



## Transfusion Camp: Successes and challenges in scaling and expanding a transfusion medicine education program

Yulia Lin<sup>a,b,c,\*</sup>, Aditi Khandelwal<sup>c,d</sup>, Casey Kapitany<sup>d</sup>, Sophie Chargé<sup>d</sup>

<sup>a</sup> Precision Diagnostics and Therapeutics Program, Sunnybrook Health Sciences Centre, Toronto, Canada

<sup>b</sup> Department of Laboratory Medicine and Pathobiology, University of Toronto, Toronto, Canada

<sup>c</sup> University of Toronto Quality in Utilization, Education and Safety in Transfusion (QUEST) Research Program, Toronto, Canada

<sup>d</sup> Canadian Blood Services, Ottawa, Canada

### 1. Introduction

Transfusion medicine (TM) education is essential as physicians and nurse practitioners in almost every specialty prescribe blood transfusion. [1] Yet, multiple studies have demonstrated TM knowledge deficiencies in postgraduate trainees. [2–10] This may stem from insufficient TM education during medical school: two thirds of American medical schools provided 2 hours or less of TM teaching in 2011 [11] and a recent survey of Canadian medical schools reported that half provided 4 hours or less. [12] The knowledge deficiency may reflect the topics covered in medical school which may focus on the immunology of blood groups, for example, rather than on more practical and clinically relevant topics such as the indications for blood components and transfusion reactions. [13] The timing of TM education delivery may be important where TM education may be better incorporated into a trainee's practice once they are prescribing blood components in the clinical years of medical school [11] or when they are in the early years of postgraduate training and can apply knowledge specifically to their chosen specialties. [14,15] Finally, although TM rotations for postgraduate trainees would be ideal and comprehensive, often there are not enough teaching resources, whether it be TM specialists, TM medical laboratory technologists or physical space in the TM laboratory to accommodate all those who would benefit. [16] Locally, at the University of Toronto, we noted similar TM knowledge deficiencies in postgraduate trainees and challenges in delivering TM education. [9,10].

Up until 2012, at the University of Toronto, postgraduate trainees from anesthesiology, critical care, hematology and hematopathology completed one-month blood bank rotations. These rotations were limited to two to three trainees at a time due to physical limitations in the labs. Thus not all requests could be accommodated. More than 20 hours of teaching were delivered by the TM team including medical laboratory technologists, transfusion safety nurses, and physicians. The process was inefficient as the TM team would repeat the same educational content every month with limited time to update the sessions. Starting July 2012, the University of Toronto introduced a centralized

TM education curriculum that brought together all members of the University of Toronto TM faculty to provide high-quality TM education to postgraduate trainees from multiple specialties. The specific focus was on trainees from clinical specialties outside of hematology and hematopathology.

### 2. What is Transfusion Camp?

Transfusion Camp is a TM education program that enables medical professionals to better understand basic and practical TM principles based on current evidence. The curriculum is delivered over five days across the academic year, targeted towards postgraduate medical trainees. Each of the themed days addresses specific learning objectives and is broken down into two half days, consisting of two to three didactic lectures followed by a modified team-based learning (TBL) seminar (Table 1). The modified TBL seminars are attended by small groups of 5–15 trainees and facilitated by a local faculty member based on a seminar moderator package with cases followed by multiple choice questions. Trainees are asked to select a response and then a discussion ensues as trainees justify their responses. At the end of the discussion, the facilitator provides a brief summary of the learning points. In total, the Transfusion Camp curriculum contains approximately 15 hours of didactic lectures, 13 hours of TBL seminars and multiple prereading materials.

Transfusion Camp is coordinated by the University of Toronto Transfusion Camp planning committee comprised of members from TM, hematology, critical care, anesthesiology, Canadian Blood Services and a trainee. The planning committee meets after each day and reviews the participants' feedback and the trainee assessments to iteratively adjust the curriculum. For example, in 2022–2023, Transfusion Camp was shortened to four days and the days were organized closer together to span September to March of the Canadian academic year compared with July to June in its initial iterations. A detailed description of the Transfusion Camp curriculum, the modified TBL method and the organization of the planning committee, is provided in Lin et al., 2019. [17].

\* Correspondence to: 2075 Bayview Avenue, Room B2–04, Toronto, Ontario M4N 3M5, Canada.

