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RESEARCH

Reducing blood product waste through the implementation of a four-step protocol during the COVID-19 pandemic

COVID-19 döneminde 4 adımlı protokolle israf edilen kan ürünlerinin azaltılması

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Abstract

Purpose: Blood banking is critical for patients who require transfusions. Blood banks must stock blood products and update their inventory depending on the transfusion demands of hospitals. This demand subject to fluctuations caused by factors such as seasonal variations, emergent medical situations, and disasters. Unexpected changes in transfusion demand also have the potential to affect the number of waste blood products, thereby exacerbating the economic burden borne by blood centers. Our aim in this study is to reduce the destruction rates of blood products.
Materials and Methods: In this study, we evaluated the number and cause of discarded blood products in a tertiary hospital in the southeast of Turkey between 2019 and 2022. We also analyzed the effect of the COVID-19 pandemic on blood product waste. In addition, we developed a four-step protocol to reduce wasted blood products in our center.
Results: In the first year of the study, the waste/stock (W/S) ratio was 3.0% for packed red blood cells (pRBCs) and 9.2% for platelets (PLTs). However, this ratio increased to 3.2% for pRBCs and 10.1% for PLTs during the COVID-19 restrictions in 2020. Upon the implementation of the four-step protocol, the W/S ratio decreased for both pRBCs (2.3%) and PLTs (6.9%) in 2021, but this trend continued for only pRBCs (1.8%) in 2022.
Conclusion: The number of waste products increased during the COVID-19 restrictions in our center. After we developed the four-step protocol, the waste of pRBCs decreased for two consecutive years, but this was not observed for other blood products. To verify our results, the presented 4-step protocol should be tested in a larger center over a longer period.
Keywords:. Blood banking, blood product waste, COVID-19, four -step protocol

Öz

Amaç: Kan bankacılığı, transfüzyona ihtiyaç duyan hastalar için kritik öneme sahiptir. Kan bankalarının kan ürünlerini stoklamaları ve hastanelerin transfüzyon taleplerine göre stoklarını güncellemeleri gerekmektedir. Bu talep mevsimler, acil durumlar ve afetler gibi bazı faktörler tarafından değiştirilebilir. Transfüzyon talebindeki beklenmeyen değişiklikler atık kan ürünlerinin sayısını da etkileyebilir. Atık ürünler kan merkezlerinin maliyet yükünü artırabilmektedir. Bu çalışmada amacımız kan ürünlerinin imha oranlarını düşürmektir.
Gereç ve Yöntem: Bu çalışmada, 2019-2022 yılları arasında Türkiye'nin güneydoğusundaki üçüncü basamak bir hastanede atık kan ürünlerinin sayısını ve nedenini değerlendirdik. Ayrıca COVID-19 salgınının atık ürünler üzerindeki etkisini de analiz ettik. Ayrıca merkezimizde atık ürünlerin azaltılmasına yönelik 4 aşamalı bir protokol geliştirdik.
Bulgular: Çalışmanın ilk yılında atık/stok (W/S) oranı kırmızı kan hücreleri (pRBC'ler) için %3,0 ve trombositler (PLT'ler) için %9,2 idi. Ancak bu oran 2020 yılında Kovid-19 kısıtlamaları sırasında pRBC'ler için %3,2'ye, PLT'ler için ise %10,1'e yükseldi. 4 adımlı protokolü kullanmaya başladıktan sonra, 2021'de pRBC'ler (%2,3) ve PLT'ler (%6,9) için W/S oranı düştü ancak bu eğilim 2022'de yalnızca pRBC'ler (%1,8) için devam etti, ancak PLT'ler için aynı durum söz konusu değildi.
Sonuç: Merkezimizde COVID-19 kısıtlamaları sırasında atık ürün sayısında artış yaşandı. 4 adımlı protokolü geliştirdikten sonra, pRBC'lerin israfı art arda 2 yıl boyunca azaldı ancak diğer kan ürünleri için bu azalma olmadı. Sonuçlarımızı doğrulamak için 4 adımlı protokolü daha büyük bir merkezde daha uzun bir çalışma süresi boyunca test etmemiz gerekiyor.
Anahtar kelimeler: Kan bankacılığı, kan ürünleri israfı, COVID-19, 4 aşamalı protokol

