

Original article

Blood donation and blood reserve management before and after the COVID-19 pandemic: experiences from Songklanagarind Hospital

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Abstract:

Introduction: The 2019 global coronavirus pandemic resulted in numerous infections and deaths, with varying consequences, including decreased blood donation levels in many countries, which caused problems with blood banking management. **Objective:** This study focused on the changes in the number of blood donors, blood reserves, and blood usage at Songklanagarind Hospital during the outbreak and the management methods implemented to ameliorate the blood shortages. **Materials and Methods:** This retrospective study used Analysis of Variance (ANOVA), chi-square tests, and descriptive statistics to determine the number of blood donations, blood reservations, and blood usage before and during the COVID-19 outbreak. The outbreak of the disease was divided into five periods based on the characteristics of the pandemic as well as the public health interventions and policies, including the period following the implementation of solutions for all blood units at Songklanagarind Hospital. **Results:** The average numbers of blood donations per month for each period were 2,029, 1,926, 2,096, 1,767, 1,839, and 1,995 units, respectively, with no statistically significant differences (p -value = 0.205). The average numbers of packed red blood cells requested during each period were 3,544, 3,418, 3,690, 3,006, 3,075, and 3,278 units, respectively, with a significant difference of 0.001 in p -values among the pre-outbreak period and outbreak waves 3 & 4, and 5. The average numbers of red cell usage were 1,827, 1,804, 1,968, 1,703, 1,756, and 1,885 units, with no significant differences (p -value = 0.228). **Conclusion:** The demand for blood during each period did not decrease significantly, as did the number of blood donors, since the blood bank adjusted its blood supply model and managed blood reserves to ensure an adequate and safe blood supply. In the event of future blood shortages or pandemics, these guidelines can also be applied to blood management.

Keywords : ● COVID-19 ● Blood donation ● Hospital-based blood banking
● Crossmatch-to- transfusion ratio

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นิพนธ์ต้นฉบับ

การรับบริจาคโลหิตและการบริหารจัดการเลือดสำรองก่อนและหลังการระบาดของโรคติดเชื้อไวรัสโคโรนา-19: ประสบการณ์จากโรงพยาบาลสงขลานครินทร์

วรรณวิมล ยินดี และ สรัญญา หัสรินทร์

หน่วยคลังเลือดและเวชศาสตร์บริการโลหิต ภาควิชาพยาธิวิทยา คณะแพทยศาสตร์ มหาวิทยาลัยสงขลานครินทร์

บทคัดย่อ

บทนำ การระบาดของไวรัสโคโรนา 2019 ที่เกิดขึ้นระดับโลกส่งผลให้เกิดการติดเชื้อและการเสียชีวิตจำนวนมาก มีผลกระทบเป็นวงกว้างในหลายด้านที่แตกต่างกัน รวมถึงจำนวนการบริจาคเลือดที่ลดลงในหลายประเทศ เกิดปัญหาในการบริหารจัดการเลือดของคลังเลือด **วัตถุประสงค์** ศึกษาการเปลี่ยนแปลงจำนวนการบริจาคเลือด การสั่งเตรียมและการใช้เลือดที่โรงพยาบาลสงขลานครินทร์ในช่วงการระบาดของไวรัสโคโรนา 2019 และการบริหารจัดการเพื่อบรรเทาสถานการณ์ขาดแคลนเลือด **วัสดุและวิธีการ** ศึกษาจำนวนการบริจาคเลือด การสั่งเตรียมเลือด และการใช้เลือดจริงของผู้ป่วยของโรงพยาบาลสงขลานครินทร์ ย้อนหลังทุกยูนิต โดยแบ่งเป็นช่วงก่อนการระบาดของ COVID-19 ระหว่างการระบาดและช่วงหลังผ่อนคลายมาตรการ ช่วงระบาดของโรคถูกแบ่งเป็นห้าช่วงโดยอิงจากลักษณะของการระบาดรวมทั้งมาตรการและนโยบายด้านสาธารณสุข โดยใช้สถิติเชิงพรรณนา ANOVA และ chi-squared test **ผลการศึกษา** จำนวนการบริจาคเลือดเฉลี่ยต่อเดือนอยู่ที่ 2,029, 1,926, 2,096, 1,767, 1,839 และ 1,995 หน่วย โดยไม่มีความแตกต่างที่มีนัยสำคัญทางสถิติ (p -value = 0.205) จำนวนผลิตภัณฑ์เม็ดเลือดแดงเฉลี่ยที่สั่งเตรียมในแต่ละช่วงคือ 3,544, 3,418, 3,690, 3,006, 3,075 และ 3,278 ตามลำดับ พบความแตกต่างที่มีนัยสำคัญทางสถิติ ระหว่างช่วงก่อนการระบาดและคลื่นการระบาดที่ 3 และ 4 และ 5 ที่ $p < 0.001$ จำนวนการใช้เลือดแดงเฉลี่ยแต่ละช่วงคือ 1,827, 1,804, 1,968, 1,703, 1,756 และ 1,885 ตามลำดับ โดยไม่มีความแตกต่างที่มีนัยสำคัญทางสถิติ (p -values = 0.228) **สรุป** ความต้องการเลือดในแต่ละช่วงไม่ลดลงอย่างมีนัยสำคัญทางสถิติเช่นเดียวกับจำนวนผู้บริจาคเลือด เนื่องจากคลังเลือดได้ปรับรูปแบบการจัดการและการจัดการสำรองเลือดเพื่อให้แน่ใจว่ามีเลือดใช้ได้อย่างเพียงพอและปลอดภัย ในกรณีที่เกิดการขาดแคลนเลือดหรือการระบาดของโรคในอนาคต แนวทางเหล่านี้ยังสามารถนำมาใช้ในการจัดการเลือดได้เช่นกัน

