

ORIGINAL ARTICLE

Blood Transfusions per Hospitalization in the Local Public Health Network of Belo Horizonte Between 2008 and 2021: A Time Series Analysis

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Highlights:

1. A decrease in blood transfusions rate was observed at three hospitals.
2. All series were non-stationary with a trend and seasonality component present.
3. Packed red blood cells were the most commonly used blood component at three hospitals

ABSTRACT

Background: Blood transfusion rates are increasing worldwide. This work was a longitudinal retrospective study conducted with data referent to the use of blood components between January 2008 and December 2021 in the local public health network of Belo Horizonte, Minas Gerais, at Hospital Risoleta Tolentino Neves (HRTN), Hospital Metropolitano Dr. Célio de Castro (HMDCC), and Hospital Metropolitano Odilon Behrens (HMOB). Objective: This study sought to describe the time series of the number of blood transfusions and blood transfusion rates per general hospitalization through a time series analysis. Methods: Through data from the Hospital Information System of the Unified Health System (HIS-SUS), this study formulated six monthly time series of the number of blood transfusions and blood transfusion rates per hospitalization. The stationarity, trend, and seasonality of the time series were verified by the unit root test, using the Mann-Kendall and the Fisher tests, respectively. The normality hypothesis of the data was verified by the Shapiro-Wilk test. All of the statistical tests considered a significance level of 5%. Results: The average monthly blood transfusion rates per hospitalization observed in this study were 45.5%, 26.9%, and 26.3% at HRTN, HMDCC, and HMOB, respectively. The highest decrease in the number of blood transfusions was observed at HMDCC and the highest decrease in blood transfusion rates was observed at HRTN. Packed red blood cells were the most commonly used blood component at HRTN, HMOB, and HMDCC (54.6%, 58.3%, and 65.4%, respectively). The time series showed that they were non-stationary, with a downward trend and the presence of a 12-month seasonal component. Conclusion: The decline in the number of blood transfusions should be considered a positive phenomenon in public health due to best use and quality management, since a decrease in blood donation rates was also observed.

Keywords (MeSH terms): blood; blood transfusion; transfusion.

Keywords: blood components; time series, hospitalization.

TRANSFUSÕES DE HEMOCOMPONENTES POR INTERNAÇÃO HOSPITALAR NA REDE PÚBLICA MUNICIPAL DE BELO HORIZONTE ENTRE 2008 E 2021: UMA ANÁLISE DE SÉRIE TEMPORAL

RESUMO

As taxas de transfusões de sangue aumentam em todo o mundo. Este trabalho é um estudo retrospectivo longitudinal com dados referentes ao uso de hemocomponentes entre janeiro de 2008 e dezembro de 2021 na rede hospitalar pública do município de Belo Horizonte, Minas Gerais: HRTN – Hospital Risoleta Tolentino Neves, HMDCC – Hospital Metropolitano Dr. Célio de Castro e HMOB – Hospital Metropolitano Odilon Behrens. **Objetivos:** Descrever as séries mensais do número de transfusões de hemocomponentes e a taxa de transfusão por internação em internações gerais sob a perspectiva da análise de séries temporais. **Métodos:** A partir de dados do Sistema de Informação Hospitalar do SUS (SIH-SUS) foram criadas seis séries temporais, de periodicidade mensal, do número de transfusões de hemocomponentes e da taxa de transfusão por internação. A estacionariedade, a tendência e a sazonalidade das séries foram verificadas pelo teste de raiz unitária, pelo teste de Mann-Kendall e pelo teste de Fisher, respectivamente. A hipótese de normalidade dos dados foi verificada pelo teste de Shapiro-Wilk. Todos os testes estatísticos utilizaram o nível de significância de 5%. **Resultados:** A taxa média mensal de uso de hemocomponentes por internação hospitalar observada foi de 45,5%, 26,9% e 26,3% no HRTN, HMDCC e HMOB, respectivamente. A maior redução do número de transfusões de hemocomponentes foi observada no HMDCC e a maior redução da taxa de uso de hemocomponentes foi observada no HRTN. O concentrado de hemácias foi o hemocomponente mais utilizado no HRTN, HMOB e HMDCC (54,6%, 58,3% e 65,4%, respectivamente). Todas as séries apresentaram-se não estacionárias, com tendência de queda e presença do componente sazonal com periodicidade de 12 meses. **Conclusão:** A redução do número de transfusões deve ser considerada um fenômeno positivo no que se refere à Saúde Pública pela melhor gestão da utilização e qualidade, pois observa-se redução das taxas de doação de sangue.

