

# Implementation of a blood bank generated tube for second blood group determination: Challenges, yield, and cost

Noora Obaidallah<sup>1</sup>  | Helen Downie<sup>2</sup> | Connie Colavecchia<sup>2</sup> |  
Jeannie Callum<sup>3,4,5</sup>  | Yulia Lin<sup>2,3,4</sup> 

<sup>1</sup>Department of Medicine, University of Toronto, Toronto, Ontario, Canada

<sup>2</sup>Division of Transfusion Medicine and Tissue Bank, Sunnybrook Health Sciences Centre, Toronto, Ontario, Canada

<sup>3</sup>Department of Laboratory Medicine and Pathobiology, University of Toronto, Toronto, Ontario, Canada

<sup>4</sup>University of Toronto Quality in Utilization, Education and Safety in Transfusion (QUEST) Research Program, Toronto, Ontario, Canada

<sup>5</sup>Department of Pathology and Molecular Medicine, Kingston Health Sciences Centre and Queen's University, Kingston, Ontario, Canada

## Correspondence

Yulia Lin, 2075 Bayview Avenue, Room B2-04, Toronto, ON M4N 3M5, Canada.  
Email: yulia.lin@sunnybrook.ca

## Funding information

Canadian Blood Services; provincial and territorial ministries of health; federal government (Health Canada)

## Abstract

**Background:** The second blood group determination or group check sample is a process of verifying the ABO group with a second blood sample prior to transfusion. It has been used to detect errors related to wrong blood in tube (WBIT) events and reduce the risk of ABO-incompatible transfusions. To prevent the clinical team from collecting the group check sample at the same time as the first sample, a tan top tube only available from the blood bank was introduced for second blood group determinations if drawn within 24 h of the first group and screen.

**Study design and methods:** This is a retrospective study analyzing data from 2005 to 2020 before and after the implementation of the blood bank supplied tan top tube for group check. The number of WBIT events, transfusion delays, and health care costs were determined.

**Results:** The number of WBIT events remained unchanged throughout the time period. No delays in transfusion or procedure were reported due to the tan top tube group check. There was no increase in group O transfusions over time. In comparison to using an ethylenediaminetetraacetic acid (EDTA) tube, the tan top tube was estimated to add an extra yearly cost of \$790.79 Canadian dollars.

**Conclusion:** Second blood group determination using the blood bank supplied tan top tube did not increase the number of WBIT events detected but ensured an independent sample draw. A minimal incremental cost of implementing the tan top tube was noted with no delay in transfusions or procedures.

## KEYWORDS

blood transfusion, laboratory safety, patient safety, patient testing and transfusion medicine clinical practices

## 1 | INTRODUCTION

“Wrong blood in tube” (WBIT) errors, where the blood in the tube is not that of the patient identified on the label,

may lead to catastrophic outcomes.<sup>1</sup> When a blood sample is not that of the intended patient, the interpretation of the results could lead to misdiagnosis, inappropriate interventions, and serious adverse events. WBIT errors

This is an open access article under the terms of the Creative Commons Attribution-NonCommercial License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited and is not used for commercial purposes.

© 2022 The Authors. *Transfusion* published by Wiley Periodicals LLC on behalf of AABB.

can also result in ABO-incompatible blood transfusions, which may result in death or major morbidity.<sup>2</sup> In one report, the overall WBIT rate was 6.2 per 10,000, (1 per 1613) with variability by site (sites with error detection mechanisms, such as regrouping second sample requirements, had lower error rates than sites that did not).<sup>3</sup> In another report, 10 per 23,234 (1 per 2323) specimens were identified as WBIT errors.<sup>4</sup> WBIT errors are greatly underestimated and are the most difficult to detect because they require a historical sample or a second sample to identify an error.<sup>3</sup>

There are several different potential strategies for reducing wrong blood transfusion errors: electronic technologies (e.g., using positive patient identification and electronic physician order entry); use of barrier devices; and/or ABO/Rh verification or second blood group determination.<sup>5</sup> In a large study by Kaufman and colleagues, they reported a WBIT rate corrected for repeat samples and silent WBIT errors, of 1 per 3046 for sites using manual identification and 1 per 14,606 for sites using electronic identification.<sup>6</sup> In their study, electronic patient identification was associated with approximately five-fold fewer WBIT errors compared with using manual patient identification.<sup>6</sup>

