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ORIGINAL RESEARCH

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Objective indexes for comparing platelet usage among peer hospitals during the COVID-19 pandemic: A cross-sectional study

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Abstract

Background and Aims: Besides hospital size, clinical diagnosis and severity of patient cases determine the total platelet usage. Therefore, the appropriateness of platelet usage could not be compared simply with the total units of platelet usage in each hospital. This study aimed to objectively monitor and analyze platelet usage after implementing a single-unit issuing policy for each platelet transfusion in our hospital in October 2020.

Materials and Methods: We used three objective indices, X, Y, and Z, to monitor platelet usage and compared it with other hospitals. Three indices were generated by dividing the annual total units of platelet usage by the total annual reimbursement, total number of admissions, and average total reimbursement per admission for each hospital.

Results: The new indices X and Y alleviated hospital size–dependent differences. Index Y was preferred over X because its value fluctuated less during the COVID-19 pandemic. The Z index was adjusted for the average total reimbursement per admission, and the results showed that more patients with higher disease complexity did not have increased platelet usage during the COVID-19 pandemic. In our hospital (H1), index Z decreased from 2019 to 2021 due to a policy of issuing a single unit for each platelet transfusion.

Conclusion: These three objective indices are suitable for peer comparison and monitoring platelet usage in hospitals, irrespective of their size. They could be applied to promote patient blood management and provide an early response to the gradual shortage of blood resources owing to the aging population and declining birth rate in Taiwan.

KEYWORDS

blood transfusion index, patient blood management, peer comparison

1 | INTRODUCTION

Patient blood management (PBM) aims to reduce or eliminate unnecessary blood transfusions.[1] The main goal of PBM is to optimize the supply and use of blood products while minimizing the risks and costs associated with blood transfusions.[2] According to a World Health Organization (WHO) report, Taiwan has a high blood donation rate.[3] Consequently, the inexhaustible blood resource result in high consumption rates of blood products per thousand people.[4] Several efforts have been made to eliminate unnecessary transfusions owing to the great concern about excessive blood transfusions.[5–7] Under the illusion of a balance between supply and demand, we need quality indexes to compare and clarify the appropriate usage of all hospital blood products.

In the past, the overuse of fresh frozen plasma was a common problem in Taiwan. This problem was rapidly addressed by introducing the red blood cell/plasma ratio as a quality index in the hospital accreditation system.[8] Peer comparison indices effectively promote PBM. Currently, no peer comparison index exists for analyzing and comparing platelet consumption. Although platelet transfusion is essential for preventing or treating bleeding,[9,10] the cost of platelet products is high, and unnecessary frequent platelet transfusions may increase the risk of transfusion reactions.[11–17] Therefore, it is necessary to comprehensively analyze and monitor the proper use of platelets.

Our national clinical guidelines recommend the appropriate indications and dosage for platelet usage.[18] Each hospital also regularly reviews the validity of the timing and transfusion dosage of blood products in their blood transfusion committee. However, there is still a lack of objective indices for monitoring platelet usage in each hospital and for interhospital peer comparison because the total number of platelets used in each hospital may be affected by multiple factors, such as hospital size, total number of admissions, type of disease, and complexity of the disease.

In 2020, hospitalized patients with COVID-19 had a high mortality rate (11.5%–13%),[19–21] and the incidence of thrombocytopenia in these patients was as high as 57.7%.[19] During the COVID-19 pandemic, these critically ill patients experienced an imbalance in platelet production and destruction mechanisms and coagulation dysfunction. Cautious platelet transfusion is recommended, especially for patients suspected of virus-induced thrombogenic thrombocytopenia (VITT).[20,21] We could not analyze whether platelet usage increased with a higher proportion of severe and complex cases during the pandemic.