Palavras-chave (MeSH): sangue; transfusão de sangue; transfusão.

Palavras-chave: hemocomponente; série temporal; internação.

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INTRODUCTION

The Brazilian Ministry of Health defined the use of blood components as expensive¹. Hospital expenses related to the use of blood components is estimated to be around 5% to 9%^{2,3}. The purchase of blood components or transfers of resources to blood banks are associated with the direct costs of blood component transfusions. In turn, the material used for administration, storage, equipment, structure and transport, human resources, adverse reactions, a longer associated hospitalization time, and compatibility and tracking tests are related to the indirect costs of blood transfusions⁴.

The risks associated with the use of blood components and the occurrence of population aging, which raises blood transfusion rates and reduces blood donation rates, also increased blood transfusion costs⁵⁻⁷. Likewise, the increase in the elderly population contributes to the increase in blood transfusion rates. This phenomenon has been observed both in Brazil and around the world⁶. Therefore, the increase in expenses related to blood transfusions can be explained simultaneously by the increase in blood transfusion rates and the increase in the number of procedures performed in order to ensure blood transfusion safety, to conduct hemovigilance, and to alleviate side effects related to blood transfusions, as they are not risk-free⁵⁻⁷.

There are a number of studies with the profile of hospital patients who underwent blood transfusions, their sociodemographic characteristics, and the type of blood component used. However, there are few studies about the use of blood components in the hospital environment from the viewpoint of a time series and which enable the identification of critical points to be faced by health managers as a trend in blood transfusion rates and the presence of seasonality⁷.

In this sense, the present study sought to describe the use of blood components in three hospitals of the local public hospital network of Belo Horizonte, using the data referent to the period from January 2008 to December 2021, retrieved from the Hospital Information System of the Unified Health System (HIS-SUS)⁸⁻¹⁰.

MATERIALS AND METHODS

A longitudinal retrospective study was conducted with data regarding the use of blood components and hospitalizations from January 1, 2008 to December 31, 2021, in the local public hospital network of Belo Horizonte, Minas Gerais, Brazil, consisting of three medium and high complexity hospitals: Hospital Risoleta Tolentino Neves (HRTN), Hospital Metropolitano Odilon Behrens (HMOB), and Hospital Metropolitano Dr. Célio de Castro (HMDCC).

The choice of this period was due to the fact that key data was identified in the HIS-SUS as of 2008 for HRTN and HMOB. HMDCC, inaugurated in December 2015, reached its maximum capacity only in December 2017; therefore, data were only collected from this hospital as of 2018.

For each studied hospital, two monthly time series were set up with data referent to the use of blood components: one time series referent to the number of transfusions and another referent to the blood transfusion rate per hospitalization. The HRTN and the HMOB time series consisted of 168 observations, while the HMDCC time series consisted of 48 observations.

Data collection related to blood transfusions was conducted on May 6, 2022, at HIS-SUS during the period of 2008 to 2021^{9,10}. Data were also collected referent to the approved quantities from the following procedures per medical care center: 0306020050; 0306020068; 0306020076; 0306020084; 0306020092; 0306020106; 0306020114; 0306020122; and 0306020149. The choice of these procedures is in accordance with that established by the Brazilian Ministry of Health for blood transfusion procedures¹¹⁻¹⁴.

The data used in this work are public and freely accessible to anyone and were extracted from the Hospital Information System of the Brazilian Unified Health System, which provides secondary data on hospital production of public and private services contracted in Brazil¹⁰. The collection of data used in this study can be replicated by accessing the TabNet DataSUS website of the Brazilian Ministry of Health, in the Hospital Production in Health Care tab⁹. Since this study's data were extracted from public information systems, they are considered to be secondary data¹⁰, and according to Resolution 466 of 2012, set forth by the National Health Council, and to the Brazilian General Data Protection Law 13,709 of 2018, it was not necessary to submit this study to a Research Ethics Committee.

Statistical analysis.