คำสำคัญ : ● ไวรัสโคโรนาสายพันธุ์ใหม่ 2019 ● การบริจาคโลหิต ● ธนาคารเลือดในโรงพยาบาล
● สัดส่วนจำนวนเลือดที่จองกับเลือดที่ใช้

วารสารโลหิตวิทยาและเวชศาสตร์บริการโลหิต. 2567;34:91-9.

Introduction

The emergence of the novel coronavirus disease 2019 (COVID-19), initially reported in December 2019 in Wuhan, Hubei Province, China, had significant global repercussions due to its rapid spread across borders. In June 2023, the World Health Organization (WHO) Thailand and the Department of Disease Control of Thailand reported over 4,700,000 COVID-19 cases in Thailand, contributing to the staggering global tally of more than 689,000,000 infections. The widespread impact of the pandemic prompted Thailand's public health system to implement various preventive measures at different stages of the outbreak.¹⁻³ During the initial phase of the COVID-19 outbreak, several variants, such as S, GH, Alpha, Delta, and Omicron, circulated. As the virus spreads through contact with mucosal membranes and large droplets or small aerosol particles, the risk of infection is reduced when maintaining a distance of over 6 feet from an infected individual, limiting contact to under 15 minutes, and engaging in activities that do not involve heavy breathing, such as conversing and light physical exercise.⁴⁻⁵

The government adopted several preventative measures, including proactive and reactive outbreak search mechanisms to reduce and stop infection, and provided quarantine facilities. Personal precautions such as wearing a mask, washing hands, and rapid testing for COVID-19 were also recommended. The DMHT (D: social distancing, M: mask wearing, H: hand washing, and T: testing) guidelines included social distancing, staying at home, and not traveling. Worldwide data indicated that blood components were in short supply. In Thailand, the National Blood Centre, Thai Red Cross Society (NBC, TRCS) reported a reduction of over 50% in blood donors nationwide during the outbreak starting on January 8, 2021, causing a direct impact on patients who needed routine and emergency blood transfusions such as thalassemia patients and emergency heart surgery patients.

A blood bank's purpose is to provide enough blood and blood components to meet the needs of patients, and this process is impacted by blood shortages. The appropriate amount of blood in stock can be calculated based on blood usage and the validity period of the various blood components. This stock evaluation should be done periodically because there are numerous factors related to increased blood use, which include hospital expansion, admitting patients who require a large amount of blood (massive blood transfusion), or modification of the recommendations for giving blood. Another important factor is the amount of blood that the blood bank can accept for donation, which must be balanced between the needs of patients and the number of blood donors.⁷ During the pandemic, a survey of blood donors at Songklanagarind Hospital revealed that the primary concerns preventing donors from coming were fears of contracting infections during travel, or in crowded environments, and the inconvenience of COVID-19 testing.

