


ORIGINAL ARTICLE

Impacts of COVID-19 and elective surgery cancellations on platelet supply and utilization in the Canadian Province of British Columbia

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Abstract

Background and Objectives: The coronavirus disease 2019 (COVID-19) pandemic raised concerns about the vulnerability of platelet supply and the uncertain impact of the resumption of elective surgery on utilization. We report the impact of COVID-19 on platelet supply and utilization across a large, integrated healthcare system in the Canadian province of British Columbia (BC).

Materials and Methods: Historical platelet use in BC by indication was compiled for fiscal year 2010/2011–2019/2020. Platelet collections, initial daily inventory and disposition data were assessed pre-COVID-19 (1 April 2018–15 March 2020) and for two COVID-19 time periods in BC: a shutdown phase with elective surgeries halted (16 March–17 May, 2020) and a renewal phase when elective surgeries resumed (18 May–27 September 2020); comparisons were made provincially and for individual health authorities.

Results: Historically, elective surgeries accounted for 10% of platelets transfused in BC. Initial daily supplier inventory increased from baseline during both COVID-19 periods (93/90 units vs. 75 units pre-COVID-19). During the shutdown phase, platelet utilization decreased 10.4% (41 units/week; $p < 0.0001$), and remained significantly decreased during the ensuing renewal period. Decreased platelet utilization was attributed to fewer transfusions during the shutdown phase followed by a decreased discard/expiry rate during the renewal phase compared to pre-COVID-19 (15.2% vs. 18.9% pre-COVID-19; $p < 0.0001$). Differences in COVID-19 platelet utilization patterns were noted between health authorities.

Conclusion: Decreased platelet utilization was observed in BC compared to pre-COVID-19, likely due to a transient reduction in elective surgery as well as practice and policy changes triggered by pandemic concerns.

KEYWORDS

platelet transfusion, transfusion medicine, transfusion strategy

INTRODUCTION

Blood products rely on a complex infrastructure of donors, distribution networks and hospital transfusion services to meet clinical demand. Platelets, with a relatively short shelf-life of 5–7 days, are particularly vulnerable to perturbations to the supply–demand equilibrium. Concerns over potential platelet shortages are not new, for example, related to ageing donor and recipient populations [1]; however, the COVID-19 pandemic had the potential to exacerbate these vulnerabilities in ways not previously experienced by healthcare systems. Potential problems included the disruption of donor networks and blood collection, production and logistics networks (reduced supply) and/or by increasing platelet use through large numbers of critically ill COVID-19 patients (increased demand). On the other hand, decreases in non-COVID-19-related healthcare visits due to both behavioural changes and policies like halting elective surgeries [2, 3], or policies to extend platelet shelf life, for example, through cold storage [4], could counter-balance these stressors by reducing demand.

Understanding the multifaceted influence of COVID-19 on platelet supply and demand is crucial for ongoing resource management and future planning. Data are emerging on the effects of the pandemic on platelet utilization [5]. Studies from diverse geographical regions have suggested that although COVID-19 infection is associated with thrombocytopenia [6], significant bleeding is uncommon, and hospitalized patients have relatively low platelet transfusion requirements, with some centres reporting decreased overall platelet utilization during the first wave of the pandemic [7–10]. In one study from a tertiary care centre in India, a diminished inventory caused by decreased donations was offset by a lower demand for platelets during the early phase of the pandemic [11]. Additional data from large health systems over longer time periods are useful to further understand the manifold impacts of COVID-19 on platelet supply and utilization.

The Canadian province of British Columbia (BC) maintains a centralized transfusion database for six health authorities (HAs) that service a population of roughly 5 million residents. Here, we report on BC's baseline platelet use patterns and experience with platelet supply and utilization during the initial 6 months of the COVID-19 pandemic. This time period encompasses an initial response phase when all elective surgeries were suspended in the province and, subsequently, when elective surgeries were resumed. To our knowledge, this study represents the largest analysis to-date of system-wide platelet use during the COVID-19 pandemic.

MATERIALS AND METHODS

Platelet supply in BC

BC receives blood components from Canadian Blood Services (CBS), which operates the national blood system outside the province of Quebec. While the majority of platelets issued to hospitals in BC are collected in the province, some are imported from other provinces. Platelets are produced from both whole blood and apheresis

collections. Buffy coat platelet units, each manufactured from four whole blood units, comprise ~70% of platelet production in the province. Pre-hospital bacterial testing by CBS allows for an extended 7-day platelet shelf life. CBS's BC inventory fluctuates during the day as hospital orders are filled and donor collections from previous days become available for release to hospitals. At the start of each day, initial daily CBS inventory is communicated to hospitals.