The second blood group determination or group check is a process of confirming the ABO group with a second blood sample prior to transfusion. ABO verification may be necessary even after the implementation of barcoding and/or radio-frequency identification (RFID) chips because human errors continue to occur even with systems improvements.<sup>5</sup> The estimated risk of issuing the wrong blood unit decreases from 1 in 630 (corrected) to 1 in 396,000 when using two independent samples.<sup>5</sup> For emergency blood transfusion and to minimize the risk of acute hemolytic reaction, group O blood transfusion is safer than group-specific blood when the blood group of the patient has only been tested once.<sup>7</sup> A second sample to confirm the patient's ABO group if electronic positive patient identification (ePPID) is not used, is a requirement by the Canadian Standards Association<sup>8</sup> and the AABB.<sup>9</sup> ABO/Rh identification is needed for compatible blood transfusion and to minimize the use of group O blood for nongroup O patients. The practice of using group O blood in ABO nonidentical recipients has been increasing and can lead to recurrent shortages in group O blood.<sup>10</sup>

However, there are multiple challenges and concerns about implementing the second blood group determination policy. These include how to ensure that the two samples are not collected at the same time without repeating the patient identification process with one sample being held back until the second sample is requested, potential delays in providing crossmatched red blood cells (RBCs), possible increased use of uncrossmatched

group O RBCs, and finally, the added cost, including nursing or phlebotomy costs to redraw blood, cost of transport, and reagent costs and technologist time for testing the second sample. To address the issue of two samples being collected at the same time, a restricted specimen tube type (a tan top tube) that is only available from the blood bank, was implemented at our institution.

The objective of this study was to determine if the second blood group determination policy using a blood bank generated tan top tube increased rate of WBIT detection, caused delays in blood transfusion, increased costs, or increased the use of group O blood over time. Understanding the effect of this requirement on cost and time and how to implement such a requirement, is of high value and impact for transfusion services.

## 2 | MATERIALS AND METHODS

This is a retrospective study analyzing data available in the blood bank laboratory information system (HCLL™, Wellsky, USA) and the transfusion error surveillance system (TESS) database from 2005 to 2020. This study was approved by the Sunnybrook Health Sciences Center research ethics board.

### 2.1 | Policy

In November 2005, the transfusion committee set a policy that prior to transfusion, every patient's blood group had to be verified on an independent sample. This could be done using a historical blood group recorded in the blood bank laboratory information system; or if no historical blood group was available, then a second blood group determination (or group check sample) had to be drawn prior to issuing a nongroup O unit. Samples drawn in hospital locations utilizing ePPID did not require the collection of a group check sample (in these cases, the single sample was tested twice if there was no historical blood group).

In 2011, this policy was modified so that if the initial group and screen was less than 24 h old, a group check sample had to be drawn in a separate tube that was only available from and supplied by the blood bank. This was to prevent the clinical team from collecting both samples at the same time and holding one back until the second sample was requested (and the potential of having mislabeled both). In 2010, 16 events occurred where two group and screen samples were received by the blood bank at the same time. Thus, a royal blue top tube was implemented for the group check on January 4, 2011. Because of the need to use the royal blue top tube for other biochemistry tests, this was switched to a tan top

tube in October 2011. The blood bank supplied tube was not pre-labeled but sent out to the clinical area in a bag with the patient details on the bag to ensure procedures were followed in labeling the sample tube at the bedside. In situations where urgent blood transfusion was required, uncrossmatched group O RBCs were issued until a group check was completed. Thus, the study period covered the time period before and after the implementation of the blood bank supplied tan top tube for the group check.

## 2.2 | Population

All patients, in the inpatient or outpatient setting, who required a group and screen and a group check as per policy were included. Neonates were excluded as these patients receive only group O RBCs at our institution.