Three indexes were therefore established, and their respective calculation methods are listed below.

$$\text{IndexX} = \frac{\text{Annual Platelet Usage}}{\text{Annual Total Reimbursement}} \ *10^{-6}$$

$$\text{IndexY} = \frac{\text{Annual Platelet Usage}}{\text{Total No. of Readmissions}} \ *10$$

$$\text{IndexZ} = \frac{\text{Annual Platelet Usage}}{\text{Total Reimbursement per Admission}} \ *10$$

These objective indices reflect the appropriateness of platelet usage among hospitals by collectively considering factors such as hospital size, patient population, and disease diagnosis. Moreover, the transfusion committee of our hospital (Lin-Kou Chang Gung Memorial Hospital [CGMH]) has implemented a single-unit policy for each platelet transfusion since October 2020, aiming to reduce platelet usage and promote the appropriate utilization of platelet products. Although the total units of monthly platelet usage declined in our hospital, we could not clarify whether the decreased platelet transfusions were related to concerns regarding VITT during the COVID-19 pandemic. Our goal was to evaluate and determine the most suitable objective index for chronologically monitoring platelet usage and to compare our platelet usage with that of other hospitals. These indices are useful for investigating the outcomes after promoting PBM in hospitals and help respond quickly to the imminent imbalance between the supply and demand of blood products in Taiwan.[22]

2 | METHODS

2.1 | Data source

This study included six medical centers, with a scale from approximately 4000 beds (H1–H3) to 1500 beds (H4–H6), and data from 2019 to 2021 were collected. The total number of platelets used in the study was obtained from the Taiwan Hemovigilance Network (Website: https://www.thn.org.tw/account/acnt_login.aspx), jointly established by the Taiwan Blood Services Foundation and the Taiwan Society of Blood Transfusion. Monthly total reimbursements and individual hospitals' total admissions were obtained and pooled together as yearly data from the National Health Insurance Administration website (https://www.nhi.gov.tw/Content_List.aspx?n=FD1225865A44D665&topn=23C660CAACAA159D). The Chang Gung Research Database (CGRD), a deidentified database maintained by the CGMH, is a multi-institutional system and the largest healthcare provider in Taiwan.[23,24]

2.2 | Statistical analysis

Data were analyzed using SAS (version 9.4). Pearson's correlation coefficient R was used to analyze the correlation between total platelet usage and total reimbursement, total number of admissions, and average total reimbursement per admission. A two-tailed Student's *t*-test was used for comparisons between the two groups. All statistical and data analysis were assisted and interpretated by the Center for Big Data Analytics and Statistics, CGMH, Linkou.

3 | RESULTS

3.1 | Larger hospitals consume more platelet products

This study analyzed the changes in total platelet usage in six medical centers over the past 3 years (Figure 1). The total annual platelet usage in the large hospitals H1–H3 was greater than that in the medium-sized hospitals H4–H6. The annual total platelet usage in hospitals H1, H3, and H6 decreased over time, with H3 showing the most significant decrease in 2021. However, there was no significant difference in annual total platelet usage between hospitals H4 and H5, whereas annual total platelet usage in hospital H2 increased over time. This finding shows that each hospital's annual total platelet usage fluctuated, even oppositely.

3.2 | Index X presents less hospital size–dependent difference

In addition to the number of hospital beds, other factors may also affect the number of platelets used. This study used three parameters from each hospital to adjust total annual platelet usage: total annual reimbursement, total number of admissions, and average reimbursement per admission (Figures 2–4). The first parameter, total annual reimbursement, represents the overall consumption of medical resources (Figure 2A). After dividing the total platelet usage by the annual reimbursement, multiplying it by the same constant to single digits, and rounding it to the nearest tenth, an index X was established to evaluate platelet usage (Figure 2B). The values of index X were not directly divided into two groups according to hospital size, but were similar to total platelet usage. The hospital size-dependent effect was reduced after adjusting for total reimbursement, and only hospital H3's index X value was higher than that of other hospitals. Upon observing the changes in the index X value over 3 years, the index X values of hospitals H1, H3, and H6 decreased by year. Hospital H3 had the greatest drop in the index X value in 2021, whereas hospitals H4 and H5's index X values remained unchanged, and hospital H2's index X value increased.

