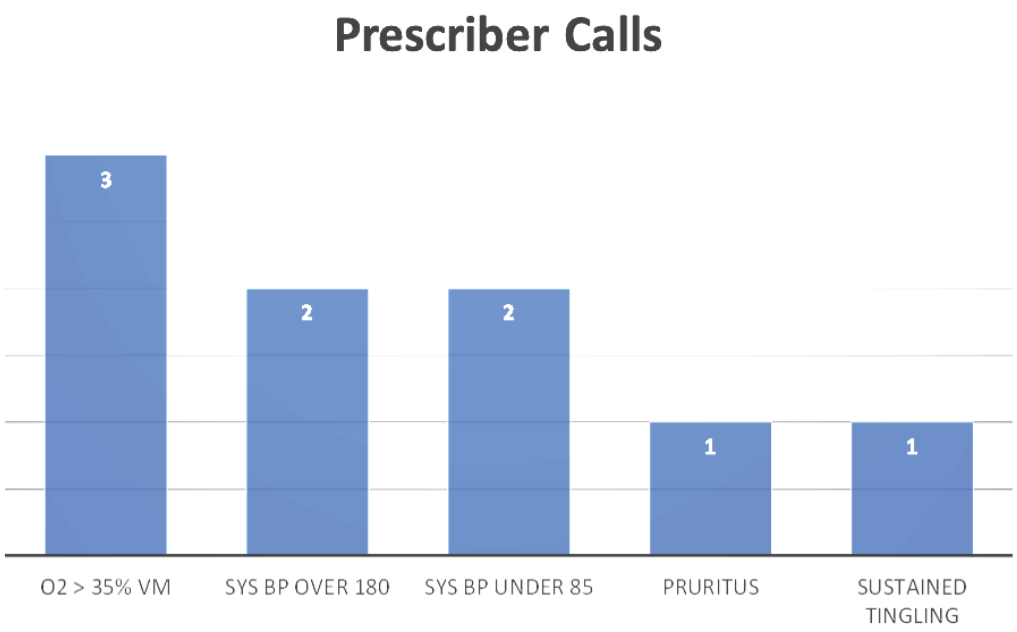


Figure 4

Kirkpatrick Level 1 Evaluation—Reaction as Self-Reported on a Likert Scale (Strongly Disagree, Disagree, Neither Agree or Disagree, Agree, or Strongly Agree)