Data sources

The BC Provincial Blood Coordinating Office Central Transfusion Registry (CTR) is a comprehensive database of all transfusions that have occurred in the province of BC since 1999. We performed a retrospective analysis of BC platelet utilization for pre- and COVID-19 time periods. Historical data on platelet use, by indication, were analysed for fiscal years 2010/2011–2019/2020 (FY: 1 April–31 March). Platelet transfusions were linked to surgical procedures via the provincial Surgical Patient Registry and considered related to the surgical event when a patient received platelets from 1 day prior to surgery to 30 days after the surgery. Surgeries were further differentiated between elective and urgent/emergency procedures. All other platelet transfusions were considered to be non-surgical. Surveillance data on provincial COVID-19 cases and hospitalizations were obtained from the publicly available COVID-19 Tracker Canada [12]. Total hospital admission, intensive care unit (ICU) admissions and surgical volumes in BC from March to June 2020 with year-over-year comparisons to 2019 were available from the Canadian Institute for Health Information [13]. Total population and age data for BC and its HAs were obtained from publicly available government data [14]. Median ages were estimated from population data capped at age 90 years (i.e., individuals aged ≥ 90 were binned together as 90+).

Data related to blood donations and the number of platelet units supplied to hospitals within BC were obtained from CBS for the period from 1 December 2019 to 27 November 2020. Initial daily supplier platelet availability within BC (CBS BC inventory at midnight) was obtained for the period from 1 April 2018 to 27 September 2020 (last available data point at the time of writing). Platelet disposition is reported as transfused units and expired/discarded units. The total number of units is the sum of transfused and expired/discarded units. Daily platelet disposition data were obtained from CTR for 1 April 2018 to 27 September 2020. Three time periods are considered throughout the study: pre-COVID-19 baseline (until 15 March 2020); COVID-19 shutdown period, when elective surgeries in BC were halted (16 March 2020 to 17 May 2020), and COVID-19 renewal phase, when elective surgeries resumed in BC (18 May 2020 to 27 September 2020).

Statistical analysis

The mean of total weekly platelet use in BC was calculated for the three time periods noted above (pre-COVID-19, shutdown, renewal),

and statistical testing was performed by analysis of variance with a post-hoc Tukey test for pairwise comparisons. Linear regression was used to assess trend over time for historical annual platelet usage. Initial daily platelet inventory and platelet usage are reported as 7-day rolling average to remove the periodicity of daily counts related to different transfusion practices on weekend versus weekdays. Statistical values are all reported as mean with 95% confidence intervals (CIs) unless otherwise indicated. Weekly mean with 95% CI was also calculated for each of the three largest HAs within the province and for the sub-categories of weekly transfused and expired platelet units (formal statistical testing not carried out for these sub-categories). Province-wide and HA-specific discard rates were calculated as expired/discarded units divided by total units for the three time periods. For the total provincial data, these rates were statistically compared by chi-squared test for both overall trend and pairwise comparisons with Bonferroni correction. *p*-values <0.05 were considered to be statistically significant for all comparisons.

RESULTS

Historical platelet use in BC

Over the 10-year period beginning with FY 2010/2011, an average of 15,642 platelet units per year were transfused in BC, with 17,120 units transfused over the last complete fiscal year with available data (2019/2020; Figure 1a). Over the past 10 years, non-surgical indications have accounted for 67.0% of platelet transfusions (yearly range = 63.4%–72.5%; Figure 1b). The remaining third of platelet units were associated with surgical procedures, of which 23.2% of the provincial total were transfused for emergency procedures (range = 19.4%–27.2%) and 9.8% for elective procedures (range = 7.4%–12.6%). Eighty percent of platelets transfused during the peri-operative period occur within 5 days of surgery (Figure S1). Two surgical specialties – general surgery (which includes trauma) and

cardiac surgery – were historically the greatest platelet users by a large margin, each accounting for approximately 33% of surgical platelet usage. We found there was a significant increase in platelet transfusions over time from FY 2010/2011 to 2019/2020 (+248 units/year; *p* = 0.001), but we did not detect a significant trend when correcting for population growth (*p* = 0.7) nor in the proportion of platelets transfused for surgical events (*p* = 0.4) over this time period.

