

Article

The Impact of COVID-19 Pandemic on Supply of Platelet Products in Provincial Blood Centers of China: A Multi-Center Retrospective Analysis

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ABSTRACT: This study aims to retrospectively review how the COVID-19 pandemic affected the supply of platelet products (PLTs) in provincial blood centers in Chinese mainland. Data from 21 provincial centers covering 2017 to 2022 were analyzed. The median number of PLTs issued in 21 centers showed a consistent increase from 20 043 ATUs in 2017 to 31 340 ATUs in 2022. Blood centers were categorized into four groups based on the cumulative number of PLTs issued. Group 4, with the largest issuance scale, saw the most substantial decrease of 11.90% in 2020, while Group 1, with the smallest scale, experienced a substantial 9.66% decrease in 2022. From 2017 to 2019, most centers saw a steady increase in PLTs issuance, but the pandemic disrupted this trend. In 2020, 38.10% of the centers reported reduced issuance, with four centers experiencing reductions of over 10%, three of which were in Group 4. These reductions were mainly in eastern and central regions which were severely impacted by the pandemic. By 2021, 90.48% of the centers saw increased issuance. However, in 2022, 66.67% of the centers reported reductions, indicating ongoing pandemic effects on donation behaviors, with all centers experiencing reductions over 10% concentrated in Group 1. Apheresis platelets (APLTs) followed trends similar to overall PLTs, while whole blood-derived platelet concentrates (WBD-PLTs), issued by only 9 out of 21 centers, showed fluctuating trends. Despite their lower issuance, WBD-PLTs provided crucial supplementary support when the APLTs supply decreased. In conclusion, the study highlights significant variations in platelet products issuance influenced by the pandemic. Understanding these trends is essential for optimizing platelet supply strategies and addressing future challenges.

Keywords: Platelet product; Apheresis platelets; Whole blood-derived platelet concentrates; COVID-19



1. Introduction

In 2006, the former Ministry of Health of China issued a national regulation to guide the development of a national blood collection and supply system, consisting of three tiers of blood establishments (BEs). At the top are provincial blood centers, which supply blood to provincial capitals and municipalities and supervise tasks such as blood quality monitoring and provincial blood regulation. Below them are prefectural central blood stations and county-level central blood banks, mainly in remote areas. As of December 2018, the National Health Commission reported the existence of 32 provincial blood centers, 321 prefectural-level central blood stations, and 99 county-level central blood banks [1]. Provincial blood centers are pivotal in coordinating regional blood supply and shouldering multiple responsibilities, which explains why this study focused on the provincial blood center group.

Over the years, China has witnessed a substantial increase in voluntary non-remunerated blood donors, surging from 328 000 in 1998 to 16.035 million in 2022. This increase was reflected in the blood donation rate, which has risen from 4.8‰ in 1998 to 11.5‰ in 2022 [2]. Whole blood (WB) collection primarily took place at mobile blood collection sites where a significant portion were first-time donors [3]. The proportion of first-time WB donors at provincial blood centers in China ranged from 41.1% to 75.73% [4]. In contrast, on average, first-time donors for single apheresis platelets contributed 1.21% to 43.83% of the donations [5], lower than that for WB donors. The blood supply per thousand people for WB and red blood cells ranged from 7.9 to 24.1 units at provincial blood centers, while the platelets ranged from 1.1 to 8.2 units [3]. There are two types of platelet products (PLTs) used for clinical purposes in China: apheresis platelets (APLTs) collected from a single donor using apheresis equipment and whole blood-derived platelet concentrates (WBD-PLTs) prepared from 4–6 donated WBs by platelet-rich plasma (PRP) method or buffy coat (BC) method. The majority of platelets produced in Chinese BEs are APLTs [5].

Despite the rising numbers of donors and the expanding blood collection efforts in China, expanding healthcare needs, longer life expectancy, rapid advancements in medical technology, and improved medical service quality contributed to a continuous surge in clinical blood demand. Moreover, the outbreak of COVID-19 in 2020 triggered a historic public health crisis with widespread social and economic consequences. The pandemic also adversely affected blood supply, aggravating the burden on BEs. This posed a great challenge on BEs, emphasizing the necessity for scientific analysis of the platelets supply capacity in China.