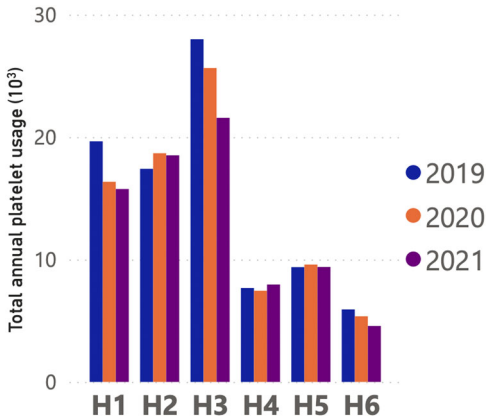

FIGURE 1 Total annual platelet usage (units) of six medical centers in 2019–2021.

3.3 | Index Y stays consistent irrespective of hospital size or total annual reimbursement

Total reimbursement may over-adjust total platelet usage because of much greater reimbursements for medicines, examinations, and other hospitalization fees than for platelet products per se. Therefore, the total number of admissions was used as the adjusted parameter (Figure 3A). After dividing the total platelet usage by the total number of admissions, multiplying it by the same constant to single digits, and rounding it to the nearest tenth, the index Y was established to evaluate platelet usage (Figure 3B). The index Y value presented fewer hospital size–dependent differences than index X. The Y value of hospital H3 was still higher than that of the other hospitals, whereas the values of the other hospitals, except for hospital H2, remained relatively consistent over 3 years. The standard deviation of the hospital's H2 index Y values was two to five times larger than those of the other five hospitals (Table 1).

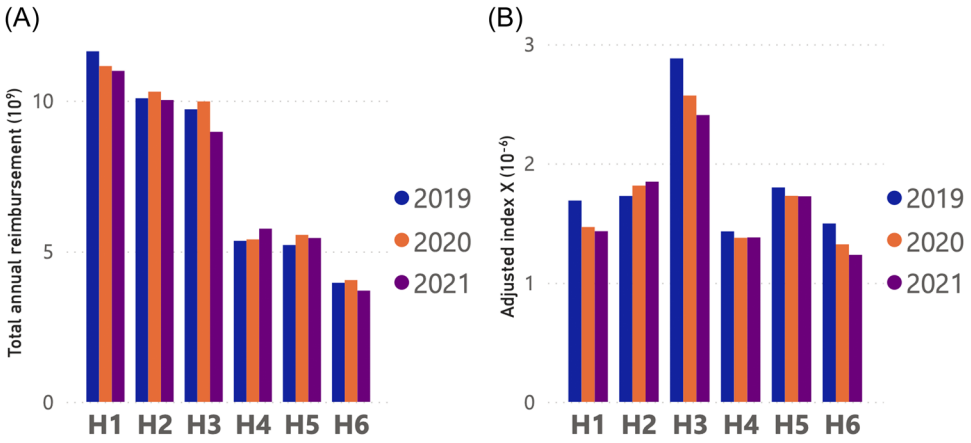

FIGURE 2 (A) Total annual reimbursement and (B) adjusted index X of six medical centers in 2019–2021. Adjusted index X was established by dividing the total platelet usage with the annual reimbursement, multiplying it by the same constant (10^{-6}) to single digits, and rounding it to the nearest tenth.

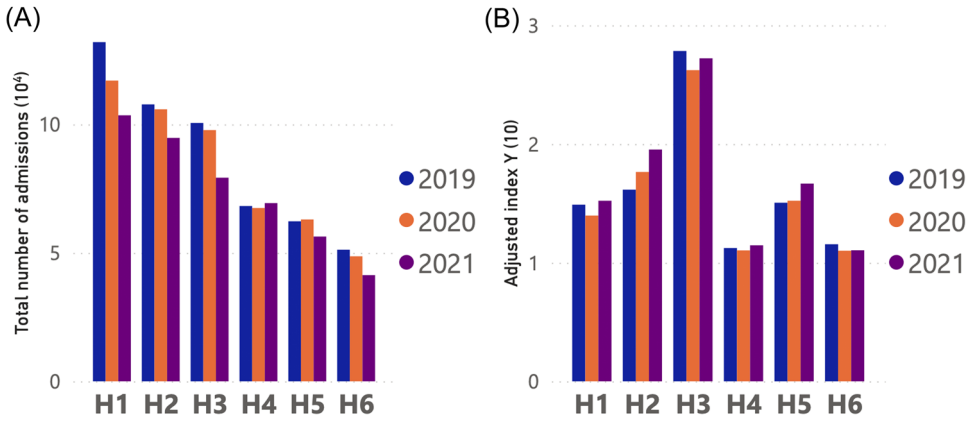

FIGURE 3 (A) Total admissions and (B) adjusted index Y of six medical centers in 2019–2021. Adjusted index Y was established by dividing the total platelet usage by the total number of admissions, multiplying it by the same constant (10) to single digits, and rounding it to the nearest tenth.