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INTRODUCTION

Blood banking and storage of blood products are critical for hospitals to serve patients who require transfusion in acute or elective settings[1,2]. The demand for blood products may increase in cases of emergencies and disasters and decrease during holidays[1-3]. Therefore, blood banks must prepare their stocks to meet transfusion demands. However, the process of preparing and storing blood products is labor-intensive and expensive, and any wastage of these products inevitably increases the costs incurred by blood centers[4]. Various factors contribute to the wastage of blood products, including the expiration of shelf life, structural damage to storage bags, and unfavorable storage conditions[4,5].

The COVID-19 pandemic precipitated a substantial strain on healthcare systems worldwide, manifesting in increased patient volumes necessitating COVID-19 testing, outpatient care, and hospital admissions[6]. To reduce the burden of the COVID-19 pandemic on the health system in Turkey, health authorities implemented several strategic modifications to patient care protocols, such as postponing elective surgery, facilitating virtual hospital consultations, and designating some hospitals exclusively to the care of patients with COVID-19[7].

In this study, we investigated the number of blood transfusions, the quantity of blood product wastage, and the potential causes of wastage in a tertiary health center in the southeast of Turkey during the COVID-19 pandemic. In addition, we developed a four-step protocol aimed at refining the process of blood product requisition and introduced a feedback mechanism within our local blood center to reduce the wastage of blood products in our hospital. Our study holds promise in reducing blood waste not only during the routine operation of the hospital but also in exigent situations, such as earthquakes and epidemics.

MATERIALS AND METHODS

The data for this study was collected from the database of Mehmet Akif Inan Research and Training Hospital between January 2019 and December 2022. This hospital is a tertiary health care center that only serves adult patients in inpatient and outpatient settings. It serves three million patients per year in Sanliurfa and the neighboring rural areas of the southeast region of Turkey. Equipped with a bed capacity of 900, the hospital offers a diverse array of medical specialties and services, including emergency, surgery and trauma, hematology, and oncology, as well as multiple intensive care units. Necessary permissions have been obtained from the institution. The people doing the work are competent.

The ethics committee of the Harran University Faculty of Medicine approved the study (February 20. 2023. HRU. 23/03/12), and the study was conducted according to the ethical standards of the Declaration of Helsinki.

Blood banking and storage conditions

Blood products are processed, transferred, and stored under product-specific conditions until transfusion. Blood products are received from the southeast regional center of the Red Crescent (Kizilay), following physician orders in elective cases where these products may be deemed necessary. These products are transferred within three hours to our local blood center in the hospital. In addition, in cases of emergencies, our local blood center has the capability to generate blood products through the contributions of volunteer donors.

As part of our standard operating procedures, we routinely test blood products for anti-HIV1/2, HIV RNA, HBsAg, HBV DNA, anti-HCV, HCV RNA, and Treponema pallidum (Syphilis). Fresh frozen plasma (FFP) and cryoprecipitate (CP) are stored at -80°C with a designated shelf life of 36 months. These products are thawed using Sahara-3 instruments approximately 30 minutes before transfusions. Packed red blood cells (pRBC) are stored at 2-6°C, and their shelf life is 42 days. Platelets (PLTs) are stored at room temperature (22-24°C), and their shelf life is five days. FFPs, CP, and PLTs are transfused after being tested for ABO and Rh matching. pRBCs are also tested for crossmatching in addition to ABO and Rh matching before transfusions. Blood groups and crossmatch tests are run utilizing the ORTHO AutoVue® Innova System.

Four-step protocol to reduce blood product waste

In 2021, we developed a four-step protocol aimed at mitigating the wastage of blood products in our center. The details of this protocol are given below.

Step 1 (Education): The transfusion and blood banking team conducted educational seminars to improve the knowledge of blood storage and transfusion medicine among medical teams.