E-mail address: [yulia.lin@sunnybrook.ca](mailto:yulia.lin@sunnybrook.ca) (Y. Lin).

**Table 1**  
Transfusion Camp Educational Program.

Day	Theme	Learning Objectives
1	Blood components and products indications	<ul style="list-style-type: none"> <li>• Appropriately prescribe components</li> <li>• Appropriate prescribe plasma protein products</li> <li>• Summarize basics of blood bank tests</li> <li>• Explain the implications of a positive antibody screen</li> <li>• Know when to screen patients for platelet alloimmunization</li> </ul>
2	Transfusion risks: acute and delayed	<ul style="list-style-type: none"> <li>• Obtain informed consent for transfusion</li> <li>• Prevent, diagnose, manage and report acute and delayed transfusion reactions</li> <li>• State the current risks of transfusion-transmitted infections</li> <li>• Know when to order irradiated blood components</li> <li>• Describe challenges to transfusion safety</li> </ul>
3	Special transfusion situations: maternal, perioperative bleeding assessment and sickle cell disease	<ul style="list-style-type: none"> <li>• State when and how Rh immunoglobulin is administered in pregnancy</li> <li>• Perform a preoperative bleeding history</li> <li>• Interpret coagulation testing results</li> <li>• Have a reasonable approach to correction of coagulation prior to procedures</li> <li>• Safely transfuse a patient with sickle cell disease</li> </ul>
4	Patient blood management and complex hemostasis	<ul style="list-style-type: none"> <li>• Have a standard approach to preoperative anemia</li> <li>• Apply patient blood management strategies, including for patients who refuse blood</li> <li>• Develop an approach to congenital or acquired bleeding disorders</li> </ul>
5	Massive hemorrhage protocols	<ul style="list-style-type: none"> <li>• Manage a massively hemorrhaging patient, including surgical, trauma and obstetrical patients</li> </ul>

### 2.1. Early successes

Early on, the planning committee recognized the importance of assessing the impact of Transfusion Camp on trainees. In the second year of Transfusion Camp (2013–2014), the validated multiple choice exam developed by the Biomedical Excellence for Safer Transfusion (BEST) collaborative [8] was adopted to assess trainee knowledge, attitudes and self-reported impact on behavior. In that second year, there were 67 trainees who attended at least two of the five days of Transfusion Camp from multiple residency programs at the University of Toronto (anesthesiology, critical care, emergency medicine, family medicine, family medicine emergency, hematology, hematopathology, obstetrics and pediatric hematology oncology). Trainees were asked to complete the test before and after attending Transfusion Camp. A consistent improvement in knowledge was demonstrated across all trainee sub-specialties (pre-Camp score  $50\% \pm 18\%$  ( $n = 53$ ) vs post-Camp score  $76\% \pm 16\%$  ( $n = 52$ ), two-tailed t-test  $p < 0.00001$ ). [16] The assessment also identified areas where trainees performed poorly including transfusion-related acute lung injury (TRALI) prevention and management, decision for RBC transfusion in symptomatic patients, allergic reaction and warfarin reversal. These assessments were relayed to content developers and provided valuable data to further improve the Transfusion Camp curriculum. The data also demonstrated to program directors of specialty training programs that Transfusion Camp was effective at delivering TM training to their trainees. With the expansion of Transfusion Camp to other university sites (described below), the pre- and post-Camp tests have been maintained to ensure the continued

evaluation of Transfusion Camp. [17].

In the initial two years of Transfusion Camp, the number of small group interactive seminars was increased to include one seminar in each half day. Trainees rated the seminars highly, often describing them as the element of Transfusion Camp they most enjoyed [personal communication, Casey Kapitany, Canadian Blood Services]. The seminars are designed to provide trainees with the opportunity to apply the learnings from the didactic lectures directly into clinical practice scenarios. The seminars also allow the trainees to get to know their local transfusion experts who could assist them in the future. In turn, the local transfusion experts have the opportunity to learn what transfusion knowledge gaps might be present.