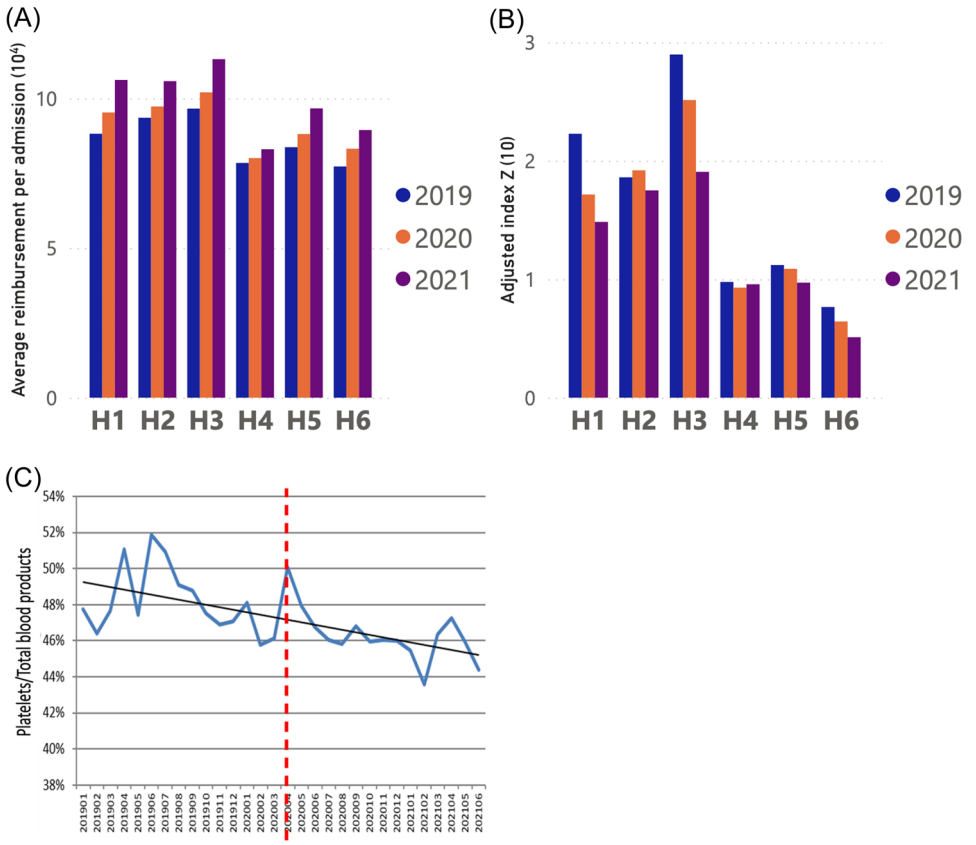

FIGURE 4 (A) Average reimbursement per admission and (B) adjusted index Z of six medical centers in 2019–2021. Adjusted index Z was established by dividing the total platelet usage by the average reimbursement per admission, multiplying it by the same constant (10) to single digits, and rounding it to the nearest tenth. (C) Trends of platelet to total blood products in H1 hospital.

3.4 | Index Z reflects the change in platelet usage pattern

Finally, the total reimbursement was divided by the total number of admissions to obtain the average total reimbursement per admission (Figure 4A). After dividing the total annual platelet usage by the average total reimbursement per admission, multiplying it by the same constant as single digits, and rounding to the nearest tenth, an index Z was established to evaluate platelet usage (Figure 4B). The index Z value was presented as a hospital-size-dependent factor, with hospitals H1–H3 having a higher index Z value than hospitals H4–H6. Although the average

TABLE 1 Means and standard deviations (SD) of the adjusted indexes Y of six medical centers.