## 2.3 | Data collection

During the time period of the study, WBIT events were documented and reported in the TESS, an error surveillance system that has been prospectively identifying errors in transfusion medicine at our institution since 2005. The TESS surveillance system data were extracted for the study period and analyzed to determine if using a blood bank supplied tan top tube for the group check had increased the yield of detecting WBIT events in comparison with using two EDTA tubes, which are available anywhere outside the blood bank. The specific TESS codes for WBIT errors included SC01 for correct patient collected and incorrect patient identification label and SC03 for wrong patient collected with intended patient identification.<sup>11</sup> The number of WBIT events in TESS were recorded for the period of 2005–2010 prior to implementation of the tan top tube for group check and for the period of 2011–2020 after the implementation of the tan top tube. The TESS data extract was also analyzed for delays in procedures or transfusion before and after the policy change.

For cost analysis and delays in providing transfusion, we looked at 1 year of data in 2018, the most recent year when the project was started. In 2018, there were three locations at our center with ePPID: the operating room, the outpatient transfusion medicine clinic and the hematology inpatient ward. The group check was not required in these areas. The blood bank laboratory information system was used to identify the total number of group and screens and group check samples using a tan top tube. It was also used to analyze the turnaround time for group and screens, which is the time from group and screen receipt to result. The group check samples were

further reviewed for location, turnaround time (time from receipt of group check to result), and number that were followed by transfusion within 24 and 72 h.

## 2.4 | Outcomes

The primary outcome of the study was the number of WBIT events per 10,000 specimens collected during the period of 2005 to 2010 compared with 2011–2020 after implementation of the tan top tube for group check. Secondary outcomes were identified as (1) reports of delays in procedure or transfusion in the TESS data extract; (2) the turnaround time for the second sample to be reported; (3) the number of group and screens that required a group check and how many of these were followed by a transfusion; (4) the cost of using a blood bank supplied tan top tube for a second sample in blood group check; and (5) number of group O blood transfusions annually over time.

To quantify the yearly cost of using a blood bank supplied tan top tube for a second sample, the total number of blood group checks using tan top tube in the year 2018 were identified from blood bank laboratory information system. Costs are in Canadian dollars. The price of the tan top tube (\$0.30/tube) was compared to an EDTA tube (\$0.08/tube). Wages of lab technologists, registered nurses, and porters are \$52.90/h, \$59.90/h, and \$28.80/h, respectively. Average time of the following was calculated: (a) delivering a tan top tube to site of blood draw by porter average 1.45 min (\$0.69/tube); (b) nursing time to draw second blood group average 3.13 min (\$3.13/tube); and, (c) Technologist time to process second group and result average 7.65 min (\$6.7/tube).

To detect if using a blood bank supplied tan top tube had increased the number of group O transfusions over time, the annual number of group O RBC transfusion from 2005 to 2020 was extracted from the blood bank laboratory information system. This was further broken down to look separately at annual group O negative and group O positive RBC transfusions.

## 2.5 | Statistical methods

Descriptive analysis was summarized using mean, standard deviation (SD), median and range for continuous variables, and count and percentage for categorical variables. To determine significant time trends for WBIT per 10,000 events, total number of RBCs, O positive and O negative RBCs transfused, Poisson regression analysis was conducted for modeling this count data in the period of 2005–2020 and compared between two time periods