Step 2 (Review): If there were more than two units of blood product orders for a patient, the transfusion medicine team reviewed the patient's chart, except for emergency cases. For emergency cases, blood products were transferred to the department immediately, while in other cases, the transfusion team contacted the attending physician to deliberate on a transfusion plan.

Step 3 (Storage): Designated refrigerators were used to store pRBCs at the patient's side for each department or operation room until transfusion time.

Step 4 (Feedback): At the end of each month, the transfusion team shared the number of waste products with the medical teams and administration of the hospital by e-mail (Figure 1).

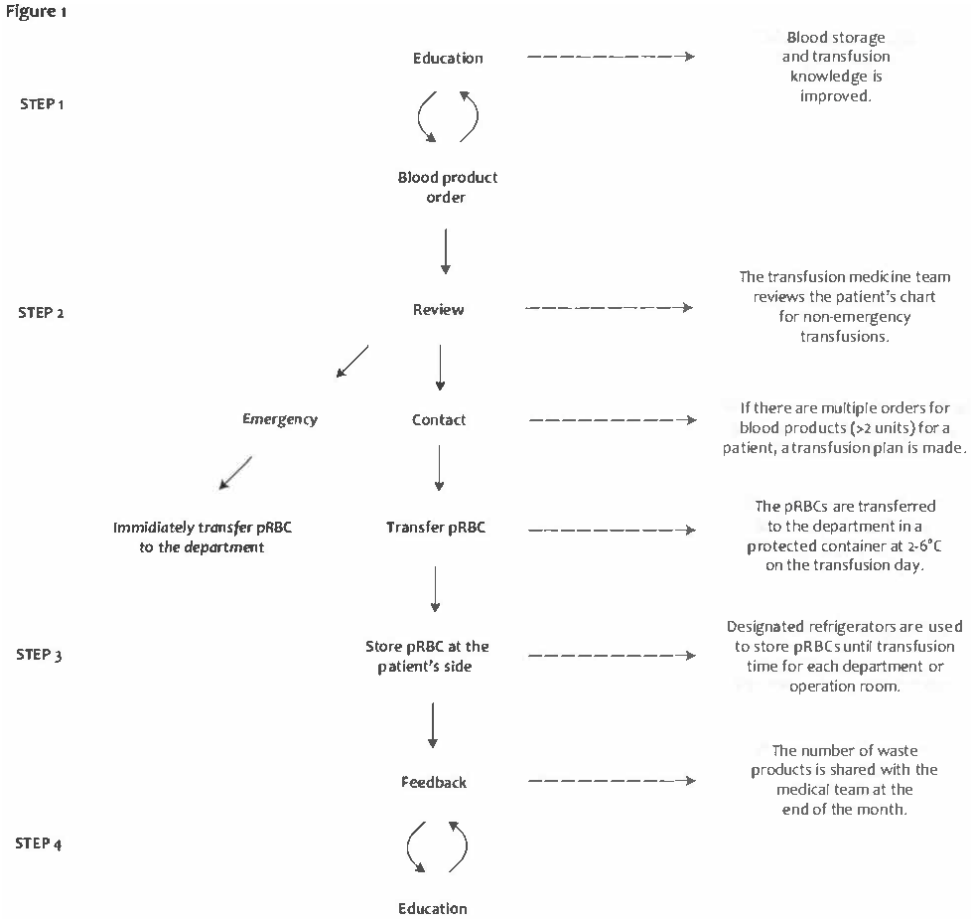


Figure 1. Four-step protocol developed in 2021 in our center.

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics for Windows, version 25.0 (Statistical Package for the Social Sciences, IBM Corp., Armonk, NY, USA). Descriptive statistics were presented as numbers and percentages for categorical variables and as mean ± standard deviation and median (interquartile range) values for continuous variables.The Pearson chi-square and Fisher exact tests were performed to compare categorical variables. A p value of <0.05 was considered statistically significant. The number of discarded

blood products during the COVID-19 period and other periods was compared.