Effect of COVID-19 on provincial platelet supply and demand

At the outset of the COVID-19 pandemic, several precautionary measures were put into place in BC, including the suspension of elective surgeries between 16 March 2020 and 17 May 2020, which led to a large decrease in planned surgeries in the province from March to June 2020 compared to the previous year (Figure S2A). In March 2020, day surgeries decreased by 35% in BC compared to the previous year (although BC-specific data were not available for the months leading up to the shutdown, national surgical volumes had been stable through the end of February 2020) [13]. Surgical volume reached a nadir during the middle of the shutdown phase in April, when day surgeries, planned inpatient surgeries and total surgeries had decreased by 81%, 59% and 70%, respectively, compared to April 2019. Of note, in addition to the expected decrease in planned surgeries, April also saw a 27% decrease in unplanned surgeries. During this initial shutdown period, BC experienced its first wave of COVID-19, reaching a peak of 149 hospitalized COVID-19 patients during the first week of April (including a peak of 72 patients in critical care; Figure S3). Concurrently, overall inpatient occupancy and ICU occupancy were down by 33% and 20%, year over year, respectively (Figure S2B). Elective surgeries were resumed on 18 May 2020, and continued unabated throughout the second wave of COVID-19 in BC (renewal phase), with surgeries beginning to approach baseline levels by June (Figure S2A). In late August, COVID-19 hospitalizations again rose

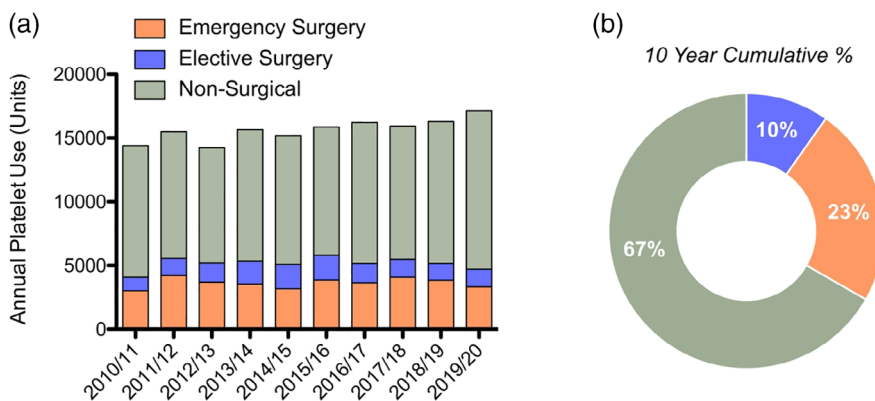


FIGURE 1 Platelets transfused by indication in BC from fiscal year 2010/2011–2019/2020. (a) Annual transfused platelet units in BC by indication. (b) Cumulative percentage of transfused platelets by indication over the 10-year time period. BC, British Columbia

from a minimum of <10 to 69 by the end of September with 19 in critical care (Figure S3).

The trends in whole blood donations (a proxy for buffy coat-derived platelets) and apheresis platelet donations for baseline and COVID-19 time periods, both nationally and specifically for BC, are

shown in Figure 2. There was a decrease in CBS national whole blood donations from late March to early June, only partly compensated for by an increase in apheresis platelet donations (Figure 2a). Towards the end of May 2020, there was a steep increase in whole blood donations (similar to pre-COVID-19 levels) that was sustained until the end