The change from the traditional open ended question seminar to the modified TBL format was another key early success led by Dr. Elianna Saidenberg at the University of Ottawa. In a survey comparing the two formats, faculty preferred the modified TBL format noting increased trainee participation, attention, and improved quality of discussion. Because each trainee had to respond to each question, faculty reported improved insight into each trainee's knowledge gaps. [17] With each iteration, the TBL seminars have provided opportunities to trial different models. Discussion of indications for blood components and patient blood management is enriched by combining trainees from multiple specialties providing them with a rare opportunity to discuss their specialties' view and learn from one another. For other seminar topics, where the initial level of knowledge and the depth of knowledge required are variable such as congenital and acquired bleeding disorders, the seminar groups are organized by specialty. Different learning needs were also addressed by creating additional advanced questions for some seminars, specifically for hematology trainees. Moreover, the target audience has also been refined with trainees in at least the second year of postgraduate training so that trainees have a more consistent knowledge base and have had more time within their specialty to appreciate the relevance of Transfusion Camp in their daily practice. These adaptations reflect the desire of the planning committee to balance between providing foundational knowledge and tailoring knowledge to each specialty.

A key ingredient to the success of Transfusion Camp has been the commitment of various stakeholders from the transfusion community. Residency program directors have supported trainee participation in Transfusion Camp including providing protected time to attend and in some programs, such as anesthesiology at the University of Toronto, participation is mandatory. Faculty members have delivered didactic lectures and developed seminar materials consistently striving for practical, up-to-date and evidence-based content. Seminar facilitators, who may include TM experts, hematologists and anesthesiologists, have dedicated their time to facilitating the TBL seminars and benefit from updating their knowledge base or, at times, re-evaluating their local practices. Overall, Transfusion Camp provides a mechanism through which the transfusion community can share clinical practices and up-to-date information. It also provides professional development opportunities whereby hematology and TM fellows who first participate as trainees can later join the Transfusion Camp faculty as seminar facilitators and content experts.

Finally, there has been an increase in trainees from multiple specialties becoming engaged more deeply in transfusion. By day 5, 80% of trainees report that they had applied learning from Transfusion Camp into clinical practice. [17] The longitudinal experience over the academic year allows trainees to have repeated dedicated time points where they can check-in and ask questions. Trainees often bring their clinical transfusion questions or challenging cases to the seminars for discussion. Participation in Transfusion Camp has also led to trainees from specialties outside of hematology and transfusion, pursuing TM research projects. [18,19].

## 2.2. Expansion of Transfusion Camp across Canada

The early success of Transfusion Camp led to a partnership with Canadian Blood Services to expand the program across Canada. In 2015, a pilot with the University of Ottawa was initiated. Didactic lectures were delivered locally in Toronto and broadcast by webinar (GoToWebinar, Goto Group, Inc. Boston MA) to trainees in Ottawa. Modified TBL seminars were facilitated by local faculty. The pilot was successful and through word of mouth, Transfusion Camp expanded to additional sites each year. In 2022–2023, 16 of the 17 medical schools in Canada and an additional four sites in the United Kingdom are delivering Transfusion Camp to over 400 trainees from more than 12 different specialties. Additional partners have supported the program such as the Ontario Regional Blood Coordinating Network which facilitated participation of trainees from the six medical universities in Ontario by providing financial support for refreshments, and Héma-Québec which has been translating the seminar materials into French.

To expand Transfusion Camp, effective administrative support and a technology solution and infrastructure were essential. Canadian Blood Services provides administrative, coordinating and technology support for the effective participation of all sites. A guide on how to get started in setting up Transfusion Camp at the local site was created. Steps include identifying a local faculty/physician lead and administrative lead, approaching local program directors of specialty training residency programs to gauge interest, identifying seminar facilitators, deciding on the format of delivery for the site and for in-person sessions, ensuring rooms are booked and that the audiovisual connection is functional. Local site leads also ensure trainee attendance tracking and that the pre- and post-Camp assessments are completed. Canadian Blood Services provides access to two portals where materials developed by the planning committee and faculty are shared: a SharePoint collaborative for the presenters, seminar facilitators and local administrative leads; and a password protected subsite on Canadian Blood Services' professional education website (ProfessionalEducation.blood.ca) for participants to access the program schedule, pre-readings, lecture slide presentations and recordings (available two weeks after the live event), highlight summaries of each day and the seminar materials. Once all sites have completed the day, the seminar moderator guide is posted for trainees to review the answers.