RESULTS

A total of 72,030 blood products were transfused at Mehmet Akif Inan Research and Training Hospital over the 48 months between January 2019 and December 2022. All transfused patients were adults (≥18), and 58.2% of them were female. The cross-match to transfusion ratio (C/T) was 1.57. Blood products were mainly transfused at the hematology, surgical intensive care, oncology, and internal medicine intensive care wards (Table 1).

Table 1. Numbers of blood products transfused in the departments and divisions of our center.

Departments	2019	2020	2021	2022
Hematology	3.454 (19.5%)	3.403 (22.8%)	3.871(22.0%)	2.469 (11.3%)
Surgical ICU	2.225 (12.6%)	1.187 (7.9%)	1.536 (8.7%)	2.018 (9.3%)
Oncology	2.190 (12.4%)	925 (6.2%)	885 (5.0%)	1.252 (5.7%)
IM ICU	1.616 (9.1%)	916 (6.1%)	726 (4.1%)	985 (4.5%)
Cardiovascular surgery	1.371 (7.7%)	1.171(7.8%)	1.648 (9.4%)	1.805 (8.3%)
ER	894 (5.0%)	827 (5.5%)	1.148 (6.5%)	1.180 (5.4%)
Neuro-ICU	534 (3.0%)	1.046 (7.0%)	894 (5.1%)	551 (2.5%)

Number of units (percentage of units). ICU; intensive care unit, IM; internal medicine, ER: emergency service, Neuro; neurology, neurosurgery.

The number of transfused products was the lowest (14,941 units) in 2020 and the highest (21,807 units) in 2022 (Figure 2A). The percentage of transfused blood products was 70.2% for pRBCs, 22.2% for FFPs, 7.1% for PLTs, and 0.5 for CP (0.5) (Figure 2B). According to the AB0 and Rh blood group systems, the distribution of transfused blood products was as follows: 32.4% for 0 Rh (+), 31.4% for A (+), and 18.9% for B(+) (Figure 2C).

During the study period, a total of 2,176 blood products were discarded, with the highest number (620 units) being observed in 2019 and the lowest (502 units) in 2022 (Figure 3A). The number of discarded blood products decreased in 2021 and 2022 compared to 2019 ($p = 0.049$ and $p = 0.031$, respectively). During the study period, pRBCs emerged as the most commonly wasted product (58.7%), followed by PLTs (22.5%), FFPs (17.7%), and CP (1.0%) (Figure 3B). The primary reasons attributed to the wastage of blood products were the expiration of shelf life, cancellation of planned transfusions, and issues related to storage bag integrity, such as damage and tearing (Figure 3C).

The number of transfused blood products exhibited monthly fluctuations, characterized by a decrease in the summer months, particularly in July and August, and an increase during the winter months (Figure 4A). The percentage of transfused blood products per month declined in the summer season (Figure 4B). However, these seasonal changes were not statistically significant over the study period (winter vs. summer, $p = 0.94$). In addition, the number and percentage of transfused blood products decreased at the beginning of the COVID-19 pandemic, particularly in April and May 2020, due to the cancellation or postponement of all surgical operations in our hospital, which was designated as the provincial COVID-19 center by the Ministry of Health of Turkey (Figure 4B). Comparative analysis revealed a statistically significant decrease in the number of transfused blood products during the COVID-19 restriction period (April and May 2020) compared to the corresponding months in the previous year (April and May 2019) ($p = 0.009$). Furthermore, the number of transfused blood products significantly increased in April and May 2021 ($p = 0.006$) and 2022 ($p = 0.001$) compared to the COVID-19 restriction period (April and May 2022). We also observed a change in the number and percentage of wasted products per month. The number and percentage of wasted products reached the highest level (154 units, 28.4%) in April 2020, coinciding with the implementation of COVID-19 restrictions (Figure 4C, D).