Hospital	2019	2020	2021	Mean	SD
H1	1.49	1.4	1.52	1.47	0.06
H2	1.62	1.76	1.95	1.78	0.17
H3	2.78	2.62	2.72	2.71	0.08
H4	1.12	1.1	1.15	1.12	0.03
H5	1.51	1.52	1.67	1.57	0.09
H6	1.16	1.1	1.11	1.12	0.03

reimbursement for a single admission in each hospital increased yearly, hospitals H1 and H3 still presented decreasing Z-index Z value by year. Hospital H1 presented a decreasing monthly ratio of total platelet transfusions versus total blood product usage (Figure 4C) because it implemented the single-unit issuing policy for platelet transfusions in October 2020. Therefore, the significant drop in the index Z value was related to the altered blood-issuing policy in our hospital H1.

3.5 | Correlation between total platelet usage and three adjusted parameters, respectively

Further correlation analysis (Figure 5) showed a weak correlation between total annual reimbursement and total platelet usage ($R^2 = 0.48$) (Figure 5A). However, a strong correlation was observed between the total annual number of hospitalizations and total platelet usage ($R^2 > 0.95$) (Figure 5B) and between the average total reimbursement per admission and total platelet usage ($R^2 > 0.98$) (Figure 5C). This finding suggests that the total annual number of hospitalizations and the average total reimbursement per admission were better-adjusted parameters. In addition, the study compared the monthly trends of the three adjusted indexes and found that the total monthly consumption of hospital H3 decreased in 2021, and only two hospital size-dependent groups, H1/H2/H3 and H4/H5/H6, remained (Figure 6). Indices X and Y in all hospitals presented consistent values by month; only hospital H3 indices X and Y were still much higher than those of the other hospitals.

4 | DISCUSSION

4.1 | Statement of principal findings

Although each hospital's blood transfusion committee recommends threshold standards for platelet transfusion and regularly evaluates physician compliance with blood transfusion guidelines, the total national supply of platelets continues to increase annually. Blood establishments and hospital blood banks may exaggerate the recruitment of too many blood donors and supply too many platelet units to satisfy the clinicians' unlimited demands in Taiwan. Providing the results of the three peer comparison indices might help the administration of hospitals realize their inappropriate usage of platelet products compared to other hospitals. This is the first step toward promoting PBM in hospitals.

4.2 | Factors of total platelet usage

Traditionally, clinicians mostly use laboratory data on platelet concentration to evaluate the indication and dosage of platelet usage; however, the clinical manifestations of patients are dynamic. Furthermore, doctors' judgment of the transfusion volume is subjective, affecting each hospital's total platelet usage. Other factors of total platelet usage also include the accessibility and distribution deviation of blood supply (e.g., there are 11 medical centers in the North District but only four in the Central District), hospital size (such as the number of beds and hospitalizations), type of disease, severity of the diseases, and differences in the cognition of doctors using blood. Thus, a comparison based entirely on the total number of platelets may not be sufficiently objective.

4.3 | Objective indexes introduced to adjust the total platelet usage

Three parameters, total annual reimbursement, total number of admissions, and average reimbursement per admission, were introduced to adjust the total platelet usage (Figures 2–4), and the variations in these three platelet usage indices during the COVID-19 pandemic are discussed in this study. After the COVID-19 pandemic in Taiwan in 2021, all hospitals implemented stringent admission criteria to save hospitalization resources for isolating and treating COVID-19–infected victims. Except for a slight increase in H4, the total annual admissions in other hospitals decreased by 10%–19% compared to 2020. In addition, the total annual reimbursements for most hospitals decreased slightly (Table 2). During the COVID-19 pandemic, only severe cases have been admitted for critical management. Therefore, the average reimbursement per admission indicates the disease complexity of the patients. Hence, the average hospital reimbursement per admission H1–H6 showed an upward trend (4%–11%). Because of the COVID-19 pandemic's severity from May to July 2021, The total number of inpatients in each hospital and platelet usage decreased. In contrast, the Z value increased, indicating that the platelet demand of patients during hospitalization was higher, which may be related to the tendency of COVID-19 to cause thrombocytopenia. Further review and analysis of medical records are required, but our proposed adjusted indices reflect that platelet usage fluctuates with the alteration of patient populations.