Transfusions Camp has been adapted by participating sites to optimize delivery. Pre-pandemic, the delivery modes varied by site. At the University of Toronto, trainees attended didactic lectures and seminars in-person. At other sites, trainees attended as a group and watched the webinar live with seminars facilitated in-person by local faculty. Where timing of Transfusion Camp was an issue (especially because of time zone differences in Canada), trainees viewed recorded didactic lectures on their own or as a group and then attended seminars in-person with local faculty. This flexibility has been important for the success of Transfusion Camp expansion as it ensures each site can adopt a format that works best for them.

Throughout the expansion of Transfusion Camp, survey and assessments were deployed centrally using an online survey tool. The learner assessments have been used to measure effectiveness of transfusion knowledge delivery and to ensure that the educational quality of Transfusion Camp continues as different delivery formats are used at various sites. The formal assessments have demonstrated improved TM knowledge [8], improved ability to manage different transfusion scenarios from assessing the need for red blood cells, platelets and plasma transfusion to assessing transfusion reactions and obtaining consent for transfusion. At the end of Transfusion Camp, 95% of trainees felt that TM knowledge was very or extremely important in providing patient care. [17] In subsequent years, despite no change in the baseline knowledge assessment scores, there has been an incremental improvement in the post-Camp assessment scores (2018–2019 post-Camp test mean score  $14.0 \pm 2.8$ ,  $n = 125$ ; 2019–2020 post-Camp test mean score  $14.5 \pm 3.4$ ,  $n = 167$ ; unpublished data, personal communication, Yulia

Lin, University of Toronto), suggesting that the delivery of knowledge by Transfusion Camp remained effective, even with the expansion to additional sites.

In 2020, the assessment was revised to be more specific to the content of Transfusion Camp. The revised assessment was validated using Rasch analysis, a psychometric approach to compare exam results to those predicted by the model based on question difficulty and examinee ability (Winsteps Version 4.0.1: <http://www.winsteps.com>). [20] Changes included replacing some questions with questions on bleeding assessment, Rh immunoglobulin, sickle cell disease, preoperative anemia and reversal of dabigatran. Examination quality was determined by calculating the “fit” of each question with the model; the ideal score being 1.0. Using the 2020–2021 pre-test scores, the item in-fit and out-fit were both 1.0; thus the revised assessment had good validity using Rasch analysis. For the 2020–2021 academic year, the mean pre-Camp test score was  $11.3 \pm 3.3$  out of 20 ( $n = 374$ ) vs. the mean post-Camp test score  $15.2 \pm 2.7$  ( $n = 217$ );  $p < 0.0001$  demonstrating consistent knowledge improvement with the revised assessment tool in a more recent evaluation.

TM knowledge and attitudes towards transfusion are not the only methods to incorporate Transfusion Camp learnings. From the program evaluation surveys, we attempted to understand the self-reported impact of Transfusion Camp on trainee transfusion practice. [unpublished data, Katie Yeung, Queen's University, oral abstract presentation at the Canadian Society of Transfusion Medicine Annual Meeting, 2022]. A retrospective analysis of surveys over three academic years (2018–2021) was conducted. Trainees were asked “Have you applied any of your learning from Transfusion Camp into your clinical practice?” Amongst the 757 trainees who completed the survey, over 65% responded that they had applied their learnings, increasing with each day of Transfusion Camp. The most frequent areas of impact included transfusion indications and transfusion reaction management. This effect persisted even after virtual adaptation of the program during the COVID-19 pandemic.

With the expansion to other sites, we also sought to understand the variations in participation, knowledge gains and impacts on practice using semi-structured individual interviews with trainees and faculty involved in Transfusion Camp. [21] Amongst the 19 participants interviewed (11 trainees and 8 faculty), distributed teaching over time appeared to hinder learning for some trainees. This led to the shortening of the time between days 1 and 5 of Transfusion Camp. Exposing trainees to the same content repeatedly and through different learning strategies was also important, leading to development of highlight summaries as a resource. Participants found inter-specialty teaching beneficial although noted different needs based on specialty. This led to the incorporation of seminar groups composed of similar specialties for specific topics (e.g. sickle cell disease, congenital and acquired bleeding disorders). With faculty, the interviews revealed an unexpected benefit of creating a community of practice amongst the Transfusion Camp educators geographically spread across the country. Faculty felt that this community of practice allowed sharing of experiences to help address local practice gaps. Transfusion Camp has also provided opportunities for recruitment and mentorship of early-career physicians, fostering interest in TM.