Figure 3

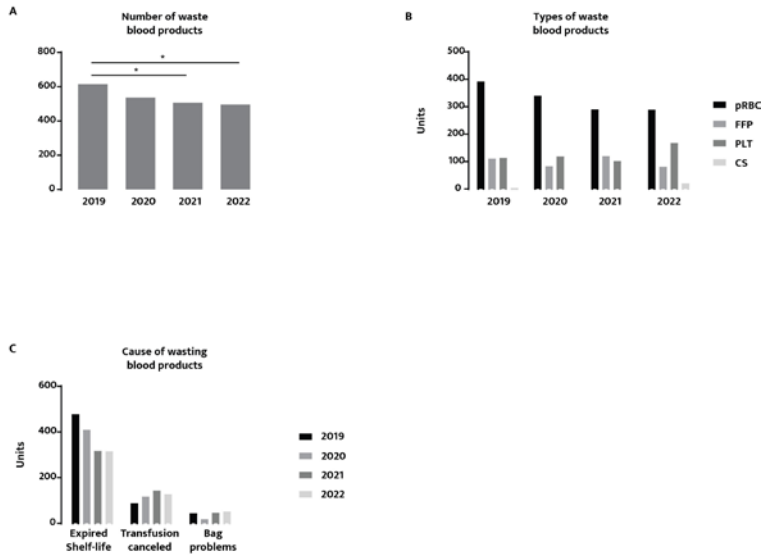


Figure 3 A. Number of wasted blood products in our center. The number of waste blood products decreased since 2020. B. Types of wasted blood products in our center. pRBCs were the most common wasted products. C. Causes of blood product wastage in our center. *p-value*; *<0.05, **<0.01, *<0.001, ****<0.0001.**

Figure 4

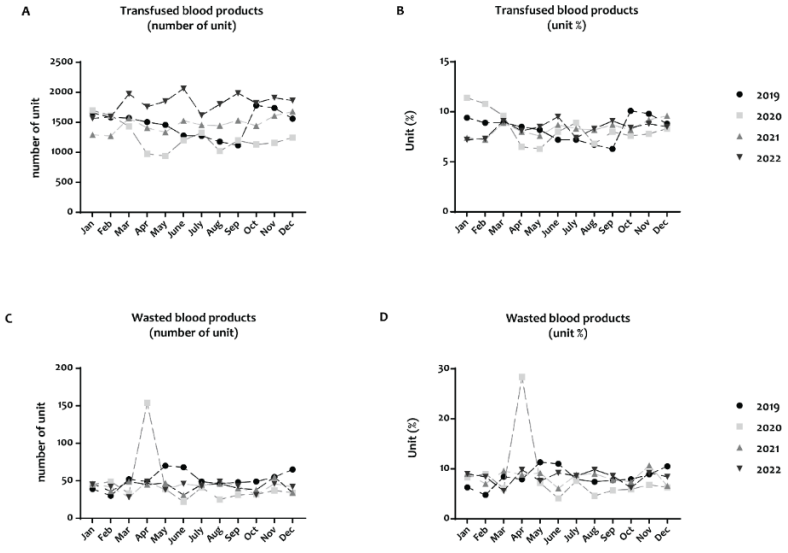
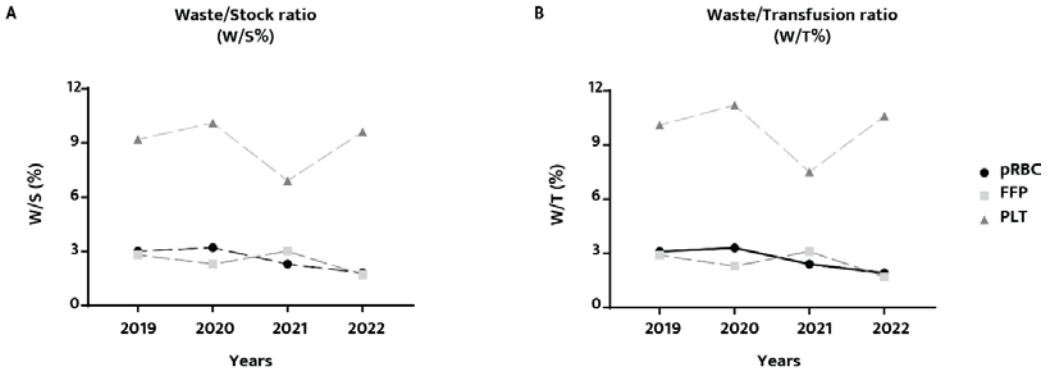