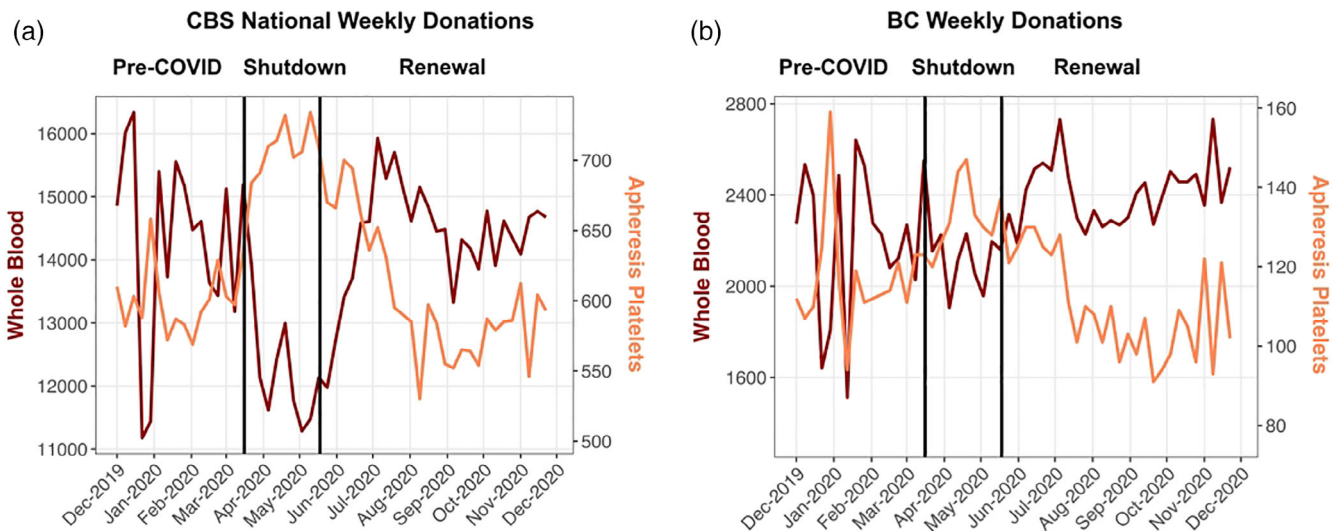


FIGURE 2 Weekly platelet donations for (a) all of Canada (excluding Quebec) and (b) British Columbia, before and after the onset of the coronavirus disease 2019 (COVID-19) pandemic. Whole blood donations are used as a proxy for buffy coat-derived platelets