According to our results, the total platelet usage in the six medical centers over the past 3 years was divided into two groups

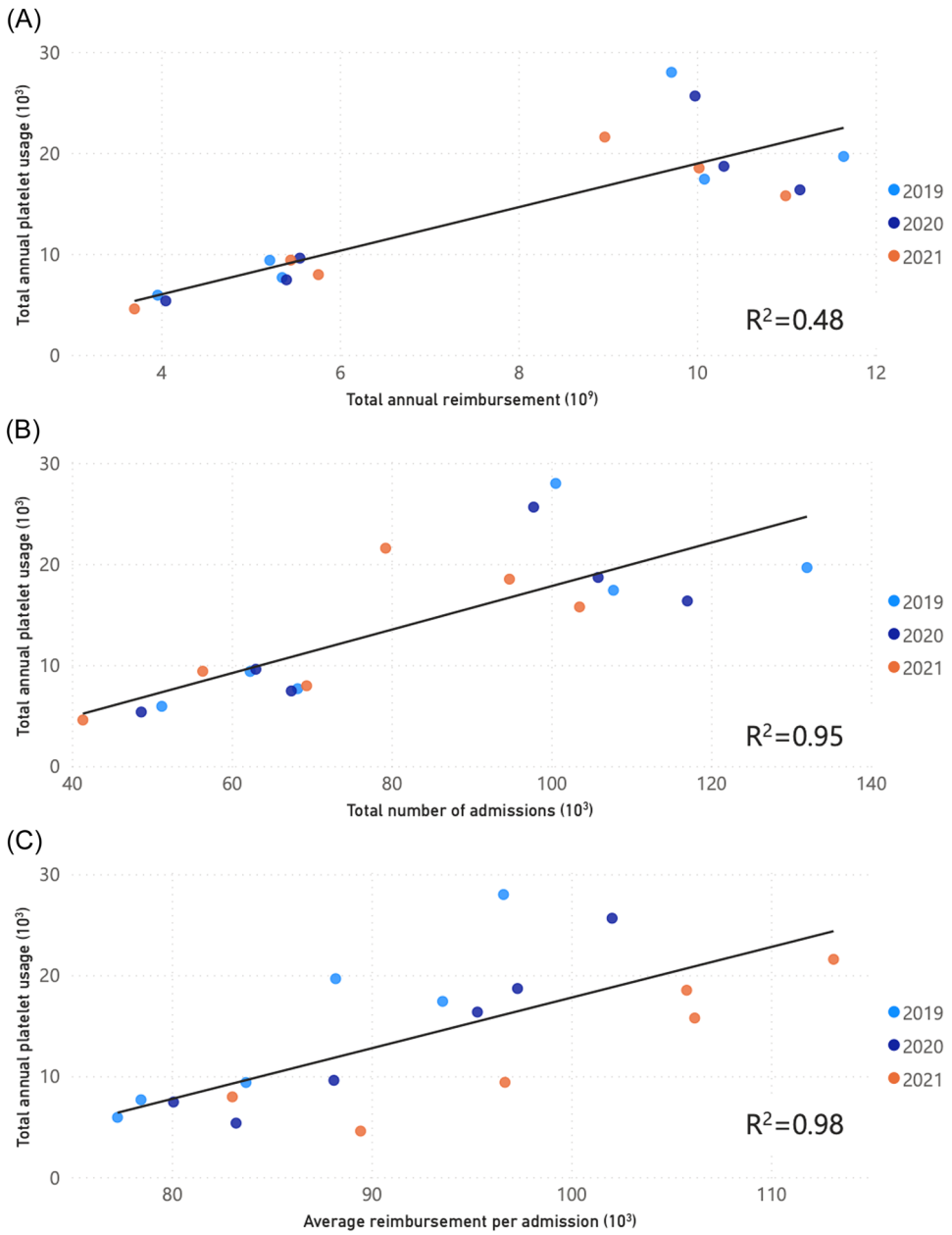

FIGURE 5 Correlation of total annual platelet usage with (A) total annual reimbursement (R^2 = 0.48), (B) total number of admissions (R^2 = 0.95), and (C) average reimbursement per admission (R^2 = 0.98), respectively.