Figure 4 A. Number of transfused blood products per month during the study period. There was a seasonal change for the transfused products in our center. Overall, there was a decrease in transfusion demands in July and August. There was a decrease in April and May 2020 due to COVID-19 restrictions. B. Percentage of transfused blood products per year in our center. C. Number of wasted blood products. D. Percentage of wasted blood products in our center. The number and percentage of wasted blood products were the highest in April 2020. In March 2020, with the implementation of COVID-19 restrictions, our hospital was designated as a COVID-19 patient care center.

We calculated the wasteto-stock ratio (W/S) during the study period (Figure 5). The mean W/S ratio was 2.5% for pRBCs, 8.9% for PLTs, and 7.0% for FFPs across the four-year period (Figure 5A). In the first year of the study, the W/S ratio was 3.0% for pRBCs, 9.2% for PLTs, and 2.8% for FFPs. However, this ratio increased to 3.2% for pRBCs and 10.1% for PLTs in 2020. After we developed the four-step protocol in our center, the W/S ratio decreased to 2.3% for pRBCs and 6.9% for PLTs in 2021, and this decrease was further pronounced for pRBCs (1.8%) ($p = 0.032$) in 2022 but not for PLTs (9.6%, Figure 5A) ($p = 0.065$).

Figure 5



Waste/stock ratio (W/S%), waste/transfusion ratio (W/T%).

Figure 5 A, B. Waste/stock (W/S) and waste/transfusion (W/T) ratios between 2019 and 2022. For pRBCs, the W/S and W/T ratios increased in 2020 during COVID-19 restrictions. After we developed the four-step protocol, these ratios decreased in 2021 and 2022 for pRBCs. For PLTs, the W/S and W/T increased in 2020 (COVID-19 restrictions). Following the implementation of the four-step protocol, these ratios decreased in 2021 but not in 2022 for PLTs.

We also calculated the wasted product to transfusion ratio (W/T) (Figure 5B). The mean W/T ratio was 2.6% for pRBCs, 9.8% for PLTs, and 2.5% for FFPs during the four-year study period. In the first year of the study, the W/T ratio was 3.1% for pRBCs, 10.1% for PLTs, and 2.9% for FFPs. However, this ratio increased to 3.3% for pRBCs and 11.2% for PLTs in 2020 due to the implementation of COVID-19 restrictions. After we initiated the four-step protocol, the W/T ratio decreased to 2.4% for pRBCs and 7.5% for PLTs in 2021, with this ratio further reducing to 1.9% for pRBCs in 2022, while there was an increase in the wastage of PLTs (10.6%) in 2022 (Figure 5B).

Storage bag damage was the main reason for FFP wastage. For FFPs, the W/S ratio was 2.8% in 2019, which decreased to 2.3% in 2020. This ratio increased to 3.1% in 2021, before declining once more to 1.7% in 2022 ($p = 0.056$) (Figure 5A, B).

DISCUSSION

The production and storage of blood products play a pivotal role in ensuring that patients receive appropriate and timely products for treatment[8]. Therefore, to minimize blood product waste and optimize the use of blood products, the US Food and Drug Administration, the Association for the Advancement of Blood and Biotherapies, and health authorities regularly publish guidelines for blood banking and transfusion practices[9]. In addition, to improve the use of blood products efficiently, some markers have been employed, such as (C/T)[10]. The ideal C/T ratio is 1%, but a C/T ratio of ≤2.5% is generally accepted as a reasonable threshold within blood banking standards. In our study, the C/T ratio was calculated to be 1.57%[10].