The average, standard deviation, and percentage of contribution of each procedure regarding blood transfusions were calculated, as were the average and the standard deviation of the approved hospital admission orders (AIH, in Portuguese) and of the blood transfusion rates per hospitalization. The statistical analysis of the time series was carried out according to the additive model with the components of trend, seasonality, and randomness¹⁵. The Kwiatkowski-Phillips-Schmidt-Shin (KPSS)¹⁶ unit test was used to test the null hypothesis that the time series was stationary. For all of the time series considered to be non-stationary in the first test, a second unit root test was performed, after the process of first-order differentiation, in an attempt to confirm the stationarity of the series after this process.

To identify the presence of the trend component, the Mann-Kendall test¹⁷ was used to test the null hypothesis to prove that the trend does not exist. To identify the presence of the component of seasonality, the Fisher test was used¹⁵, which tests the null hypothesis in order to prove that seasonality does not exist. The data normality hypothesis was verified using the Shapiro-Wilk test.¹⁸ The Mann-Kendall, Fischer, and Shapiro-Wilk tests were applied to the raw data from each time series, that is, excluding the first-order differentiation process. The statistical analyses were performed by means of the R statistics program, version 3.5.3, using the *urca*, *forecast*, *LSTS*, *stats*, *trend*, and *tseries* packages. All of the hypothesis tests used a significance level of 5%.

RESULTS

The descriptive statistics of the number of blood transfusion procedures and of AIH, as well as the blood transfusion rates per hospitalization, are presented in Table 1. Although a fewer hospitalizations were found between 2008 and 2021 regarding HMOB, HRTN presented the highest monthly average of transfusions per hospitalization (in 45.5% of the hospitalizations, blood transfusion procedures were performed), followed by HMDCC and HMOB (26.9% and 26.3%, respectively). The transfusion of packed red blood cells was the most commonly performed procedure (more than half of the procedures in the three hospitals), followed by fresh plasma transfusions and packed platelet transfusions.

Table 1 – Frequency of blood transfusion procedures, number of hospital admission orders, and blood transfusion rates per hospitalization per hospital of the local public health network of Belo Horizonte from 2008 to 2021

	HRTN			HMOB			HMDCC*		
	n	%	Monthly Average (SD)	n	%	Monthly Average (SD)	n	%	Monthly Average (SD)
AIH	25,6081	-	1,524 (68.5)	315,550	-	1,878 (281.9)	78,616	-	1,464 (150.6)
Transfusion	114,560	100	681.9 (145)	80,903	100	481.6 (100.1)	18,713	100	389.9 (81.5)
CH	62,502	54.6	372 (57)	47,147	58.3	280.6 (50.7)	12,233	65.4	254.9 (40.5)
PF	26,951	23.5	160.4 (50.4)	17,680	21.9	105.2 (37)	4,571	24.4	95.2 (35.7)
CP	17,300	15.1	103 (66)	13,170	16.3	78.4 (42)	1,490	8.0	31 (24.4)
C	7,080	6.18	42.9 (28.2)	2,145	2.65	16.8 (12.6)	411	2.2	10.8 (6.2)
CI	661	0.58	10.5 (6.2)	752	0.93	13.7 (10.6)	-	-	-
PIC	49	0.04	16.3 (12.5)	-	-	-	-	-	-
PA	17	0.01	2.8 (3.2)	-	-	-	8	0.04	2 (1)
UST	-	-	-	9	0.01	1.3 (0.5)	-	-	-
TTI	-	-	45.5 (11.6)	-	-	26.3 (7.46)	-	-	26.9 (6.6)

*Data related to the period between 2018 and 2021. AIH = Approved Hospital Admissions Orders; CH = Packed Red Blood Cells; PF = Fresh Plasma; CP = Packed Platelets; C = Cryoprecipitates; CI = Irradiated components; PIC = Plasma Free of Cryoprecipitates; PA = Apheresis Platelets; UST = Total Blood Unit; TTI = Rate of Transfusion per Hospitalization.

Data source: HIS-SUS.

Between 2008 and 2021, the change in the proportion of the use of packed red blood cells (from 51% to 62.2%), fresh plasma (from 22.8% to 25.5%), and packed platelets (from 22.84% to 3.5%) was identified at HRTN, and packed red blood cells (from 64.1% to 56.7%), fresh plasma (from 21.4% to 20%), and packed platelets (from 14% to 13.9%) at HMOB. At HMDCC, we observed changes in the proportion of packed red blood cells (from 62.5% to 75.4%), fresh plasma (from 25% to 19%), and packed platelets (from 11.1% to 3.7%) during the period of 2018 to 2021.