Restricting the areas that may facilitate the spread of infectious diseases and having a vaccination management plan are examples of social interventions to ameliorate the concerns of blood donors regarding traveling to blood donation locations.⁶ The Blood Bank and Blood Transfusion Medicine Unit at Songklanagarind Hospital followed the measures for the safety and selection of blood donors stipulated by the NBC, TRCS and WHO during the COVID-19 outbreak.^{6,8} Moreover, all of the blood donors were asked to complete a symptom and infection risk questionnaire as a method to screen for COVID-19. Staff members of the blood donation site were split into two groups in order to minimize interpersonal interactions, and the use of personal protective equipment (PPE), such as gowns and gloves, and routine handwashing were increased. Finally, after each blood donation, the touched surfaces were cleaned. This study examined the impact of changes in the number of blood donors on blood reserve management and blood

component use. The results can be used as a guideline to follow during any future pandemic or disaster that causes a blood shortage.

Materials and Methods

This retrospective study was conducted on the numbers of blood donations, blood requests and blood transfusions from Songklanagarind Hospital, Prince of Songkla University in southern Thailand over a period of 5 years and 6 months; before the COVID-19 outbreak (January 2018 to December 2019), during the COVID-19 outbreak (January 2020 to May 2022), and the period after the disease prevention measures were reduced (June 2022 to June 2023). The outbreak period was classified into five waves based on critical events as well as public health interventions and policies.¹⁰⁻¹¹ During the first wave from January to November 2020, the pandemic spread widely from the Lumpinee Boxing Stadium and other entertainment venues. In the second wave from December 2020 to February 2021, outbreaks started at a shrimp market in Samut Sakhon Province. During waves 3 and 4, from March to December 2021, outbreaks spread from various entertainment venues and the Narathiwat Provincial Prison. Wave 5 lasted

from January to May 2022, during which the Omicron outbreak spread throughout Thailand. Every unit of blood donation, request and usage were counted and analyzed using descriptive statistical methods, ANOVA and chi-squared tests⁹ with Microsoft Excel version 2016 and a significance level alpha of 0.05. The relevant variables are shown in Figure 1. Basic information on the donors was collected, including those who passed and those who did not pass the screening, as well as the age, gender, and domicile specified in the blood donor form. Data on patients included the number of blood requests as the number of units or cross-matched units that retained blood components through the type and screen methods. Actual blood count referred to the number of units of actual blood components, including the crossmatch-to-transfusion ratio (C:T ratio), which is the number of units cross-matched divided by the number of units transfused to the patient. A value of less than 2 indicated appropriate use of blood which has impact on blood retention and supply.¹² This study was approved by the Human Research Ethics Committee of Prince of Songkla University with the project code REC 66-273-5-8.