In this study, we calculated both the W/S and W/T ratios as key metrics to assess the efficiency of blood

banking and the transfusion of blood products in our center. Bashir et al.[4] reported a W/S ratio of 8.87% for blood products over a 15-month study period. In our study, the mean W/S ratio was 3.0% over 48 months. During the study period, we observed that the W/S and W/T ratios exhibited similar trends. Specifically, in 2020, compared to the previous year, both ratios increased for pRBCs and PLTs, attributable to the cancellation or postponement of all planned operations in our hospital due to the COVID-19 pandemic. Conversely, in 2021, compared to the previous two years, both ratios decreased for pRBCs and PLTs. This decrease could be explained by two factors; the implementation of the four-step protocol in our hospital and the resumption of healthcare services following the relaxation of COVID-19 restrictions in 2021, resulting in a heightened demand for healthcare services, including transfusions.

In 2022, compared to the previous three years, the W/S and W/T ratios decreased for pRBCs but not for PLTs. We observed a dramatic decrease in both ratios for pRBCs after the second year of the four-step protocol. This finding can be explained by two factors, namely the differences in storage conditions and the shelf life of pRBCs[4, 11]. Compared to PLTs, pRBCs have a longer shelf life and do not require special conditions for storage (cold storage without agitation for pRBCs versus room temperature with agitation for PLTs[11]. Compared to FFPs, pRBCs can be stored at the departments (in designated refrigerators, 2-6 °C) until transfusion time; however, FFPs require more special storage conditions (at -80 °C) and pre-transfusion processing (thawing before transfusion)[4].

For FFPs, the W/S and W/T ratios exhibited different trends compared to those for pRBCs and PLTs. These ratios decreased in the first year of the pandemic (2020) compared to 2019. This decrease can be attributed to the longer shelf life of FFPs, despite a decline in transfusion demands during COVID-19 restrictions. However, the W/S and W/T ratios increased in 2021, the first year into the implementation of the protocol, and subsequently decreased in 2022, in the second year. Unfortunately, the available data only spans two years post-protocol implementation, limiting our ability to fully assess the long-term impact of the protocol on reducing blood product wastage. Therefore, to better understand the efficacy of the four-step protocol in mitigating blood product waste, further investigation over an extended follow-up period is warranted.

The storage of blood products is contingent upon the dynamic demands for these products and the transfusion needs of hospitals[12]. Changes in transfusion demands are the main problem for blood banking inventory and waste[13, 14]. These demands may change daily, monthly, and seasonally depending on holidays, weather conditions, emergencies, natural disasters, and other crises, such as the COVID-19 pandemic[14,15]. As previously reported, we also observed a similar trend wherein transfusion demands exhibited a seasonal pattern, declining during the summer months and increasing during the winter months[14]. Additionally, we determined that blood product wastage increased during COVID-19 due to the cancellation of elective operations[15]. Almost 90% of hospitals canceled elective surgery due to COVID-19 in the United states of America(USA) during the first week of the national shutdown (third week of March 2020), and the wastage of blood products was reported to reach 25.7% that week. Four weeks later (first week of May 2020), the wasted product ratio peaked at 54%, which decreased to 52% in the second week of May 2020, following the reinstatement of elective operations in the USA[15]. We observed a similar trend in our study.

Our study has certain limitations. As a tertiary healthcare center, our hospital serves exclusively adult patients and does not have any pediatric units. In addition, due to the study being conducted in a single center within a rural area of Turkey, the findings are not able to reflect transfusion demands prevalent in urban settings. Lastly, we tested the four-step protocol over a short study period (only two years). To comprehensively assess the efficacy of this protocol, future studies should consider testing it in larger centers with higher transfusion demands over a longer study period.

In conclusion, our study highlighted the seasonal and monthly fluctuations in transfusion demands and the increased wastage of blood products in 2020 due to the COVID-19 pandemic. However, the presented four-step protocol reduced the wastage of pRBCs in our hospital. Moving forward, blood banks should update their stocks dynamically in response to evolving demands, considering factors such as seasons, holidays, emergencies, and disasters, to ensure optimal utilization of blood products while minimizing waste.

Author Contributions: Concept/Design : İHD, SÖ; Data acquisition: SÖ; Data analysis and interpretation: İHD; Drafting manuscript: İHD; Critical revision of manuscript: SÖ; Final approval and accountability: İHD, SÖ; Technical or material support: -; Supervision: SÖ; Securing funding (if available): n/a.
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