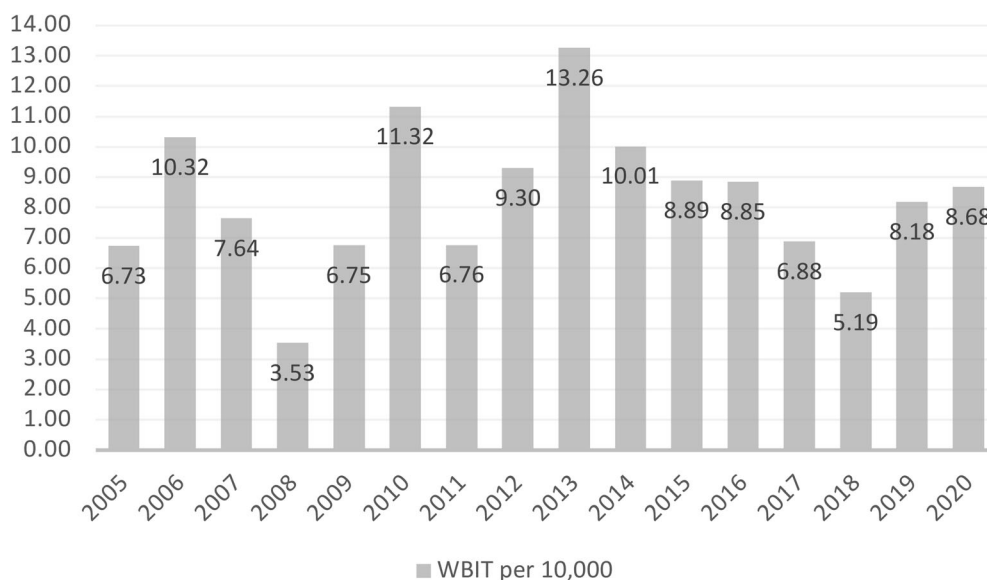
before and after implementation of the tan top tube (i.e., 2005–2010 vs. 2011–2020). GENMOD procedure in Statistical Analysis Software (SAS version 9.4, Cary, NC) was used for Poisson regression models with log link function.  $p$ -value  $< .05$  was considered significant.

### 3 | RESULTS

There were 379 reported WBIT events in the TESS from 2005 to 2020. The rate of WBIT per 10,000 samples remained stable without significant change ( $p = .82$ ) through the time period (Figure 1). When WBIT per 10,000 samples between years 2005–2010 and 2011–2020 were compared, there was again no significant change ( $p = .48$ ). WBIT events were classified by location from 2005 to 2020: obstetrics (128; 34%), emergency department (101; 27%), medical–surgical wards (62; 16%), critical care units (54; 14%), outpatient clinics (22; 6%) and

operating rooms (12; 3%). No delays in transfusion or procedure were reported in the TESS due to the tan top tube policy. No ABO-incompatible transfusions were reported during the time period.

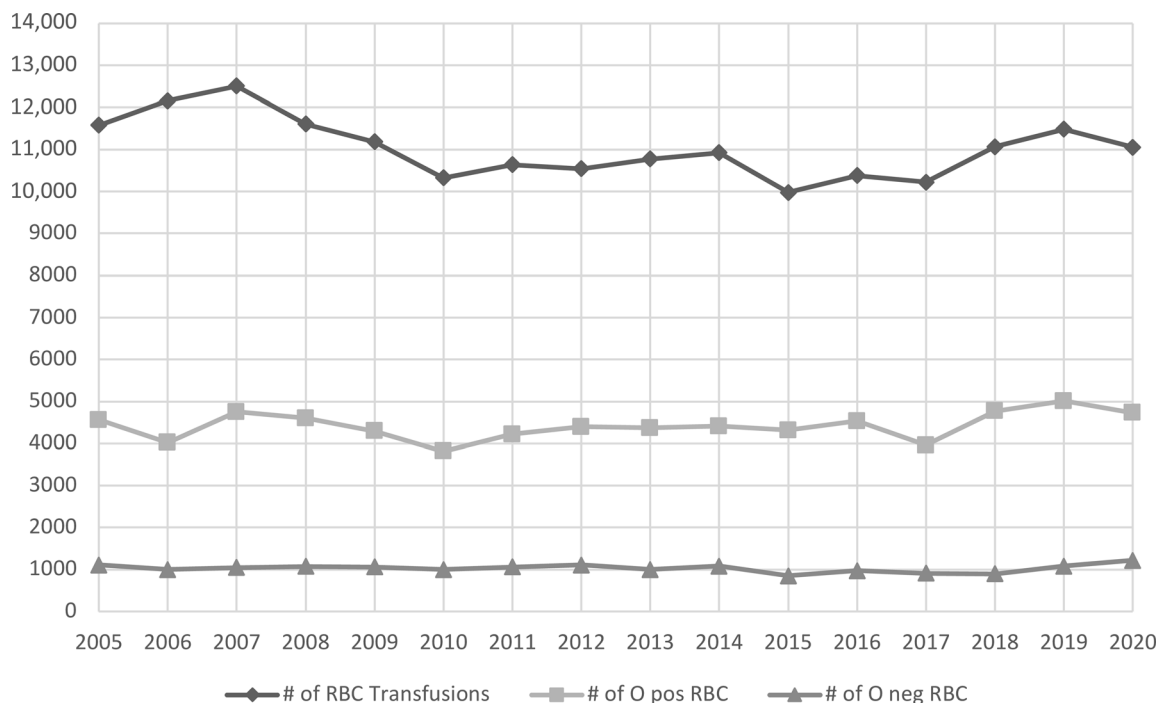
In 2018, there were 27,646 blood group and screens tested and 869 (3%) of group and screens required a blood group check. The most common location for requesting group check samples was the emergency department with a total of 406 samples in 2018, accounting for 47% of the group check samples. Other areas where group checks were done included medical–surgical wards, operating rooms, critical care units, and outpatient settings accounting for 25%, 15%, 8%, and 5% of group checks, respectively. The average turnaround time for the group and screen was 77 min (SD  $\pm$  78 min) whereas the average turnaround time for the group check was 59 min (SD  $\pm$  58 min). In 35 patients (4%), the group check resulted before the group and screen.