The Asia Pacific Blood Network (APBN) is a regional collaborative platform that assists member countries in improving blood transfusion services [6,7]. A key mission of the APBN is to facilitate the comparison of practices (CoP) among its members through benchmarking, a valuable management tool. This comparison encompasses various aspects, such as patients, hospitals, donors, and organizations [8]. Beijing Red Cross Blood Center (BRCBC), representing Chinese mainland, participated in the APBN and benchmarked its practices with other members [3]. As one of the biggest provincial-level blood centers, BRCBC initiated and organized a CoP work-party (CoP-WP) in Chinese mainland, employing APBN measures to benchmark the national BEs against international counterparts [9–11]. This study utilized CoP data from Chinese mainland, specifically focusing on information related to the supply of APLTs and WBD-PLTs from 2017 to 2022 through the Information Management System [11] to retrospectively review the supply capacity of PLTs in provincial blood centers.

2. Materials and Methods

2.1. Data Sources

This study sourced data from the CoP-WP in Chinese mainland, extracted from the Information Management System for CoP between 2017 and 2022 [9–11]. Five key indicators were considered: plateletpheresis attendances, eligible donors for plateletpheresis, active donors for plateletpheresis, apheresis-derived platelets issued, and whole blood donations-derived platelets issued. Data were collected from 24 provincial blood centers, then sorted and processed using Office software. One blood center with partial-year data and two centers that did not receive data authorization due to legal ownership changes were excluded, leaving 21 blood centers for analysis. These blood centers

were categorized geographically into Eastern (Y9, K5, A8, V2, C3, and B1), Central (N1, C6, Z4, F3, U2), Western (M5, I8, T7, F6, A5, H4, W2, U4, and Q1) and Northeast (R3) regions based on China's regional divisions [12].

2.2. Data Computation and Analysis

All measurements related to several platelet products issued were standardized and expressed in terms of Adult Therapy Units (ATUs), defined as a platelet count equal to or greater than 2.5×10^{11} per bag. The number of WBD-PLTs issued was converted into ATU. For instance, WBD-PLTs prepared from 5 bags of 400 mL WB or 10 bags of 200 mL WB were considered equivalent to one ATU [10].

The following formulas were applied to calculate blood donor-related indicators:

- (1) Number of plateletpheresis attendance = number of eligible donors plateletpheresis + number of ineligible donors plateletpheresis
- (2) Number of eligible donors plateletpheresis = number of individuals who are qualified for apheresis platelet donation after pre-donation health examination and interview
- (3) Number of active donors plateletpheresis = number of donors who completed at least one apheresis donation within a specified 12-month reporting period

Data were handled by year and blood center code and the results were graphically presented using line graphs and bar charts. Within these graphical representations, blood centers were ranked in ascending order based on the issued number of PLTs, from the smallest to the largest.

2.3. Statistical Analysis

Statistical analysis was performed using the SPSS version 18.0. Median and quartiles, as well as mean and standard deviation, were used to describe variables. Trend analysis of the number of platelets issued was performed using the Mann–Kendall trend test. Statistical significance was assessed using a two-sided test at the $\alpha = 0.05$ level for all analyses.

3. Results

3.1. Number of Platelets (PLTs) Issued from 2017 to 2022

The median number of PLTs issued in 21 provincial blood centers consistently increased from 20 043 ATUs in 2017 to 31 340 ATUs in 2022 ($Z = 2.63$, $P < 0.05$). The interquartile range (IQR) also expanded (Table 1).

Table 1. Yearly percentile value of platelet products from 2017 to 2022.

Year	Q ₂₅ (ATUs)	Median (ATUs)	Q ₇₅ (ATUs)	IQR (ATUs)
2017	11 720	20 043	30 149	18 429
2018	12 700	22 602	35 406	22 706
2019	14 893	22 923	40 787	25 894
2020	16 044	24 909	44 161	28 117
2021	17 452	29 379	49 404	31 952
2022	16 102	31 340	51 753	35 651

ATUs: adult therapy units; IQR: interquartile range.