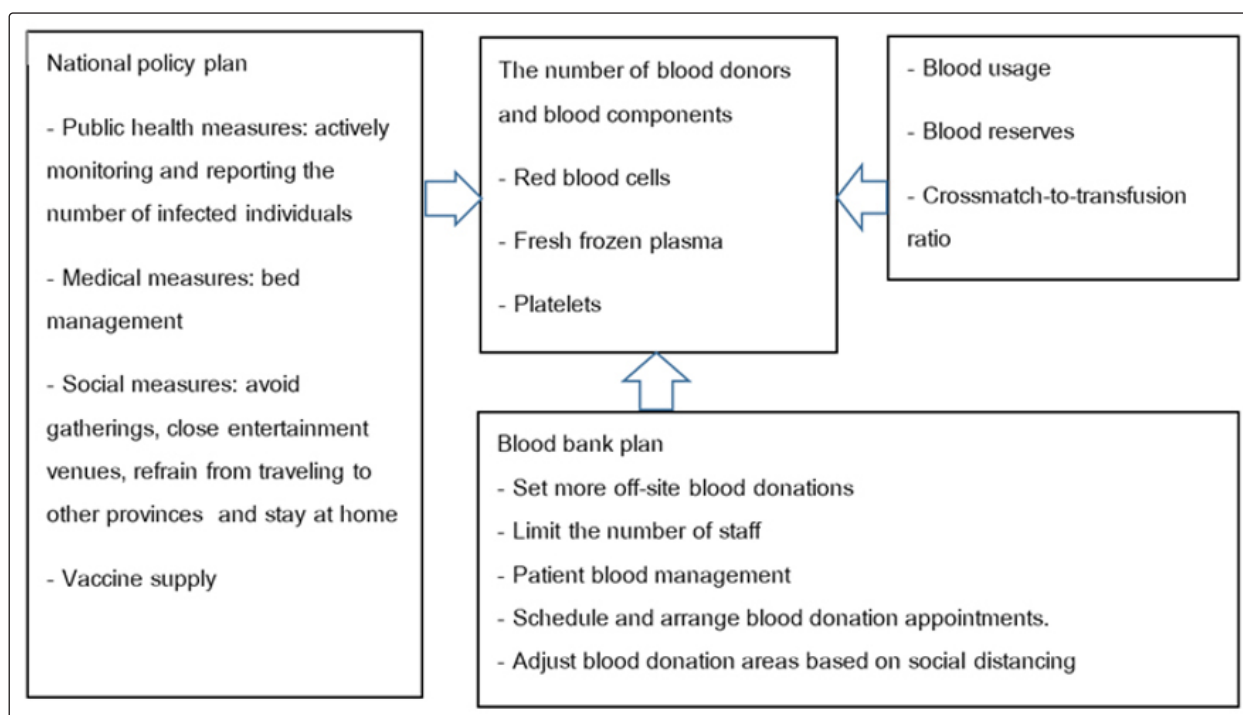


Figure 1 The relevant variables that influence blood management

Results

The annual blood donation data from January 2018 to June 2023 revealed the number of donors over the specified period. In 2018, a total of 23,610 blood donors were recorded, followed by 25,074 in 2019, 23,168 in 2020, 21,977 in 2021, 23,442 in 2022, and 11,690 from January to June 2023. Demographic characteristics of the blood donors indicated a balanced distribution across genders, with 48.76% male and 51.24% female donors. Students and college students accounted for 24% of the total number of blood donors, with varying age distributions across different age groups. The age distribution among donors was delineated as follows: 15-20 years (9.53%), 21-30 years (40%), 31-40 years (25.32%), 41-50 years (22.62%), 51-60 years (11.78%), and over 60 years (0.35%). Geographically, 48.25% of the donors resided in Hat Yai, 29.50% in Songkhla, and 22.25% in other provinces. The mean monthly blood donations were

categorized according to the five pandemic periods, yielding figures of 2,029, 1,926, 2,096, 1,767, 1,839, and 1,995 units, respectively. Statistical analysis revealed no significant differences among these figures (p -value = 0.205). Correspondingly, the mean quantities of packed red blood cells requested during each period were 3,544, 3,418, 3,690, 3,006, 3,075, and 3,278 units, respectively, with significant differences observed in the p -values ($p < 0.001$) between the pre-outbreak period and the outbreak waves 3 and 4, as well as wave 5, resulting in a reduction of the C:T ratio ($p < 0.001$), whereas the blood requests by the type and screen (T&S) method had no significant differences ($p = 0.253$). The average amounts of red blood cell utilization were 1,827, 1,804, 1,968, 1,703, 1,756, and 1,885 units, respectively, showing no significant disparities with a p -value of 0.228 (Table 1). The distribution of blood donors for each category is presented in Table 2. Off-site blood

Table 1 The quantity of blood donors, red cell reservations and utilization C:T ratio, and average monthly type and screen (T&S) request numbers during the pre-pandemic, the five-wave pandemic, and post-pandemic periods

Groups	Months	Number of donors (units/month)	Number of red cell reservations (units/month)	Number of red cell usage (units/month)	C:T ratio	T&S (units/month)
Pre-pandemic	24	2,029	3,544	1,827	1.94	257
Wave 1	11	1,926	3,418	1,804	1.89	254
Wave 2	3	2,096	3,690	1,968	1.88	266
Waves 3 & 4	10	1,767	3,006	1,703	1.77	228
Wave 5	5	1,839	3,075	1,756	1.75	242
After easing the measures	13	1,995	3,278	1,885	1.74	245
<i>p</i> -values		0.205	< 0.001	0.228	< 0.001	0.253

The p -value was calculated by comparing the means of each variable across each month within the respective pandemic periods.