## 2.3. Adapting Transfusion Camp to other learning environments

Transfusion Camp has been modified for TM care providers in Canada. In some Canadian jurisdictions, nurse practitioners (NPs) can prescribe and administer blood and blood products in their scope of practice. In 2019, Transfusion Camp was adapted into a three day pilot curriculum for NPs in British Columbia, Canada in collaboration with the British Columbia College of Nurses and Midwives. [22] To assess the pilot, a survey of the 23 participants showed that they had minimal opportunities for TM education. Knowledge assessment using the BEST test improved during the modified NP Transfusion Camp (pre-Camp test

35.2% vs. post-Camp test 50.3%;  $p = 0.005$ ). The areas requiring improvement were questions on transfusion reactions. Transfusion Camp for NPs has continued with the support of both local NP leads, TM experts and Canadian Blood Services. From 2020–2022, 83 NPs have taken the course with continued demonstration of improvement using the BEST test (pre-Camp test 43.4% vs. post-Camp test 66.5%) [personal communication, Andrew Shih, Vancouver General Hospital]. NP leads have also incorporated TM into their local curricula and quality improvement projects. A steering committee for Transfusion Camp for NPs has been created to incorporate feedback on the curriculum delivery and relevance.

Transfusion Camp has also been adapted by other countries to meet local TM education requirements. In 2019, colleagues from Australia (Drs. L. Clarke & B. Saxon, Australian Red Cross) approached the Transfusion Camp planning committee about running a modified version for the Australian postgraduate trainees. Transfusion Camp was introduced in Australia in 2020, when the country had shifted to virtual education due to the COVID-19 pandemic. The curriculum was offered in an abridged version consisting of three modules: Module 1 on transfusion basics (Day 1); Module 2 on patient blood management (preoperative and intraoperative PBM and bleeding assessment from Day 3 and 4); and Module 3 on critical bleeding or massive hemorrhage (Day 5). The modules were complemented with online question and answer sessions with TM experts. Downloads for the different lecture recordings ranged from 47 (bleeding assessment) to 214 (red cell transfusion) and 347 (basic blood bank testing). The number of participants varied from multiple specialties including hematology, anesthesiology, emergency and general medicine. [personal communication, Dr. L. Clarke, Australian Red Cross].

Most recently in 2022, Transfusion Camp was piloted with the University of Rwanda. [unpublished data, J. Hagumimana, University of Rwanda and T. Skelton, University of Toronto, abstract presentation at the All Africa Anesthesia Congress 2022] The Transfusion Camp didactic lectures and seminars from Day 1 were adapted jointly by faculty from the University of Toronto Transfusion Camp and local Rwanda transfusion experts at the University of Rwanda and the National Centre for Blood Transfusion in Rwanda. Twenty-eight postgraduate trainees reviewed course materials and watched recorded lectures of the adapted Day 1 program on their own and then came together to participate in modified TBL seminars co-led by a local faculty member in-person and a Transfusion Camp faculty from Canada attending virtually. The pilot program was very well received and preliminary results demonstrated improvements in trainee knowledge and confidence in managing transfusion-related patient issues.

#### 2.4. Impacts and learning from the COVID 19 pandemic

When the COVID-19 pandemic was declared on March 11, 2020, faculty were pulled into priority patient care planning responsibilities to manage the health care crisis. Public health recommendations across Canada prevented in-person gatherings. Like the rest of the country, Transfusion Camp had to pivot to ensure the continued delivery of TM education. The established centralized model for delivery of Transfusion Camp across Canada, including a combination of in-person and virtual mechanisms, lent itself to converting to a fully virtual program within a short period. On April 3, 2020, Day 4 of Transfusion Camp was webcast with available speakers presenting from their offices and trainees attending remotely. The program also included an update on COVID-19 and its impact on blood transfusion. Surprisingly, over 200 trainees joined the virtual session from 11 universities, 13 specialties and 4 provinces. [23].