We categorized the blood centers into four groups based on the cumulative number of PLTs issued from 2017 to 2022 (Figure 1). Seven blood centers were classified in the first group, having issued less than 100 000 ATUs of PLTs over the six-year period. The second group comprised seven blood centers with total PLTs issuance between 100 000 and 200 000 ATUs. The third group included three blood centers with PLTs issuance ranging from 200 000 to 300 000 ATUs. The fourth group consisted of four blood centers that exceeded 300 000 ATUs.

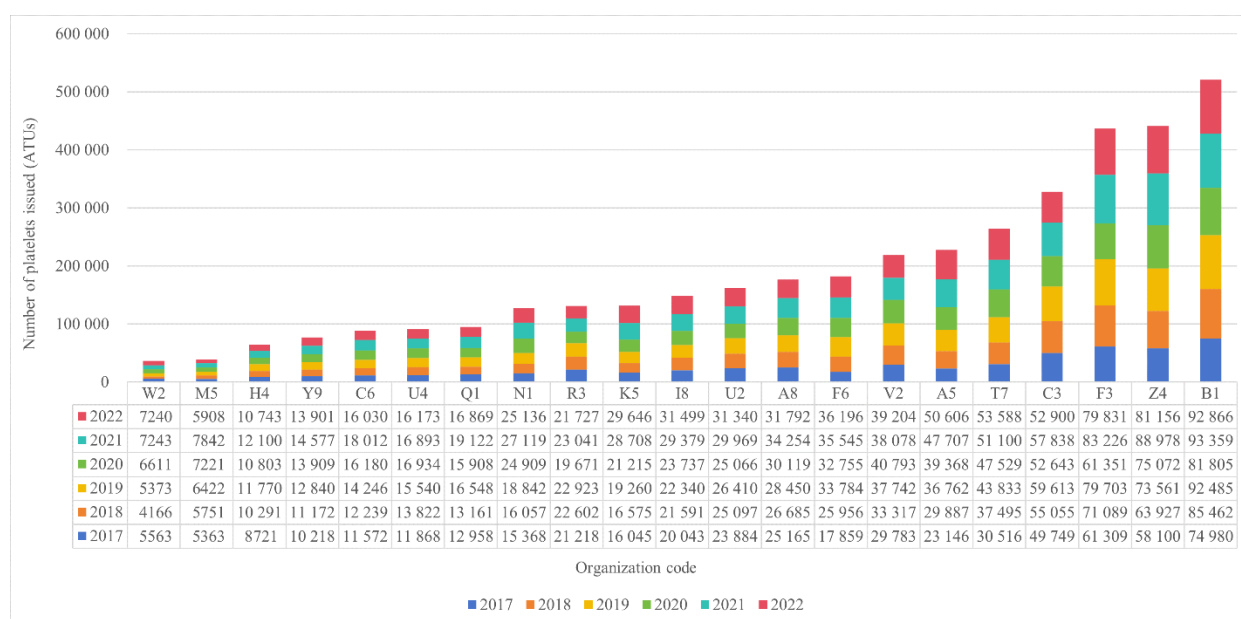


Figure 1. The cumulative number of platelet products issued over the six-year period. ATUs: adult therapy units.

Figure 2 illustrates the average number of PLTs issued across the four groups from 2017 to 2022. In 2017, the average number of PLTs was $58\,368 \pm 7859$ ATUs for Group 4, which increased to $73\,411 \pm 18\,925$ ATUs by 2022. Notably, Group 4 had an 11.90% decrease in 2020, followed by a 20.34% increase in 2021, but then experienced a 6.23% decline in 2022. Additionally, Group 1 experienced a 9.66% decrease in 2022.