Table 2 Distribution of blood donors for each donation type

Groups	On-site blood donation		Off-site blood donation		Replacement donation		Single donor platelets donation	
	Units	%	Units	%	Units	%	Units	%
Before the outbreak	1,599	78.8	300	14.8	35	1.7	82	4.0
Wave 1	1,465	74.3	339	17.2	57	2.9	89	4.5
Wave 2	1,617	76.7	319	15.1	59	2.8	94	4.4
Waves 3&4	1,412	78.9	217	12.1	52	2.9	78	4.3
Wave5	1,404	73.9	196	10.3	135	7.1	98	5.1
After easing the measures	1,425	69.6	349	17.0	77	3.8	141	6.9
Means	1,487	74.5	287	14.4	69	3.5	97	4.7

donations demonstrated a descending trajectory but experienced a resurgence following the relaxation of measures (mean = 14.4%). The reduction in on-site blood donations was counteracted by a significant rise in donor participation at donation centers, facilitated by improved transportation accessibility (mean = 75.4%). Replacement donations witnessed an escalation during wave 5 (mean = 3.5%), while single donor platelet donations remained relatively stable (mean = 4.7%). When comparing the monthly average of red cell requests, red cell usage, and blood donors before the outbreak (24 months), during the outbreak (29 months), and after the

easing of measures (13 months) (Figure 2), no significant differences were observed in the number of blood donors ($p = 0.147$), similar to the amount of blood usage ($p = 0.508$), despite a significant decrease in the number of blood reservations during and after the outbreak ($p = 0.012$). Regarding platelet products, it was discovered that the use of single donor platelets (SDP) tended to increase (Figure 3). Furthermore, no significant differences were observed in the donations, requests, or usage of SDP before or during the outbreak; however, a significant difference was observed in comparison to the post-pandemic period ($p < 0.001$).

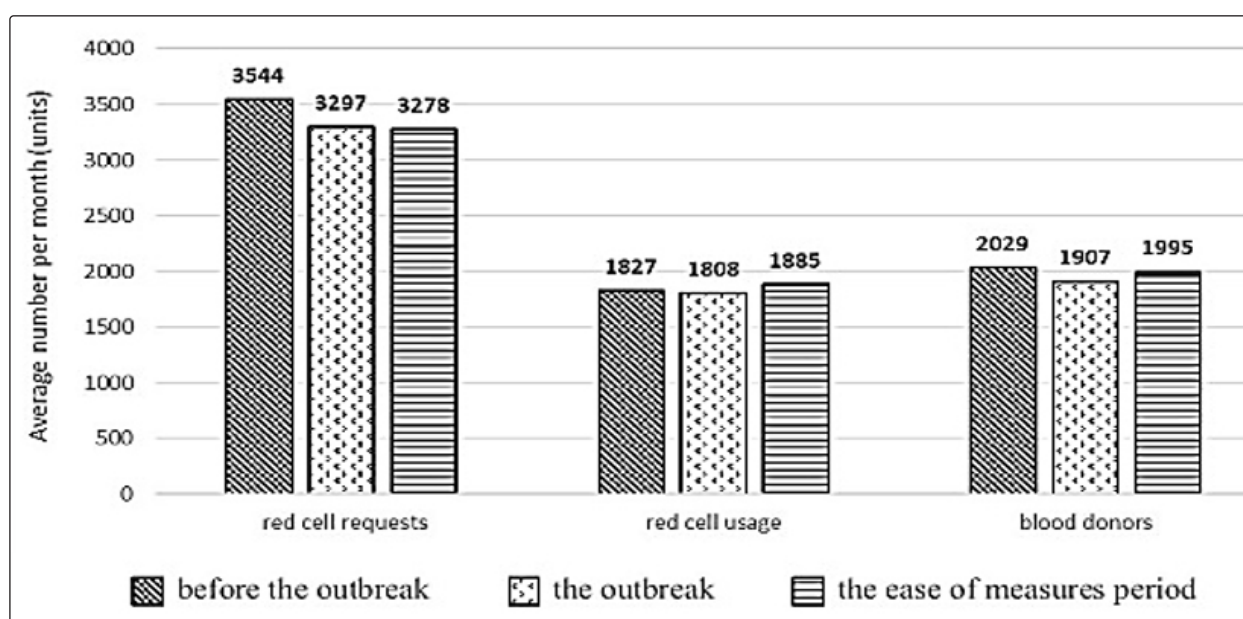


Figure 2 Mean counts of blood requests, blood utilization, and blood donors are outlined across three stages: pre-outbreak, outbreak, and post-measure relaxation