Figure 1 presents the time series of blood transfusions of the three studied hospitals between January 2008 and December 2021. In absolute terms, HMDCC presented the most expressive reduction in the monthly number of blood transfusions during the period (from 454 in 2018 to 303 in 2021), followed by HRTN (from 694 in 2008 to 560 in 2021) and HMOB (from 552 in 2008 to 428 in 2021). HMDCC also presented the highest reduction in the monthly number of blood transfusions during the observed period in relative terms (33.3%), followed by HMOB and HRTN (reduction of 22.5% and 19.3%, respectively).

Peaks were observed in the months of March 2008, August 2010, April 2012, March 2016, July 2019, and December 2020 at HRTN, with these first three points being outside the curve and the last four points being far from the curve. These spikes can be explained by the abrupt increase in demand during these months at the hospital, by the randomness of the data, or by an inconsistency in the release of information on procedures carried out in the HIS. It is recommended that future studies should more accurately analyze these peaks in order to elucidate the reasons that led to them.

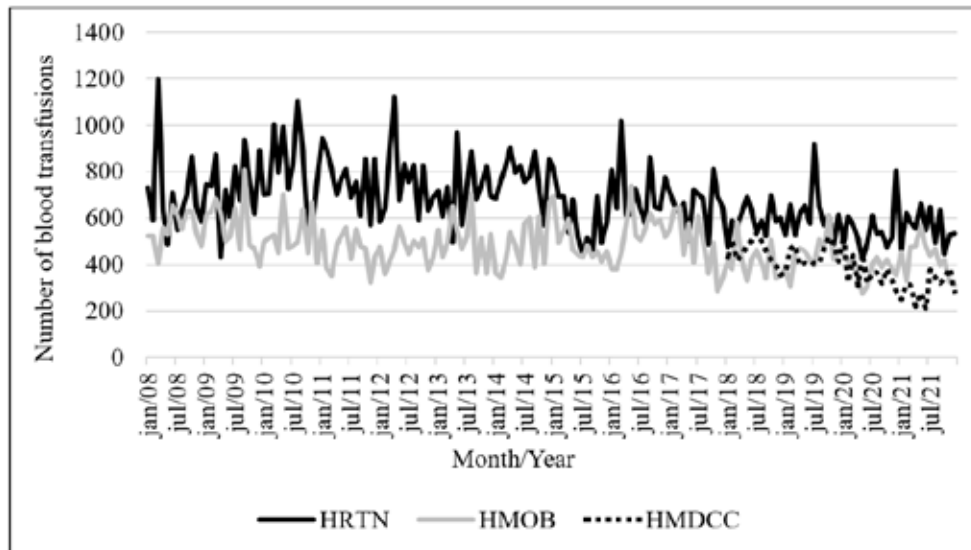


Figure 1 – Number of blood transfusions in the local public hospital network of Belo Horizonte between 2008 and 2021. HRTN: Hospital Risoleta Tolentino Neves; HMOB: Hospital Metropolitano Odilon Behrens; HMDCC: Hospital Metropolitano Dr. Célio de Castro

As regards the three last years of the series (between 2019 and 2021), we observed a behavior similar to a decline, followed by a peak in the monthly number of blood transfusions at HRTN and HMOB. By contrast, a constant downward trend was observed at HMDCC.

Figure 2 presents the time series of blood transfusion rates per hospitalization of the three studied hospitals between January 2008 and December 2021. HRTN presented the most significant decrease in blood transfusion rates per hospitalization during the period when observed in absolute terms (50.6% in 2008 to 30.7% in 2021), followed by HMDCC (from 34.1% in 2018 to 20.6% in 2021) and HMOB (from 38.7% in 2008 to 26% in 2021). By contrast, HMDCC showed a relatively high decrease in blood transfusion rates per hospitalization (39.6), followed by HRTN and HMOB (decrease of 39.3% and 32.8%, respectively).