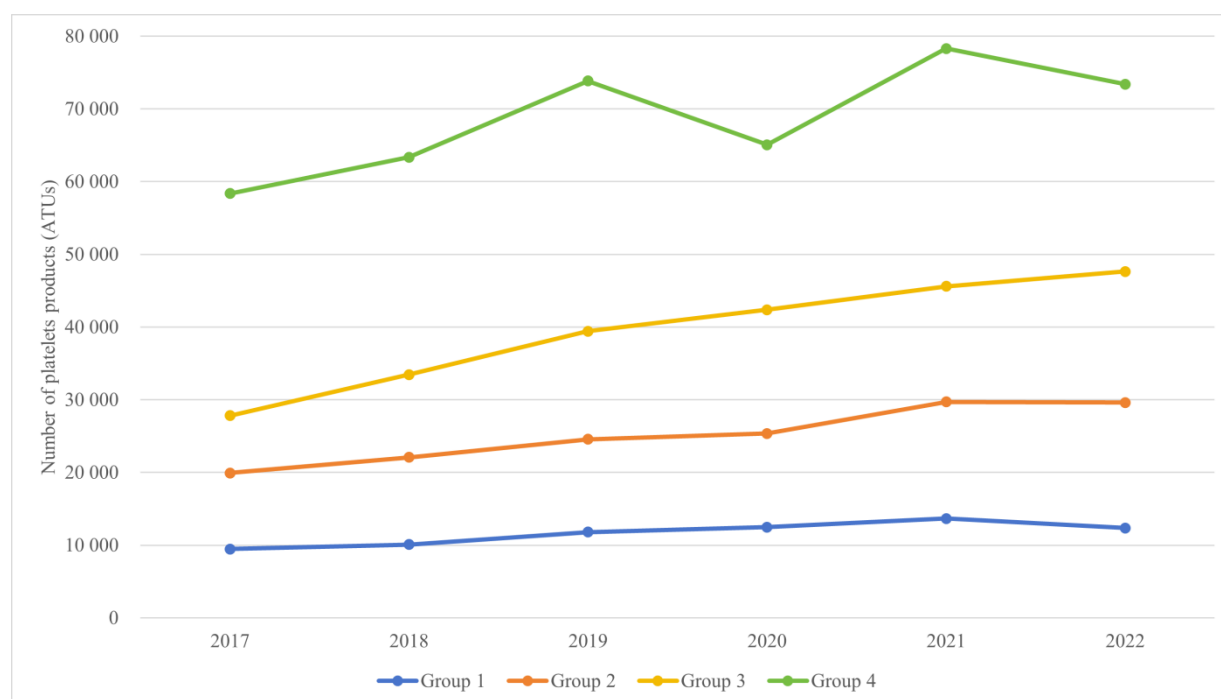


Figure 2. Average number of platelet products issued from 2017 to 2022 for 4 groups. The blood centers were categorized into four groups based on the cumulative number of PLTs issued from 2017 to 2022. Group 1 included blood centers that cumulatively issued less than 100 000 ATU of PLTs (W2, M5, H4, Y9, C6, U4, Q1). Group 2 comprised blood centers that issued between 100 000 and 200 000 ATU of PLTs (N1, R3, K5, I8, U2, A8, F6). Group 3 consisted of blood centers that issued between 200 000 and 300 000 ATU of PLTs (V2, A5, T7). Group 4 included blood centers that issued more than 300 000 ATU of PLTs (C3, F3, Z4, B1). ATUs: adult therapy units.

Of the 21 blood centers, 95.24% (20/21) and 100.00% (21/21) reported an increase in PLTs issuance in 2018 and 2019, respectively. In 2020, 38.10% (8/21) of the blood centers experienced a decrease in PLTs issuance (refer to Figure 3). Among these, 4 centers showed a significant decrease exceeding 10%, with decreases of 23.03% (F3), 14.19% (R3),

11.69% (C3), and 11.55% (B1), as indicated in Figure 3. Notably, F3 is located in the central region, while C3 and B1 are in the eastern region. It is worth noting that B1, C3, and F3, which belong to Group 4, are blood centers with cumulative issuance of PLTs exceeding 300 000 ATUs. In 2021, 90.48% (19/21) exhibited an increase in PLTs issuance. However, in 2022, a decline in PLTs issuance was observed in 66.67% (14/21) of blood centers. Among these blood centers, four experienced a decline exceeding 10%, with reductions of 24.66% (M5), 11.78% (Q1), 11.21% (H4), and 11.00% (C6), as shown in Figure 3. Remarkably, all of these blood centers belong to Group 1.