according to hospital size. The annual total platelet usage in hospitals H1–H3 was higher than in hospitals H4–H6 (Figure 1), and the average platelet usage during hospitalization was relatively high in the larger hospitals H1–H3 (Figure 3B). Upon observation of the adjusted index X from 2019 to 2021, the value of hospital H3 was approximately 1.67 times significantly higher than that of the other hospitals (Student's *t*-test, $p = 0.002$) (Figure 2B). Index X is adjusted for the total annual reimbursement, indicating the proportion of blood products to total medical costs. The cost proportion of blood products in hospital H3 was higher than in the other hospitals. In addition, the average reimbursement per admission represented the complexity or severity of patients' cases, which we observed in the large hospitals (H1–H3) to be higher than that in the medium-sized hospitals (H4–H6) (Figure 4A). Index Z values were still higher in the H1–H3 groups, implying that such hospitals consume more platelet products because of their higher disease complexity. We also observed that Hospital H1's index Z value H1 is decreasing apparently by year. However, the index Z value of Hospital H3 was still significantly higher than that of other large-scale hospitals. However, the Z values of H1 and H3 decreased significantly to approximately the same as those of the other hospitals in 2021. These results suggest that hospitals H1 and H3 may have begun implementing certain restrictive transfusion strategies. The Z value of our hospital (H1)