**FIGURE 1** Wrong blood in tube events per 10,000 specimen collected from 2005 to 2020. WBIT, wrong blood in tube

**TABLE 1** Comparing cost of blood group check using tan top tube versus EDTA tube (costs in Canadian dollars)

<b>Tan top tube (869 blood group checks in 2018 using tan top tube)</b>	<b>Cost/year</b>	<b>EDTA tube available outside blood bank</b>	<b>Cost/year</b>
Cost of tan top tube 0.30 cents/tube	\$260.70	Cost of EDTA tube is \$0.08/tube	\$69.52
Cost of technologist processing tan top tube \$6.7/tube	\$5822.30	Cost of technologist processing second sample of blood \$6.9/tube	\$5822.30
Cost of nursing to draw second sample of blood \$3.13/tube	\$2719.97	Cost of Nursing to draw second sample of blood \$3.13/tube	\$2719.97
Cost of porter to deliver tan top tube to site of blood draw \$0.69/tube	\$599.61	-	-
Cost of porter to deliver tan top tube to blood bank \$0.69/tube	\$599.61	Cost of porter to deliver second blood group sample to blood bank \$0.69/tube	\$599.61
<b>Total cost/year</b>	<b>\$10,002.19</b>	<b>Total</b>	<b>\$9211.40</b>



**FIGURE 2** Total number of all RBC transfusions, group O positive RBC transfusion and group O negative RBC transfusions from 2005 to 2020

Out of 869 blood group checks, 651 (75%) required transfusion within 24 h and 778 (89.5%) required transfusion within 72 h. Eighty-four (9.6%) blood group check samples were followed by a transfusion more than 72 h after. Only seven samples (0.8%) were not followed by any red blood cell (RBC) transfusion.

The estimated added yearly cost of the group check sample using the blood bank supplied tan top tube was \$790.79 Canadian dollars in comparison with using an EDTA tube, which is available in all clinical locations (Table 1). There was no increase in group O transfusions over time (Figure 2). When comparing between years 2005–2010 and 2011–2020, the number of group O positive and group O negative RBC transfusions were similar ( $p = .44$  and  $.52$ , respectively).

#### 4 | DISCUSSION

This study describes the experience at a single large academic center with the use of a blood bank supplied tan top tube for the group check (or second determination) in order to ensure the independent collection of two separate samples to confirm the blood group. The decision to implement this policy was prompted when the transfusion safety officer at the institution reported that two tubes were often being collected at the same time with one being held back for second blood group determination.