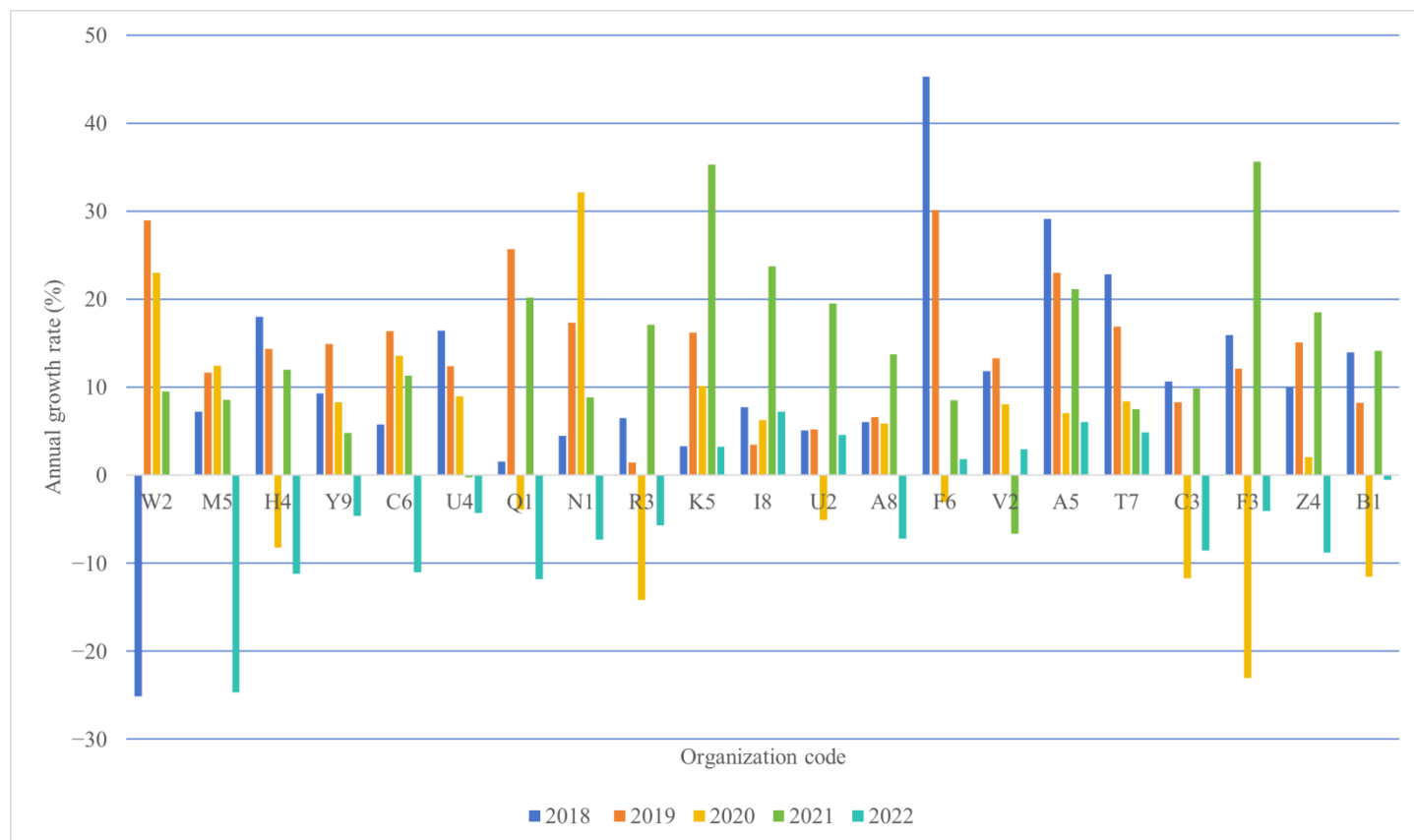


Figure 3. Annual growth rates of platelet products issued in 21 blood centers. Blood centers were ranked in ascending order based on the cumulative number of platelet products, from the smallest to the largest.