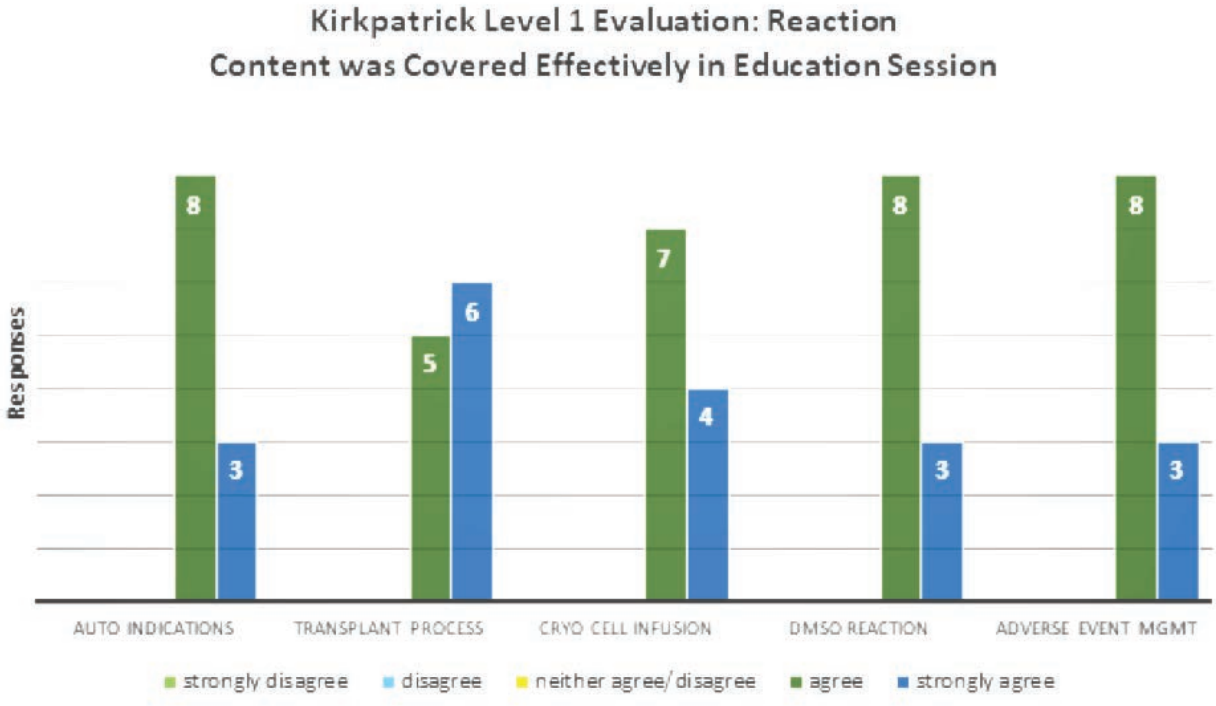
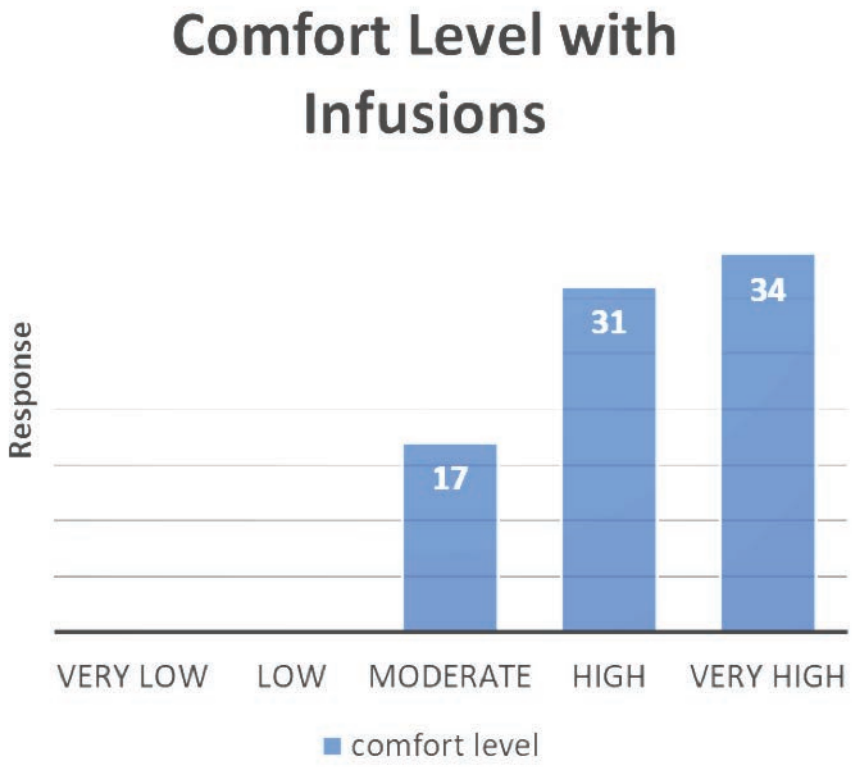


Figure 5

RN Self-Reported Comfort Level with Completing IV Push Cryopreserved HSC Infusions as Self-Reported on a Likert Scale (Very Low, Low, Moderate, High, or Very High).



Second level of evaluation: Knowledge

A Freidman test was conducted to evaluate the impact of the educational intervention on the staff's scores for knowledge (see Figure 6). In the four areas of knowledge assessed there was significant improvement in self-reported ratings in knowledge from pre-evaluation, to post evaluation and post independent skill performance evaluation on the following topics: indications for autologous transplant (p = 0.03), re-infusion of cryopreserved stem cells (p = 0.004), DMSO-related reactions (p = 0.02), and adverse reaction management (p = 0.045). For the topic of knowledge of patient flow, participants scores were high on both pre- and post-assessment, thus the change was not significant (p = 0.124).

Third level of evaluation: Behaviour

Within the assessment, the learners were asked to rate pre-intervention, post-intervention, and post-independent skill performance how they felt the supporting resources, an infusion guide and reaction management guide, helped to augment their orientation (see Figure 7). Value placed on the infusion guide and reaction management guide was high both pre- and post-orientation, thus the change was not significant (p = 0.449).