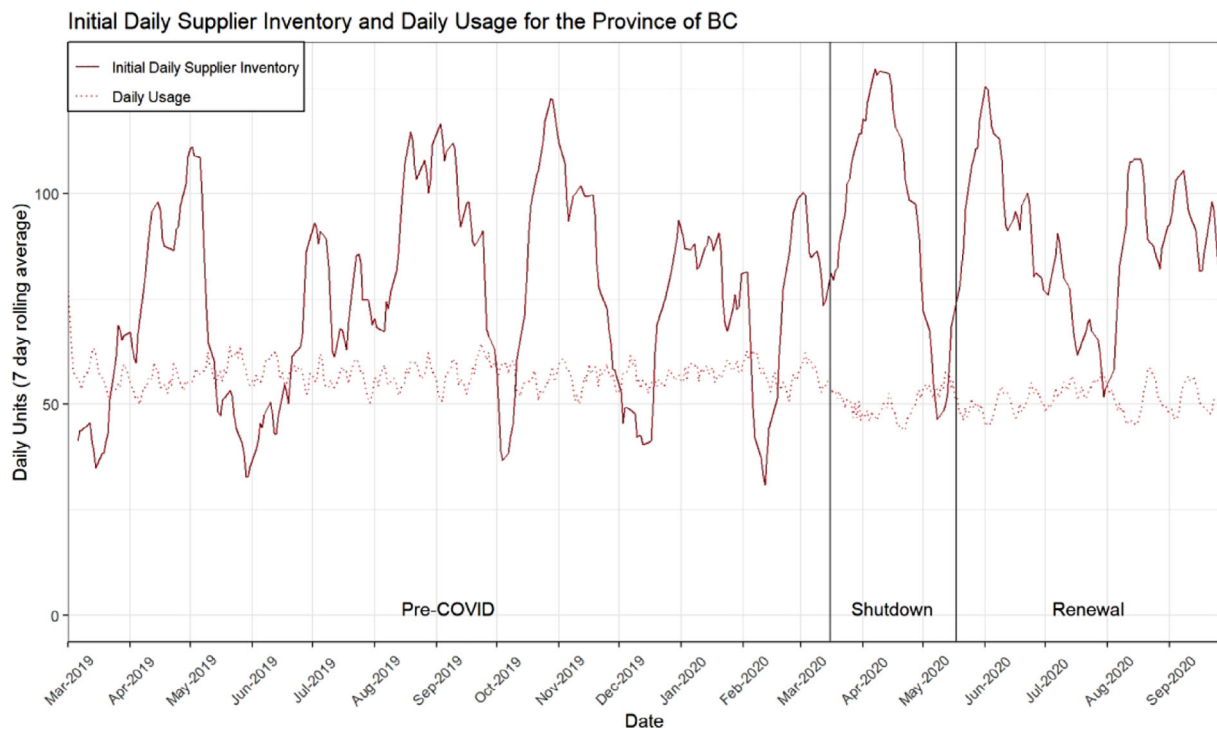


FIGURE 3 Initial daily CBS platelet inventory (solid) compared to daily usage (dashed). Both curves represent 7-day rolling averages. The average initial daily supplier inventory for different time periods are 75.1 units (pre-COVID-19), 92.8 units (shutdown) and 90.1 units (renewal). The average daily platelet usages (transfused + expired/discarded) for the same time periods are 56.4 units (pre-COVID-19), 50.5 units (shutdown) and 51.1 units (renewal), respectively. Note that for calculation of averages, a longer pre-COVID-19 period was used than what is shown on the graph (April 2018–March 2020) CBS, Canadian Blood Services; COVID, coronavirus disease 2019

of 2020, whereas apheresis donations decreased towards baseline. In BC specifically, donations remained comparatively stable during the initial shutdown phase and showed similar trends of increasing whole blood and decreasing apheresis donations from June onwards (Figure 2b). Overall, the number of platelets issued to BC by CBS decreased during both the shutdown and renewal phases compared to the preceding months (Figure S4).

Initial CBS daily inventory and daily usage for the year leading up to COVID-19, the initial shutdown period and the renewal period are shown in Figure 3. Initial daily CBS platelet inventory for BC was considerably more variable than daily platelet use, with large oscillations between ~25 and 150 units at baseline. The initial daily CBS inventory increased from a pre-COVID-19 baseline average of 75.1 units to 92.8 units for the shutdown phase and remained elevated at 90.1 units during the renewal phase. Overall, the platelet supply in BC was more secure from the onset of COVID-19 with initial daily CBS inventory minima remaining higher than pre-COVID-19, both in absolute terms and relative to daily usage. Daily platelet usage decreased from a baseline average of 56.4 units to 50.5 and 51.1 units during the

shutdown and renewal periods, respectively (Figure 3). Comparing weekly platelet utilization to remove periodicity of variable weekday and weekend practices, this decrease in platelet usage was found to be statistically significant (Table 1 and Figure 4a,e). Weekly platelet usage decreased from a pre-COVID-19 mean of 394.8 units/week (95% CI, 391.2–398.5) to 353.7 units/week (95% CI, 337.2–370.1) during the shutdown period ($p < 0.0001$) and did not significantly change from this level during the renewal period (357.7 units/week [95% CI, 346.5–368.9; $p = 0.9$]).

Effect of COVID-19 on platelet disposition provincially and in separate health regions

To further understand the effects of the COVID-19 pandemic on platelet disposition in BC, we broke down overall platelet use into units transfused and units expired/discarded for the pre-COVID-19, shutdown and renewal time periods (Table 1 and Figure 4). Figure 4a shows that the decrease in platelet use throughout the pandemic was

TABLE 1 Pairwise statistical comparisons between time periods for platelet use in British Columbia (BC)

Comparison	Mean of total weekly units used	Expired/discarded rate (chi-squared)
Pre-COVID-19 versus shutdown	395 versus 354 ($p < 0.0001$)	18.9% versus 19.8% ($p = 0.6$)
Pre-COVID-19 versus renewal	395 versus 358 ($p < 0.0001$)	18.9% versus 15.2% ($p < 0.0001$)
Shutdown versus renewal	354 versus 358 ($p = 0.9$)	19.8% versus 15.2% ($p < 0.0001$)

Abbreviation: COVID, coronavirus disease 2019.