3.2. Number of Apheresis Platelets (APLTs) Issued from 2017 to 2022

The issuance of APLTs across 21 provincial blood centers accounted for 98.01% of PLTs issuance. The growth rate of plateletpheresis attendances, eligible donors plateletpheresis, and active donor plateletpheresis are shown in Table 2.

Table 2. Growth rate of donors related to apheresis platelets and number of blood centers with decreased trends.

Year	Growth rate of plateletpheresis attendances ^a (%)	Number of centers with decreased plateletpheresis attendances ^b	Growth rate of eligible donors with plateletpheresis ^c (%)	Number of centers with decreased eligible donors with plateletpheresis ^d	Growth rate of active donors with plateletpheresis ^e (%)	Number of centers with decreased active donors with plateletpheresis ^f
2018	2.37	8	8.17	3	−5.01	8
2019	10.75	3	12.69	1	−3.44	7
2020	1.14	6	−2.37	8	−2.27	7
2021	14.49	2	13.53	2	10.29	4
2022	−2.69	13	−3.05	13	−4.4	13

^a The growth rate of plateletpheresis attendances represented the percentage change compared to the previous year in the number of eligible and ineligible donors with plateletpheresis. ^b Number of centers with decreased plateletpheresis attendance represented the number of centers with decreased trends in the number of eligible and ineligible donors with plateletpheresis compared to the

previous year. ^c The growth rate of eligible donors with plateletpheresis represented the percentage change compared to the previous year in the number of individuals who were qualified for apheresis platelet donation after pre-donation health examination and interview. ^d Number of centers with decreased eligible donors plateletpheresis represented the number of centers with decreased trends in the number of eligible donors for plateletpheresis compared to the previous year. ^e The growth rate of active donors plateletpheresis represented the percentage change compared to the previous year in number of donors who completed at least one apheresis donation within a specified 12-month reporting period. ^f Number of centers with decreased active donors plateletpheresis represented the number of centers with decreased trends in the number of donors who completed at least one apheresis donation within a specified 12-month reporting period compared to the previous year.

The median number of APLTs issued across 21 provincial blood centers is shown in Table 3.

Table 3. Yearly percentile values and number of centers with decreased issuance of apheresis platelets from 2017 to 2022.

Year	Q ₂₅ (ATUs)	Median (ATUs)	Q ₇₅ (ATUs)	IQR (ATUs)	Number of centers with decreased APLTs issuance ^a
2017	11 719	20 042	30 149	18 430	/ ^b
2018	12 662	22 602	35 226	22 564	2
2019	14 891	22 923	40 777	25 886	0
2020	15 899	24 909	43 957	28 058	8
2021	17 451	29 376	49 377	31 926	2
2022	15 958	31 340	48 092	32 134	12

ATUs: adult therapy units; APLTs: apheresis platelets. ^a Number of centers with decreased APLTs Issuance represented a number of blood centers that issued less APLTs compared to the previous year. ^b Indicated data is not available for the year 2017.

In 2020, 38.10% (8/21) of the blood centers reported a reduction in APLTs issuance (Table 3), with four centers experiencing reductions exceeding 10%, namely, F3 (23.03%), B1 (14.38%), R3 (14.19%), and C3 (10.39%). Notably, F3, C3, and B1 belong to Group 4. In 2021, 90.48% (19/21) of blood centers reported an increase in APLTs issuance. In 2022, 57.14% (12/21) of the blood centers reported a decrease in APLTs issuance (Table 2). Among these, 5 blood centers had reductions of over 10%, with decreases of 15.81% (C3), 24.66% (M5), 12.02% (Q1), 11.21% (H4), and 12.58% (C6), all of which belong to Group 1 except for C3.

3.3. Number of Whole Blood-Derived Platelet Concentrates (WBD-PLTs) Issued from 2017 to 2022

Among the 21 blood centers, only 9 issued WBD-PLTs between 2017 and 2022 (Table 4). The median number of WBD-PLTs issued fluctuated from 2017 to 2022, showing no correlation with the year ($R = 0.198$, $P = 0.183$).