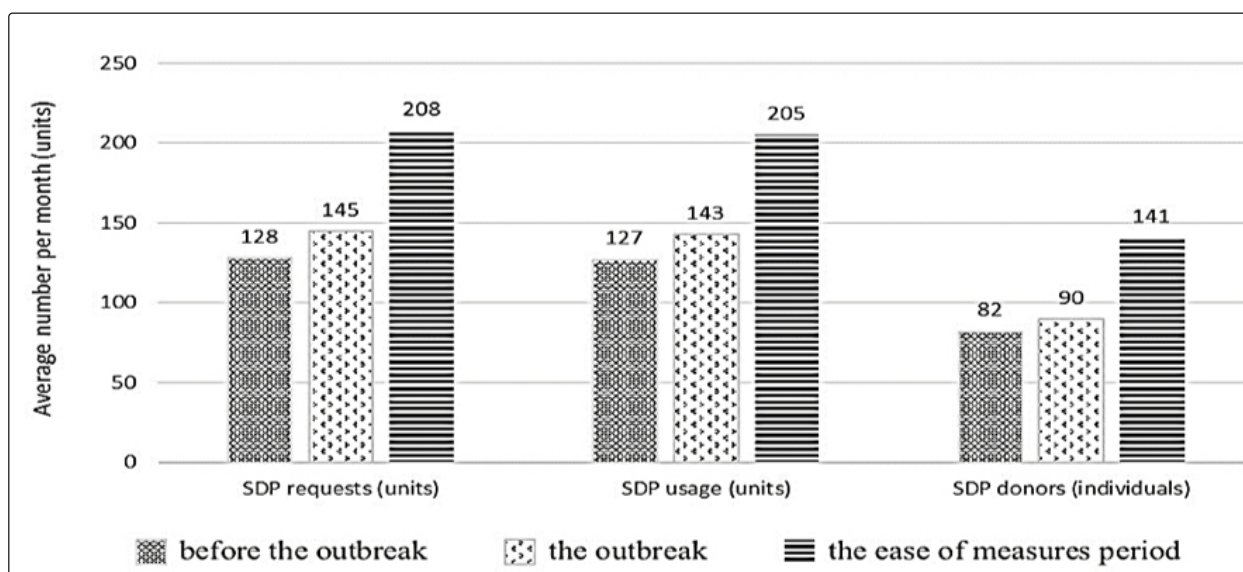


Figure 3 Utilization of SDP before the outbreak, during the outbreak, and after the relaxation of measures

Discussion

Due to the shortage of blood, the factors affecting the quantity of blood components were studied. Research was carried out in many countries to consider the impacts of the novel coronavirus outbreak in 2019. China reported that at the beginning of the outbreak, the number of whole-blood donors decreased by 67% compared with the normal level. Most donors expressed concerns about being infected if they went to donate blood.¹³ In India, the number of blood donors decreased, with the total blood and platelets 70% and 50% lower, respectively. During the lockdown period, the number of blood donors arriving at donation sites increased, while the demand of patients for blood decreased by approximately 50%, resulting in an imbalance with donations.¹⁴⁻¹⁵ A social science study in Australia focused on blood collection agencies (BCAs) and reported that the key factors in blood donation decisions were self-confidence and confidence in the blood donation organizations.¹⁶ These reports were from hospitals with blood banks having similar backgrounds to those in Thailand. A report from the NBC, TRCS mentioned that blood donation nationwide decreased by more than 50%,¹⁷ concurring with a study by Sripa, et al. Central Blood Bank, Faculty of Medicine, Khon Kaen University, which discovered that, as a result of blood donors' inability to donate, the percentage of non-remunerated donations dropped while the amount of compensated donations from family members increased.¹⁸ Lertpaisarnkul, et al. also conducted a blood management study at the Regional Blood Centre VIII, Nakhonsawan Province, Thai Red Cross Society in six provinces in the lower northern part of Thailand during the 2020 pandemic, which revealed that the Regional Blood Centre VIII, Nakhonsawan Province, Thai Red Cross Society showed a reduced blood supply of 66.45% compared with the normal situation.¹⁹