Figure 6

Kirkpatrick Level 2 Evaluation – Shift in Knowledge Post-intervention as Self-Reported on a Likert Scale (Very Low, Low, Moderate, High, or Very High)

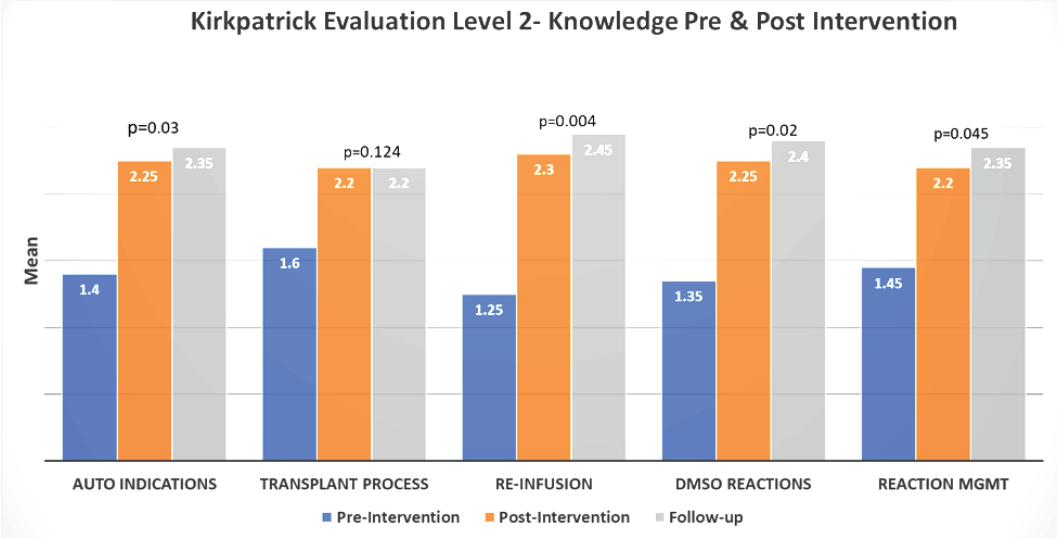
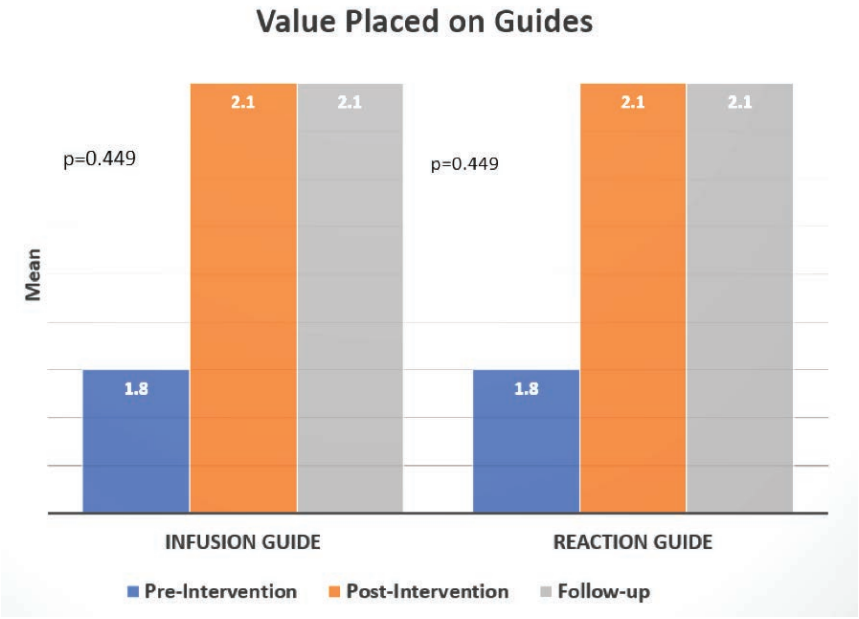


Figure 7

Value Placed on the Learning Pathway and Tools Pre- and Post-intervention as Self-Reported on a Likert Scale (Very Low, Low, Moderate, High, or Very High)



There was a significant shift in behaviour post-orientation, as demonstrated by an increase skill in three key areas, including administration, management of adverse events and management of DMSO reactions (see Figure 8). For self-reported rating on ability to administer cryopreserved HSCs, there was a statistically significant shift in these scores from pre- and post-evaluation to post-independent skill performance ($p<0.001$). For self-reported rating on ability to manage adverse events during the cryopreserved HSC infusion, there was a statistically significant shift in these scores from pre- and post-evaluation to post-independent skill performance ($p = 0.039$). Additionally, for self-reported rating on ability to manage DMSO reactions during cryopreserved HSC infusions, there was a statistically significant shift in these scores from pre- and post-evaluation, to post independent skill performance ($p = 0.074$).