Table 4. Yearly percentile values and occupation ratio of whole blood-derived platelets from 2017 to 2022.

Year	N ^a	Q ₂₅ (ATUs)	Median (ATUs)	Q ₇₅ (ATUs)	IQR (ATUs)	Occupation ratio of WBD-PLTs ^b (%)
2017	7	1	60	1872	1871	2.01
2018	8	2	82	2351	2349	3.76
2019	8	3	45	2606	2603	1.48
2020	9	24	258	1359	1335	1.73
2021	8	3	88	3025	3022	1.36
2022	7	154	459	4927	4773	1.89

ATUs: adult therapy units; WBD-PLTs: whole blood-derived platelets. ^a N = number of blood centers which issued WBD-PLTs for the respective year. ^b Occupation ratio of WBD-PLTs (%) denoted the proportion of WBD-PLTs in the total platelet products issuance for the respective year.

Over six years, the blood centers B1 and C3 exhibited the highest issuance of WBD-PLTs, collectively issuing 52 076 ATU and 21 431 ATUs, respectively. Among different blood centers, the proportion of WBD-PLTs issuance to total PLTs issuance was varied, with C3 (6.40%) and B1 (5.94%) having the highest proportions.

4. Discussion

4.1. Issuance Trends of Platelet Products (PLTs)

The categorization of blood centers into four groups revealed distinct patterns. Group 4, which had the largest issuance scale, exhibited the largest decrease of 11.90% in 2020, while Group 1, with the smallest issuance scale, experienced the largest decrease of 9.66% in 2022. This further emphasized the variable nature of platelet supply across different groups.

Most blood centers experienced a consistent increase in the PLTs issuance between 2017 and 2019. However, the COVID-19 pandemic significantly impacted platelet supply. In 2020, 38.10% of the blood centers reported a decrease in the PLTs issuance, with 4 blood centers reporting reductions over 10%. Notably, three of these belonged to Group 4, with two in the eastern region and one in the central region. The COVID-19 epidemic primarily affected the Hubei Province and surrounding provinces in central and eastern China [13,14], likely contributing to the decline in these areas. In 2021, 90.48% of the blood centers exhibited an increase in the PLTs issuance, driven by improved safety measures, government support, and increased public awareness [15–18]. In 2022, 14 blood centers experienced reductions, with 4 centers seeing decreases of over 10%, all belonging to Group 1. The decline in 2022 suggests the lingering effects of the pandemic on donation behaviors [19].

The variability in the issuance of PLTs among blood centers emphasizes the need for tailored operational strategies to address regional and temporal fluctuations.

4.2. Issuance of Apheresis Platelets (APLTs) and Donor Trends

The issuance of APLTs constituted 98.01% of total PLTs across the blood centers. The trend in issuing APLTs mirrored that of the overall issuance of PLTs. This trend in 2020 aligned with the observed reduction in overall PLTs issuance. However, in 2022, 57.14% of the blood centers reported a decrease in APLTs issuance. Among these, 5 blood centers experienced reductions exceeding 10%, with all but C3 belonging to Group 1. This pattern was not the same as the overall PLTs issuance. Although C3 reported a decrease of 15.81% in APLTs issuance in 2022, it had the highest proportion of 5.94% in WBD-PLTs issuance relative to the total PLTs issuance. Therefore, it experienced reductions of less than 10% in the total PLTs issuance.

The pandemic disrupted plateletpheresis activities, leading to a significant decrease in both eligible and active plateletpheresis donors in 2020. This decline could be attributed to the sudden outbreak of COVID-19, which was consistent with global reports of decreased blood donor numbers and blood supply during the early stages of the pandemic [20–25]. At the onset of the COVID-19 outbreak, BEs primarily focused on blood safety [26] and convalescent plasma collection [27–29]. However, social isolation policies, public fear of virus exposure during donation, and cancellations of blood collection activities due to lockdowns contributed to the decline [22,30,31].

By 2022, 13 blood centers reported a reduction in plateletpheresis attendance, eligible donors, and active donors. This decline could be attributed to ongoing pandemic-related stress and diminished donor motivation, with active and inactive donors feeling less inclined to donate [19]. While disasters generally lead to a short-term increase in blood donation rates [32], the pandemic's extended influence altered these behaviors. Increased stress levels during the pandemic and challenging economic conditions influenced donation willingness [33,34].