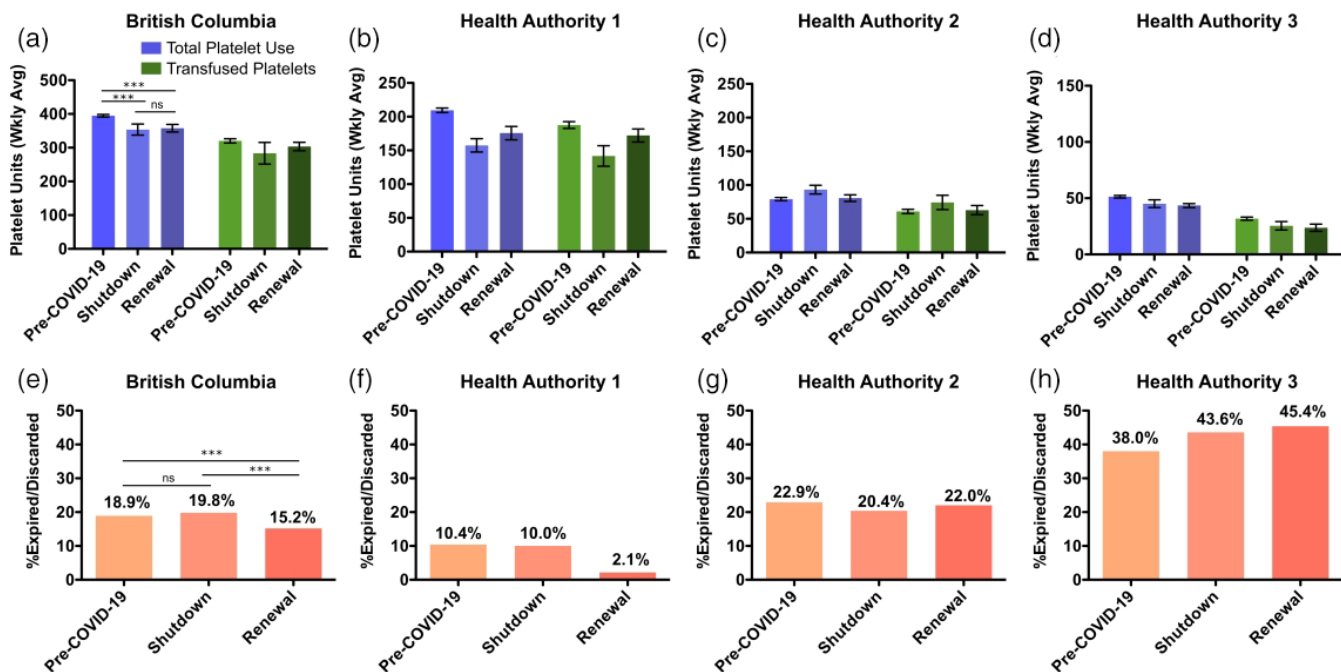


FIGURE 4 Platelet usage in BC and its three largest health authorities before and after COVID-19. (a–d) Total platelet use and transfused platelets for the pre-COVID-19, shutdown and renewal periods (weekly mean \pm 95% CI). (e–h) Expired/discarded rate for the same three time periods. For statistical comparisons: *** indicates $p < 0.0001$, ns indicates $p \geq 0.05$. BC, British Columbia; CI, confidence interval; COVID, coronavirus disease 2019

due to a combination of fewer platelet transfusions and fewer expired units; however, the timing of these influences has been different. The decrease in transfused units reached a nadir during the shutdown phase when elective surgeries were halted (11% decrease from baseline), whereas a decrease in expired units was observed only during the renewal phase (15.2% discard/expiry rate vs. 18.9% at baseline; $p < 0.0001$).

Key features of the three HAs in BC that utilize the most platelets (86% of total) are summarized in Table 2. These HAs vary by population, geographical breadth and clinical services. Over the past 10 years, the three HAs had a similar proportion of platelet transfusions related to elective surgeries (range 8.3%–10.1%), with more variability for platelet use by emergency surgeries and non-surgical indications (see Figure S5).

Although HA-1 encompasses only ~20% of the population, it includes two cardiovascular surgery centres and contains the province's major quaternary referral centre, which provides level-1 trauma care and a bone marrow transplant (BMT) program. At baseline, HA-1 accounted for 53% of platelet use in the province. During the shutdown phase, HA-1 experienced a mean decrease of 52.1 platelet units used per week, which was greater than the province-wide decrease of 41.1 units per week (Figure 4b). This was primarily driven by a mean decrease in transfused platelets in HA-1 of 45.8 units per week during the shutdown phase (24% decrease from baseline). During the

renewal phase, platelet transfusions increased in HA-1 from the shutdown nadir but still remained below baseline levels by 8%. The rate of expired/discarded units in HA-1 decreased from a baseline of 10.4% to 2.1% during the renewal phase, compared to virtually no change from baseline during the initial shutdown (Figure 4f).