The group check using the tan top tube (available only from blood bank) did not increase the rate of detected WBIT per 10,000 samples compared to using EDTA tubes (available outside the blood bank), but it ensured an independent sample draw. A previous study by Goodnough and colleagues also reported that error rates remained approximately the same after implementation of the two-specimen requirement using a color-coded collection tube for verification of ABO/Rh group.<sup>5</sup> The rate of WBIT from 2005 to 2020 in the current study was 1 per 1330 compared with 1 per 1613<sup>3</sup> and 1 per 2323<sup>4</sup> in previous reports. This higher rate could be due to increased detection with a long-standing transfusion error surveillance system or could represent a true higher rate of WBIT. Despite no reports of ABO-incompatible transfusions, a decrease in rate of WBIT over time was not seen. The rate remained stable despite multiple educational presentations and feedback sessions to clinical areas, mandatory nursing competency in transfusion, and the gradual implementation of ePPID starting in 2017 in some areas of the institution; highlighting the challenges with eliminating WBIT in a large academic institution. However, over the time period, no ABO-incompatible transfusions were detected.

An important objective of this study was to determine if the second blood group determination policy using a blood bank generated tan top tube caused delays in blood transfusion, increased cost, or increased the use of group O blood over time. Not all hospitals have implemented



ePPID; if ePPID is not used, a second sample to confirm the patient's ABO group is a requirement by the Canadian Standards Association<sup>8</sup> and the AABB.<sup>9</sup> There have been concerns about this policy's potential cost and effect on healthcare systems. In this report, there was no delay in transfusions or procedures reported. There was minimal incremental cost of implementing the group check using a tan top tube. There was no increase in group O RBC transfusions over time. The annual cost of blood group check is estimated at 10,002.19 Canadian dollars in our institution, including an annual cost of 790.79 Canadian dollars for the separate blood bank tube for the group check. The group check was valuable and used for its intended purpose with 90% of patients receiving a transfusion within 72 h of the sample. The blood group check is a cost-effective step before implementing an ePPID system. The blood group check may remain the preferred method for blood group verification even after ePPID system implementation, particularly in high activity areas with a large number of staff such as the emergency department where WBIT rates are higher and procedures for ePPID may not be reliably followed.<sup>12,13</sup> Known factors that may reduce the efficacy of ePPID include override of the electronic scanning process of the sample or the patient due to inadequate staff training, broken scanning or label printing equipment, unreadable patient or sample barcodes, or refusal of patients to allow the scanning process.

Limitations of this study include that it is a single-center study and thus may limit generalizability. It is retrospective in nature; however, data for errors were reported prospectively and collected using rigorous definitions in the TESS surveillance system. The period of 2005–2007 represent the early years of TESS and thus reporting may have been limited as users became familiar with the process of error reporting. Data from prior to implementation of the second determination (before 2005) were not available and so assessment of the effect of the second determination itself could not be analyzed and the focus of this study was on the implications of implementing a separate tube supplied by the blood bank for the second group determination.

In addition to above limitations, it should be noted that in our study only 3% of the total ABO samples required a group check. This resulted in a small sample size of 869 group checks. This is in contrast to a report by Glisch and colleagues,<sup>14</sup> which showed that 66% of their new patient ABO samples required a group check. Our samples were derived from all group and screens ordered in our institution in 2018, which included all patients new or known to us with an available historical group. Our policy also excludes those patients who do not require an urgent RBC transfusion within 24 h. Finally, group and screens did not require a group check in areas

where ePPID was implemented (the operating room, the outpatient transfusion medicine clinic, and the hematology inpatient ward). It is possible that this small sample underestimates the true impact of the benefit of the group check using a blood bank supplied tube and ultimately underestimates labor requirements and costs. The exclusion of the service areas where ePPID was implemented is an important limitation as the need for group checks in the outpatient transfusion medicine clinic could result in additional waiting time and delays for patients.

In conclusion, in an effort to overcome challenges and concerns about implementing a second blood group determination sample, which includes cost, delay in services, increase group O transfusion, and how to ensure that two samples are not collected at the same time, a tan top tube that is only available from the blood bank was implemented at our institution for blood group check. In this report, we show that this is a cost-effective method to ensure an independent sample draw with minimal incremental cost. It does not result in delayed transfusions or procedures, nor increase the use of group O transfusions.