These results suggest that understanding the long-term effects of the pandemic on donor behaviors and the disruption of specific donation patterns across different pandemic years, is crucial for optimizing platelet supply strategies.

4.3. Issuance Trends of Whole Blood-Derived Platelet Concentrates

Among the 21 blood centers, only 9 issued WBD-PLTs from 2017 to 2022. This finding was consistent with the report for prefecture-level blood stations in China, where only 29.17% were engaged in preparing WBD-PLTs [35]. The median issuance of WBD-PLTs fluctuated without a clear trend. These fluctuations could be influenced by several factors, including shifts in demand, operational changes within blood centers, and external factors like the COVID-19 pandemic. The fluctuating issuance of WBD-PLTs and their relatively low proportion compared to total PLTs suggest that the focus remains primarily on apheresis platelets. Further investigation into the factors influencing the use of whole blood-derived platelets and their potential benefits could offer insights into optimizing platelet supply strategies.

Different blood centers exhibited varying proportions of WBD-PLTs in their platelet supply. For example, B1, the highest issuer of WBD-PLTs, with cumulative totals of 52 076 ATUs, experienced a 14.38% drop in the APLTs issuance

in 2020. In contrast, the overall PLTs issuance only fell by 11.55%, highlighting the effective role of WBD-PLTs as a supplementary source. The increasing demand for platelets, driven by factors such as an aging population and the need for transfusions in patients with blood disorders and cancer [36], underscores the importance of maintaining a balanced supply of both APLTs and WBD-PLTs. Historically, APLTs were considered superior due to their higher quality and safety compared to pooled platelets. However, advancements in leukapheresis and pathogen inactivation technologies largely mitigated differences in the risk of adverse events between APLTs and WBD-PLTs [37].

Overall, the substantial differences in WBD-PLTs issuance among blood centers, driven by factors such as technological capabilities, regional needs, and operational strategies, highlight untapped production potential. WBD-PLTs serve as a supplementary source of PLTs, particularly during periods when the APLTs supply decreases, helping to maintain a relatively balanced supply of PLTs.

5. Conclusions

The analysis revealed distinct patterns in platelet products issuance across different blood centers, with significant fluctuations influenced by factors such as the COVID-19 pandemic. The pandemic disrupted plateletpheresis activities, decreasing the number of eligible and active donors and causing fluctuations in platelet issuance for individual blood centers. In 2020, 38.10% of the blood centers reported reduced issuance, with significant impacts observed among large-scale blood centers in the eastern and central regions. By 2022, 66.67% of the blood centers experienced decreases, notably among smaller blood centers, indicating the prolonged effects of the pandemic on donation behaviors. This study highlights the need for blood centers to develop tailored operational strategies to address regional and temporal fluctuations in donor availability and platelet demand. While APLTs were the predominant form of issuance, accounting for 98.01% of the total platelet products, WBD-PLTs played a crucial supplementary role. Understanding these trends and their underlying causes is essential for optimizing platelet supply strategies and addressing future challenges in blood donation.

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Asia Pacific Blood Network (APBN) et Comparison of Practice in blood transfusion services of Chinese mainland.

Author Contributions

Y.Z. (Yuan Zhang), H.Q., M.Y., M.C., N.W., Y.Y., Y.X., F.T., L.W., C.L., Z.R., H.D., X.Y., D.T., H.Z., Y.Z. (Yang Zhang), X.L., Y.L. (Yanyan Liu), Y.L. (Ying Li), H.M. and Y.Z. (Yuan Zhou) collected the data. Y.Z. (Yuan Zhang) and Y.Q. designed the research study, analyzed the data, and wrote the manuscript.

Ethics Statement

This research was a retrospective analysis of blood practice system and summary data without donation or donor identifiers, so research on human subjects was not considered. Therefore, ethical approval for human research was not required.

Informed Consent Statement

Not applicable.

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Declaration of Competing Interest

The authors declared that they had no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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