HA-2 comprises ~37% of the provincial population and contains a level-1 trauma centre and a cardiovascular surgery service. HA-2 accounted for 20% of provincial platelet use at baseline. In contrast to HA-1, HA-2 saw an increase in total platelet use (18% increase from baseline) and transfused platelet units (22% increase from baseline) during the initial shutdown but returned to baseline levels during the renewal phase, while expired/discarded units remained largely unchanged throughout both periods in HA-2 (Figure 4c,g).

HA-3 comprises ~15% of the provincial population and includes a regional hospital with a cardiovascular surgery service and other geographically dispersed hospital services with significant resupply logistics challenges. HA-3 was responsible for 13% of provincial baseline platelet use. Similar to HA-1, HA-3 experienced a decrease in total platelet use starting with the shutdown (12% decrease from baseline) that was sustained during the renewal (Figure 4d). However, in HA-3, this was driven by decreased platelet transfusions during both periods, whereas the expired/discarded platelet rate in HA-3 increased relative to baseline during both the shutdown and renewal phases (Figure 4d,h).

TABLE 2 Description of the three health authorities in British Columbia (BC) with the highest platelet demand

Health authority (baseline platelet use)	Population ^a	Major services
HA-1 (53%)	<ul style="list-style-type: none"> • Predominantly urban • Pop. 1,193,977 • Median age: 41 years 	<ul style="list-style-type: none"> • Level-1 trauma centre • Quaternary referral centre • Two cardiovascular surgery centres • Bone marrow transplantation (BMT) service • Solid organ transplant service
HA-2 (20%)	<ul style="list-style-type: none"> • Mixed urban/rural • Pop. 1,906,933 • Median age: 39 years 	<ul style="list-style-type: none"> • Level-1 trauma centre • Cardiovascular surgery • No BMT service
HA-3 (13%)	<ul style="list-style-type: none"> • Dispersed with mixture of rural and small urban centres • Significant resupply logistics challenges • Pop. 827,314 • Median age: 47 years 	<ul style="list-style-type: none"> • Cardiovascular surgery • No level-1 trauma or BMT service

^aPopulation data from 2019[14].

DISCUSSION

The COVID-19 pandemic has placed an incredible strain on healthcare systems around the world, including sustaining a stable inventory of platelets and other blood products. Initial studies have noted reduced platelet demands for critically ill COVID-19 patients compared to other ICU patients [8], and several tertiary care centres in New York [9], Washington [10] and India [11] reported decreased platelet transfusions during the first 1–2 months of the pandemic, possibly due to a combination of low platelet requirements for COVID-19 patients and policies that decreased healthcare utilization (e.g., halting elective surgeries). In our healthcare jurisdictions, we found similar findings that platelet transfusions decreased concurrently with decreased surgeries and hospital admissions. We also found that platelet use remained decreased even when elective surgeries resumed, largely driven by decreased expired/discarded units. Our comprehensive study of system-wide platelet use during the COVID-19 pandemic also demonstrates differential effects on platelet use by health region, potentially related to their different demographics and characteristics.

The overall balance of blood product supply and demand depends on many interacting factors: donors, collection services, distribution networks, hospitals and patients requiring transfusions. All of these are potentially impacted directly and indirectly by COVID-19 and related policies. The Canadian province of BC, with a large integrated healthcare system and transfusion database, provides a unique opportunity to examine these various factors. We found that platelet use significantly decreased compared to baseline during the initial shutdown phase of BC's response and remained decreased during the

subsequent renewal phase when elective surgeries were resumed. On the other hand, platelet supply declined during the first 2 months of the pandemic but subsequently rebounded to levels at or slightly above the pre-COVID-19 baseline. The initial decrease in supply was driven by fewer whole blood collections and reduced capacity to process blood, related to cancellations of mobile clinics along with decreased capacity at donation and manufacturing sites due to public health orders. Apheresis donations were less impacted by these factors because they largely occur at fixed sites and could be increased during the shutdown phase to partially compensate for the decrease in buffy coat platelets. Possible explanatory factors for the subsequent increase in whole blood collections during the renewal phase include greater donor awareness of the need for blood and the safety of donor collection sites, operational changes by CBS such as increased clinic hours/staffing and comfort with efficient donor turnaround time in the new, physically distanced environment. Importantly, by this time point, efficient COVID-19 safety procedures were in place at manufacturing sites, allowing production capacity to be safely increased. As a result, at no point during the first 6 months of COVID-19 emerging in BC, did the province observe a platelet shortage; if anything, there was a greater average platelet reserve in the province compared to the year prior to the pandemic.