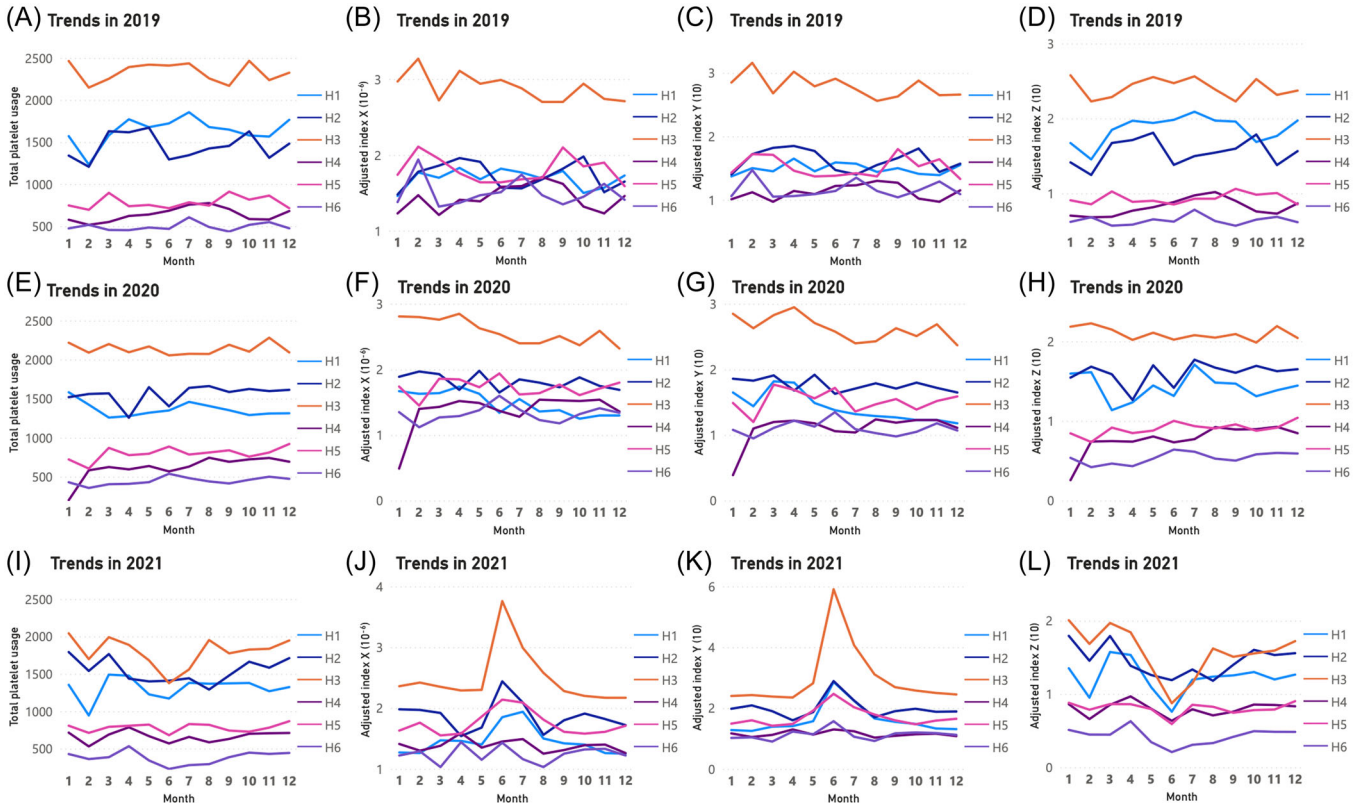

FIGURE 6 Trends of total monthly platelet usage (A, E, I), adjusted index X (B, F, J), adjusted index Y (C, G, K), and adjusted index Z (D, H, L) in 2019–2021.

TABLE 2 Changes in total annual reimbursement, the total number of admissions, and the average reimbursement per admission of six individual medical centers due to the COVID-19 pandemic, 2021.

Index	Hospital	2020	2021	Difference
Total number of admissions (10^4)	H1	11.70	10.35	−12%
	H2	10.59	9.48	−10%
	H3	9.78	7.93	−19%
	H4	6.75	6.94	3%
	H5	6.30	5.64	−11%
	H6	4.87	4.14	−15%
Total annual reimbursement (10^9)	H1	11.15	10.99	−1%
	H2	10.30	10.02	−3%
	H3	9.98	8.97	−10%
	H4	5.40	5.76	7%
	H5	5.55	5.45	−2%
	H6	4.05	3.70	−9%
Average reimbursement per admission (10^4)	H1	9.53	10.62	11%
	H2	9.73	10.58	9%
	H3	10.2	11.31	11%
	H4	8.01	8.3	4%
	H5	8.81	9.67	10%
	H6	8.32	8.94	7%

dropped as expected after implementing the single-unit issuing policy for platelet transfusion.

4.4 | Strengths and limitations

The advantage of this research design is that the data were obtained from official websites that are accessible and highly reliable. However, the data scheme is too limited to distinguish the differences related to departments, diseases, clinical conditions, and even laboratory data. In addition, we did not include data from small- or medium-sized hospitals. However, these problems must be addressed in the future. And we were not able to verify their proposed effectiveness in decreasing platelet usage because they were not generally accepted as indices of platelet usage yet. Nevertheless, this study established three adjusted indices to overcome the problem of total platelet usage directly related to hospital size.

5 | CONCLUSION

Providing these peer comparison indices to evaluate the consumption of blood resources will be helpful for blood establishments to evaluate and execute a more reasonable distribution of platelet products to hospitals. The appropriateness of platelet use will also be comparable among hospitals. Introducing these

indices into hospital accreditation programs can emphasize awareness of PBM. Finally, it could help reduce unnecessary transfusions, resulting in precious blood resources being optimally used to respond immediately to the gradual shortage of blood resources caused by the aging population and declining birth rate in Taiwan.

AUTHOR CONTRIBUTIONS

Ya-Chi Tu: Conceptualization; investigation; funding acquisition; writing—original draft; methodology; validation; visualization; writing—review and editing; software; formal analysis; project administration; data curation; supervision; resources. **Yu-Shan Hsueh**: Data curation; validation. **Yu-Chen Cheng**: Data curation; validation. **Ting-Wei Lin**: Conceptualization; investigation; data curation; validation; supervision. **Tzong-Shi Chiueh**: Conceptualization; investigation; funding acquisition; methodology; validation; writing—review and editing; resources; supervision; data curation.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ETHICS STATEMENT

This study was performed in accordance with the Taiwan Blood Services Foundation and the Taiwan Society of Blood Transfusion guidelines. The Institutional Review Board of the CGMH approved this study (IRB No. 202200407B0) and waived the requirement for informed consent.

TRANSPARENCY STATEMENT

The lead author Tzong-Shi Chiueh affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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