However, the situation in different regions varied depending on a number of factors, including the resources of the hospitals, the timing of the outbreak, and

the vaccination of medical staff and the public, which is the group of people who are willing to donate blood, causing the blood management to change. During the COVID-19 outbreak, blood donation decreased, resulting in a blood shortage and posing challenges in the management of blood for patients. Songklanagarind Hospital addressed these issues by monitoring blood stock, the amount of blood requested, and the daily blood usage. They adjusted their donation plans by implementing measures adapted from the national policy plan (Figure 1). For social distancing measures, the blood donation area was organized as an open space, with acrylic barriers between donors, and the donation area was cleaned after each donation. Bottled water was provided after donations, and equipment such as pillowcases and blankets were replaced on a one-by-one basis. Medical staff wore hygienic masks, face shields, and long gowns. Extra questions related to COVID-19 were added to the questionnaire, and the body temperature of the donors was recorded. Donors were asked to notify the blood bank immediately if they experienced any unusual symptoms or if COVID-19 was detected. Strict quarantine measures were followed for medical staff, and risk monitoring was conducted regularly. Vaccinations were made available to everyone to increase the confidence of blood donors.

The study found that blood requests significantly decreased during the outbreak and after the easing of measures because elective surgeries were postponed. While elective surgeries decreased, other patients continued to receive treatment as usual, resulting in no significant statistical difference in blood usage. As blood usage remained stable but the number of donors decreased, the blood reserves also tended to decrease. Therefore, in addition to boosting donor confidence, the blood bank launched various campaigns to attract new donors and provided convenient parking within the hospital. Furthermore, a drive-thru donation unit was established, and public broadcasts using various media such as radio, the LINE messaging app, Facebook, and announcements

were used to encourage hospital staff, students, and the general public to become regular donors. Shuttles were arranged to transport donors from different areas to the blood bank, following social distancing and DMHT guidelines, and blood donation hours were extended. Moreover, the examination of blood donor characteristics aims to gain a comprehensive understanding of donor profiles. This enhanced understanding can be utilized to refine blood donation processes and enhance donor satisfaction. These measures ensured a sufficient number of blood donors. There were no significant differences when comparing blood usage and the number of donors during each wave of the outbreak. However, after the easing of COVID-19 measures, the number of donors began to decrease, possibly due to some donors contracting COVID-19 and postponing their donations, as recommended by the NBC, TRCS. Nevertheless, the measures ensured that the hospital's blood reserves remained sufficient. In addition to red blood cells, the blood bank monitored other blood components, such as fresh frozen plasma (FFP) and platelets. FFP, which can be stored for up to two years, was not a management issue, but platelets, having a limited shelf life, required daily stock monitoring. Therefore, platelets needed to be obtained from single donor platelets (SDPs) to compensate the random platelets. The study found that SDP levels tended to increase due to the return of patients whose treatments were postponed, which required increasing SDP donations to two or three units for donors with high initial platelet counts.

In summary, during the pandemic, which reduced blood donations, daily stock checks of blood components were necessary. When the blood stock dropped below the safety level, the blood bank needed to boost donations through various methods mentioned above in order to ensure sufficient blood to meet the patient needs. These management models were adapted from the public health regulations at that time and based on the guidelines of the NBC, TRCS,²⁰ but were tailored to their specific situations. They were found to be effective as well.

Conclusion

Songklanagarind Hospital is a super tertiary hospital in southern Thailand that provides care for patients who require blood components. Data from this study identified the impacts of blood donation and the use of blood to treat patients during the COVID-19 outbreak. The number of patients at Songklanagarind Hospital before the outbreak and during the pandemic were similar, while the use of blood and blood components did not decrease. The management plan followed the guidelines of the NBC, TRCS and the WHO, resulted in sufficient blood available for patients. Blood bank staff can use these study results to improve the blood supply management in order to provide sufficient blood and blood components to the patients. Effective blood bank planning will ensure the beneficial readiness to combat future emerging diseases.