DISCUSSION

The results of this quality improvement initiative indicate that RN knowledge and behaviour regarding the administration of cryopreserved HSCs was positively affected by the training program. The program included classroom training for didactic content, simulated infusions, and case studies; supportive documents outlining a procedure guide and reaction management guide; and procedures supported by utilizing a competency record and competent preceptor. Each component was seen as useful by the nurses in helping them learn the necessary knowledge and gain a desired comfort level in performing the new skill.

The role for infusing cryopreserved HSC was successfully transitioned to the RNs, allowing for increased staffing capacity, thus supporting the expansion of the transplant program. Infusion adverse events and management during the training period were noted by staff to be consistent with when this skill was completed by a nurse practitioner or physician previously, however it would have been beneficial to have gathered data prior to the project implementation to support this supposition. We did not see additional adverse effects in patients during the time of the educational program and any reactions were managed without patient compromise. Hence, we thought our experience with this program would be of interest to other transfusion programs.

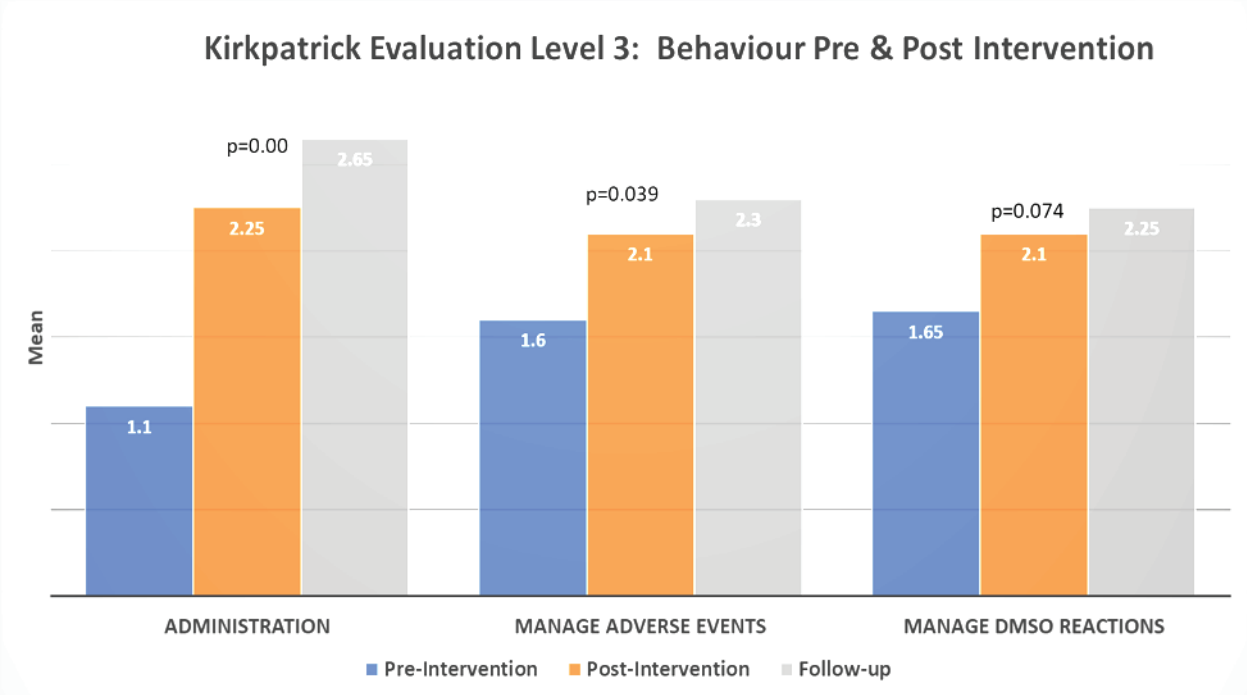
Although not measured at the time of this project, other factors could influence the learner's increase in knowledge and behaviour, including preceptor factors or participation in other continuing educational activities. Additionally, future examination of the Kirkpatrick Evaluation Model's level 4, impact on measurable outcomes, would make this quality improvement study more complete. It will also be valuable to see how these nurses move to become preceptors for future new staff entering the program.

CONCLUSION

The training program developed to support nurses to administer cryopreserved hematopoietic stem cells by IV push method was effective in preparing the RNs to safely infuse these cells. Transitioning this role to RN staff allowed the unit to expand capacity in this necessary skill. Evaluation of the training program ensures that learners new to a role translate knowledge into practice.

Figure 8

Kirkpatrick Level 3 Evaluation—Shift in Behaviour From Pre- to Post-intervention as Self-Reported Likert Scale Response to a Statement That They Can Confidently Perform Each of These Skills (Strongly Disagree, Disagree, Neither Agree nor Disagree, Agree, or Strongly Agree)



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