#### ACKNOWLEDGMENTS

The authors thank Liying Zhang for her statistical support and Ana Lima, the transfusion safety nurse who led the implementation of the blood group check using a tan top tube at Sunnybrook Health Sciences Centre. This research received funding support from Canadian Blood Services, Program Support Award (The University of Toronto QUEST Transfusion Research Program), funded by the federal government (Health Canada) and the provincial and territorial ministries of health. The views herein do not necessarily reflect the views of Canadian Blood Services, the federal, provincial, or territorial governments of Canada.

#### CONFLICT OF INTEREST

Dr Jeannie Callum has received research support from CIHR, Canadian Blood Services, Defense Research and Development Canada, and Octapharma.

#### ORCID

Noora Obaidallah  <https://orcid.org/0000-0003-2846-1610>

Jeannie Callum  <https://orcid.org/0000-0001-6133-0677>

Yulia Lin  <https://orcid.org/0000-0002-5562-9020>

#### REFERENCES

1. Bolton-Maggs PH, Wood EM, Wiersum-Osselton JC. Wrong blood in tube—potential for serious outcomes: can it be prevented? *Br J Haematol.* 2015;168(1):3–13.
2. Bolton-Maggs PHB, Cohen H. Serious hazards of transfusion (SHOT) haemovigilance and progress is improving transfusion safety. *Br J Haematol.* 2013;163(3):303–14.

3. Strauss R, Downie H, Wilson A, Mouchili A, Berry B, Cserti-Gazdewich C, et al. Sample collection and sample handling errors submitted to the transfusion error surveillance system, 2006 to 2015. *Transfusion*. 2018;58(7):1697–707.
4. Novis DA, Lindholm PF, Ramsey G, Alcorn KW, Souers RJ, Blond B. Blood bank specimen mislabeling: a College of American Pathologists Q-probes study of 41 333 blood bank specimens in 30 institutions. *Arch Pathol Lab Med*. 2017;141(2):255–9.
5. Goodnough LT, Viele M, Fontaine MJ, Jurado C, Stone N, Quach P, et al. Implementation of a two-specimen requirement for verification of ABO/Rh for blood transfusion. *Transfusion*. 2009;49(7):1321–8.
6. Kaufman RM, Dinh A, Cohn CS, Fung MK, Gorlin J, Melanson S, et al. Electronic patient identification for sample labeling reduces wrong blood in tube errors. *Transfusion*. 2019;59(3):972–80.
7. Fujii Y. Prevention of ABO-incompatible transfusion. *Masui Jpn J Anesthesiol*. 2011;60(1):47–54.
8. CSA Group. CAN/CSA-Z902:20 - blood and blood components. Canada: CSA Group; 2020.
9. American Association of Blood Banks. Standards for blood banks and transfusion services. 32nd ed. Bethesda, MD: American Association of Blood Banks; 2020.
10. Barty RL, Pai M, Liu Y, Arnold DM, Cook RJ, Zeller MP, et al. Group O RBCs: where is universal donor blood being used. *Vox Sang*. 2017;112(4):336–42.
11. Public Health Agency of Canada. Transfusion error surveillance system (TESS): user's manual. Version 1.0. Ottawa: Public Health Agency of Canada; 2008.
12. Dunbar NM, Delaney M, Murphy MF, Pagano MB, Saifee NH, Seheult J, et al. Emergency departments are higher-risk locations for wrong blood in tube errors. *Transfusion*. 2021;61(9):2601–10.
13. Dunbar NM, Kaufman RM. Factors associated with wrong blood in tube errors: an international case series – the BEST collaborative study. *Transfusion*. 2021;1-7:44–50.
14. Glisch C, Jawa Z, Brener A, Carpenter E, Gottschall J, Treml A, et al. Evaluation of a two-sample process for prevention of ABO mistransfusions in a high volume academic hospital. *BMJ Open Qual*. 2018;7(3):e000270.

**How to cite this article:** Obaidallah N, Downie H, Colavecchia C, Callum J, Lin Y. Implementation of a blood bank generated tube for second blood group determination: Challenges, yield, and cost. *Transfusion*. 2022;62:784–90. <https://doi.org/10.1111/trf.16838>