Leveraging learnings from this experience and the flexible delivery methodology, Transfusion Camp was converted to a fully virtual delivery modality with the continued technology and coordinating support of Canadian Blood Services. For the remaining two years of the pandemic, all didactic lectures and TBL seminars were delivered using a

web conferencing platform (Zoom, San Jose, USA) while the pre-and post-Camp tests were completed using an online survey platform (SurveyMonkey, San Mateo, USA) instead of paper.

Transitioning to a completely virtual modality offered several advantages. Firstly, the program was more accessible as trainees could attend from a safe and comfortable space of their own choosing. This allowed inclusion of trainees who were away for clinical electives or providing service in remote regions. The program became more time and cost-effective reducing needs associated with travel, facilities rental costs, food and refreshments. When budget was available, some participating universities offered gift cards to their trainees for refreshments, an added measure to promote attendance and wellness during the pandemic. The new delivery modality also allows for external faculty facilitators to assist with teaching and for small group sessions to be composed of trainees in the same specialty but from different sites, thus fostering knowledge exchange and a community of practice amongst trainees across the country. Most encouraging was the increased engagement of trainees during online lectures with many more questions being asked through the chat box compared to pre-pandemic, when trainees had to ask them “out loud”. In response, the program was adjusted to allow more time for the question and answer period after each lecture. As described above, assessments of trainees’ TM knowledge continued to show that transfusion knowledge was gained and being applied, thus demonstrating that the change in modality had little impact on the learning experience while providing certain advantages to the TM education community across Canada.

The major challenge was the decrease in opportunities for informal networking. Pre-pandemic, trainees interacted with each other and with faculty at break and meal times. There was also a significant impact on the delivery of seminars. Many of the faculty and trainees had not yet participated in virtual small group sessions. Increasing comfort amongst participants came with each iteration and shared experiences among faculty from all sites. Adaptations to increase engagement included smaller seminar groups (ideally less than 10 trainees), encouraging participants to turn on their webcams and using the annotation and polling functions of the web conferencing platform. Although the COVID-19 pandemic diminished “on-the-job” opportunities to learn from colleagues from different clinical specialties, Transfusion Camp was able to offer that welcomed opportunity in this difficult time.

#### 2.5. Challenges in further expansion

There remains high interest for practical TM teaching. To date, a blended model has been used where the didactic lectures and seminar materials are prepared by the Transfusion Camp planning committee and faculty with feedback from the learners and transfusion community. TBL seminars are facilitated by local faculty, allowing for inclusion of specific local practices. Each site requires local administrative support for scheduling. Each site also requires the support of local program directors to protect time for their trainees to attend. Smaller sites may be limited by available expert seminar leaders or administrative support to implement the Transfusion Camp curriculum. The faculty involved in Transfusion Camp remain highly motivated and have offered a blended model of facilitation by participating as seminar leaders for external sites remotely. Hence, sites that may have the interest but lack sufficient expert support or are struggling with administrative challenges may still be able to administer Transfusion Camp. There is also a significant administrative burden in the coordination of Transfusion Camp, supported generously by Canadian Blood Services, which may be challenged by the addition of more sites.

As with all educational programs, although we have demonstrated an improvement in the participants’ knowledge base, the challenge remains in demonstrating that Transfusion Camp can directly change patient outcomes. Also, we need to ensure, that despite expansion to distributed sites, the delivery of the content remains effective, accessible and practical for learners.

### 3. Conclusion

Transfusion Camp has demonstrated the capacity to improve trainee attitudes towards transfusion education, increase trainee transfusion knowledge and impact trainee reported transfusion practice. Transfusion Camp has fostered a community of practice for the Canadian transfusion medicine experts, where best transfusion practices can be shared and local practices recognized and discussed. Now in its 11th year, Transfusion Camp is being delivered at 16 Canadian medical schools and 4 medical schools in the United Kingdom with adapted education programs in Australia, Rwanda and for nurse practitioners. It is an example of an agile, scalable and evidence-based approach to transfusion education where ongoing feedback and scholarly assessments have driven the improvement in the curriculum and its delivery over time. The program has been sustained by its dedicated faculty from all participating sites, especially at the University of Toronto and the coordinating oversight from Canadian Blood Services. Since 2016–2017, over 1400 postgraduate medical trainees have participated in Transfusion Camp, a cohort of professionals who will be better equipped to promote best transfusion practice for the benefit of our patients.

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