The decreased platelet utilization in BC during COVID-19 was driven by different factors during the distinct periods of the province's response to the pandemic. During the initial shutdown phase, when elective surgeries were halted and overall healthcare utilization was dramatically decreased from baseline, reduced platelet utilization was mostly due to fewer platelet transfusions. Based on provincial historical data, halting elective surgeries was expected to decrease platelet transfusions by ~10% – close to the observed provincial decrease of 11%. However, the considerable differences seen between HAs, which have similar baseline proportions of platelet utilization from elective surgeries, suggest that additional factors also played a role. In BC, HA-1 saw a considerably larger decrease in platelet transfusions during the shutdown compared to the provincial average. This difference might be explained by decreased utilization of non-surgical services with high platelet requirements, only offered in HA-1, such as a BMT/dedicated haematology–oncology service. On the other hand, HA-2 saw an increase in platelet transfusions during the shutdown phase. Given the retrospective nature of our study and our inability to account for a multitude of complex confounders including clinician practice patterns and other contingency plans, which may have affected platelet usage, we are unable to determine the exact reasons why HAs were differentially affected during the pandemic.

In addition to shutting down surgeries, various provincial efforts were made across different HAs to preserve blood products. Led primarily by HA-1 physicians, these initiatives included clinical advisories and education to encourage appropriate blood utilization, screening platelet orders for appropriateness and improving inventory management to reduce wastage [15]. Of note, platelet utilization remained significantly less in BC during the renewal phase, when elective surgeries resumed. While platelet transfusions remained slightly less

compared to baseline during the renewal phase, possibly related to persistent decreases in healthcare utilization, the main driver of decreased platelet utilization after the shutdown ended was a significant decrease in the platelet expiration/discard rate. This was mainly driven by one HA (HA-1) that also implemented specific policies including a shared platelet inventory among different hospitals and prospective isoagglutinin titres of all group O platelets to facilitate their transfusion into non-group O patients [15]. The degree to which the significant decrease in platelet expiration/discard rate observed is explained by these policy changes warrants further study.

Strengths of this study include the availability of historical platelet transfusion data as well as the availability of platelet disposition data across a large population/geographical region throughout distinct phases of the COVID-19 pandemic. An important limitation of this study is that the indications for platelet transfusions (i.e., surgical vs. non-surgical) were only available for the pre-COVID-19 period. In addition, data related to healthcare utilization during the pandemic were only available until the end of June 2020. Given these limitations and the inherent confounding factors in a retrospective observational study, we cannot definitively ascribe changes to platelet demand to specific causes or factors. Another limitation is that our findings may not be generalizable to other regions that had different strains on their healthcare system due to COVID-19 or with different patient demographics or resources/organizational structures with regards to blood product distribution.

In conclusion, to our knowledge, this is the largest analysis to date of platelet supply and utilization during the COVID-19 pandemic. We found that the platelet supply in BC remained stable during the first 6 months of COVID-19, even with an initial decrease in blood donations. Platelet utilization was significantly decreased in BC during the first 6 months of the pandemic compared to baseline: this appears to have been due to province-wide policies that led to decreased healthcare utilization and platelet transfusions during the initial phase of the pandemic, followed by local practice changes that may have contributed to fewer wasted platelet units. The relatively modest contribution of elective surgery cancellations to decreased platelet utilization is noteworthy while other clinical and laboratory practice changes also likely contributed to significant reductions in platelet utilization in the HA with the highest baseline utilization. In particular, laboratory practice changes implemented in response to the threat of shortages appear to have contributed to a sustained reduction in utilization, extending for at least a 4-month period following the resumption of elective surgery and BMT activity. These findings may assist others in determining suitable practices for securing platelet supply throughout the ongoing pandemic and in other challenging scenarios.

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conception of this work and provided comments and revisions that were incorporated in the final manuscript.

CONFLICT OF INTEREST

No conflicts of interest were identified in the preparation of this manuscript.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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