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References

1. World Health Organization Coronavirus (COVID-19) Dashboard [Internet]. [cited 2023 Jul 10]. Available from: <https://covid19.who.int>
2. Stanworth SJ, New HV, Apolseth TO, Brunskill S, Cardigan R, Doree C, et al. Effects of the COVID-19 pandemic on the supply and use of blood for transfusion. *Lancet Haematology*. 2020;7:e756-64. doi: 10.1016/S2352-3026(20)30186-1.
3. Tantrakarnapa K, Bhopdhornangkul B. Challenging the spread of COVID-19 in Thailand. *One Health*. 2020;11:100173. doi: 10.1016/j.onehlt.2020.100173.
4. Wiersinga WJ, Rhodes A, Cheng AC, Peacock SJ, Prescott HC. Pathophysiology, transmission, diagnosis, and treatment of coronavirus disease 2019 (COVID-19): A Review. *JAMA*. 2020;324:782.
5. Ngo A, Masel D, Cahill C, Blumberg N, Refaai MA. Blood banking and transfusion medicine challenges during the COVID-19 pandemic. *Clinics in Laboratory Medicine*. 2020;40:587-601.

6. Ministry of Public Health of Thailand. *Strategy: Managing the new wave of the Covid-19 pandemic* [Internet]. 2021 [cited 2022 Dec 17]. Available from: <https://ddc.moph.go.th/viralpneumonia/eng/index.php>
7. Cohn CS, Delaney M, Johnson ST, Katz LM. *Technical manual*. 20th ed. Bethesda, M.D.: American Association of Blood Banks; 2020.
8. World Health Organization. *WHO Interim Guidance. Maintaining a safe and adequate blood supply and collecting convalescent plasma in the context of the COVID-19 pandemic interim guidance*. Geneva: 2021. [cited 2022 Jul 3]. Available from: <https://who.int/iris/bitstream/handle/10665/339793/WHO-2019-nCoV-BloodSupply-2021.1-eng.pdf?sequence=1>
9. Grech V. *WASP (Write a Scientific Paper) using Excel 9: Analysis of variance*. *Early Human Development*. 2018;121:62-4.
10. Triukose S, Nitinawarat S, Satian P, Somboonsavatdee A, Chotikarn P, Thammasanya T, et al. *Effects of public health interventions on the epidemiological spread during the first wave of the COVID-19 outbreak in Thailand*. *PLoS ONE*. 2021;16:e0246274. doi: 10.1371/journal.pone.0246274.
11. *The situation report on COVID19 from WHO Thailand* [Internet]. [cited 2022 Dec 31]. Available from: <https://www.who.int/thailand/news/detail/05-07-2023-the-situation-report-on-covid19>
12. Zewdie K, Genetu A, Mekonnen Y, Worku T, Sahlu A, Gulilalt D. *Efficiency of blood utilization in elective surgical patients*. *BMC Health Serv Res*. 2019;19:804.
13. Wang Y, Han W, Pan L, Wang C, Liu Y, Hu W, et al. *Impact of COVID-19 on blood centres in Zhejiang province China*. *Vox Sang*. 2020;115:502-6.
14. Bharat S, Rahul K, Indraneel D, Anubha S, Atul P, Preeti E, et al. *Impact of COVID-19 pandemic on the pattern of blood donation and blood safety: Experience from a hospital-based blood center in North India*. *Asian J Transfus Sci*. 2021;15:119-24.
15. Pandey HC, Coshic P, C S C, Arcot PJ, Kumar K. *Blood supply management in times of SARS-CoV-2 pandemic - challenges, strategies adopted, and the lessons learned from the experience of a hospital-based blood centre*. *Vox Sang*. 2021;116:497-503.
16. Masser, BM, Hyde, MK, Ferguson, E. *Exploring predictors of Australian community members' blood donation intentions and blood donation-related behavior during the COVID-19 pandemic*. *Transfusion*. 2020;60:2907-17.
17. Thai Red Cross Society. *Impact of COVID-19 pandemic on blood donation* [Internet]. 2021 [cited 2023 May 28]. Available from: <https://english.redcross.or.th/>
18. Sripara P, Boonmawongsa N, Benjangkprasert B, Thanukarn T, Phumiyot N, Jenwitheesuk K. *Impact of COVID-19 pandemic on blood donation in blood transfusion center, Faculty of Medicine, Khon Kaen University*. *SRIMEDJ*. 2023;38:104-11
19. Lertpaisankul S, Phomsila R, Thipsuwankul W, Phetsree N, Rod-wihokand T, Tadsomboon S. *Model of blood recruitment and impact of blood management of the six lower-northern provinces during the COVID-19 pandemic in 2020*. *J Hematol Transfus Med*. 2021;31:35-45.
20. Kupatawintu P. *The COVID-19 pandemic and the national blood service*. *J Hematol Transfus Med*. 2020;32:3-4.