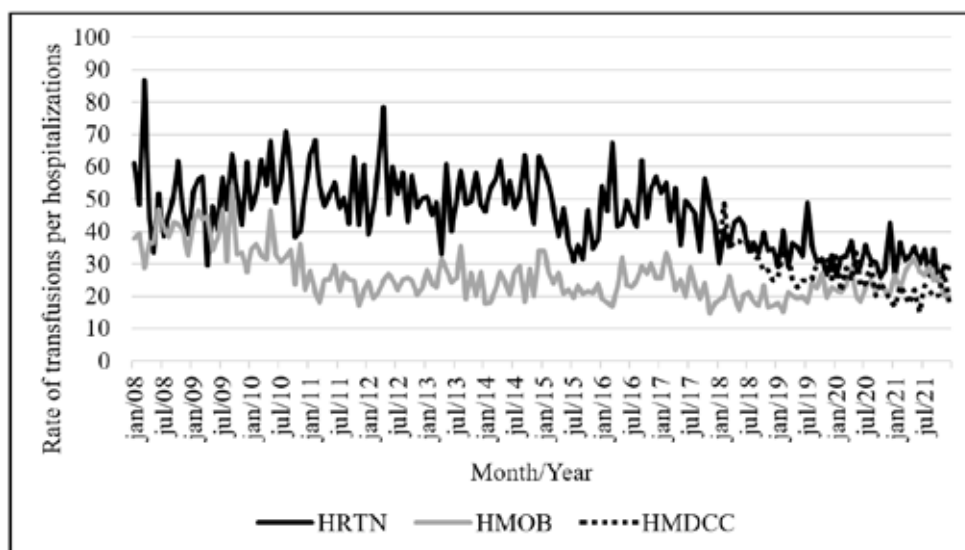


Figure 2 – Blood transfusion rates of per hospitalization in the local public hospital network of Belo Horizonte between 2008 and 2021. HRTN: Hospital Risoleta Tolentino Neves; HMOB: Hospital Metropolitano Odilon Behrens; HMDCC: Hospital Metropolitano Dr. Célio de Castro

As regards the last three years of the series (2019-2021), we observed a downward trend in the average monthly rate of blood transfusions per hospitalization at HRTN and HMDCC. By contrast, an upward trend was observed at HMOB.

The results of the stationarity, data normality, trend, and seasonality tests are presented in Table 2. All of the time series proved to be non-stationary (p -value < 0.05), with stationary periods, and all required a process of differentiation for their transformation into a stationary series. The components of trend and seasonality were present in all of the series.

Table 2 – Results of the stationarity and normality tests, together with the components of trend and seasonality, for the time series of blood transfusion rates per hospitalization in the three studied hospitals

Series	Hospital	Unit Root Test (KPSS)* p-value		Shapiro-Wilk Test** p-value	Mann-Kendall Test***	Fisher Test**** p-value
		Raw data	After first-order differentiation			
Number of Transfusions	HRTN	$p < 0.05$	$p > 0.05$	$p < 0.001$	$p < 0.001$	$p < 0.001$
	HMOB	$p < 0.05$	$p > 0.05$	$p = 0.046$	$p < 0.001$	$p < 0.001$
	HMDCC	$p < 0.05$	$p > 0.05$	$p = 0.623$	$p < 0.001$	$p < 0.001$
Rate of Transfusions	HRTN	$p < 0.05$	$p > 0.05$	$p = 0.006$	$p < 0.001$	$p < 0.001$
	HMOB	$p < 0.05$	$p > 0.05$	$p < 0.001$	$p < 0.001$	$p < 0.001$
	HMDCC	$p < 0.05$	$p > 0.05$	$p = 0.077$	$p < 0.001$	$p = 0.0107$

*Series is considered non-stationary if the p-value of the statistics test < 0.05 (critical value = 0.463) ; **Series does not present a normal distribution if the p-value < 0.05 ; ***Trend is present if the p-value < 0.05 ****Seasonality is present if the p-value < 0.05 .

Source: Drafted by the author.

The time series of blood transfusions and the blood transfusion rates at HMDCC were not considered to be distributed according to the normal probability model. Using the central limit theorem, the trend and seasonality tests were performed using raw data, since the number of observations found in the series was above 20. According to the results obtained through the statistics tests, all of the time series were influenced by trend and seasonality components in their composition.

The components of trend and seasonality of the time series, not including the number of blood transfusions and blood transfusion rates per hospitalization, are presented in Figure 3. Among the results found for the trend component, what stands out is the downward trend in the time series of blood transfusions and in the time series of blood transfusion rates per hospitalization in the three studied hospitals. In the time series of blood transfusions, what stands out is the partial upward trend between 2008 and 2010, an abrupt peak in 2016, and a partial sharp decline in 2015 and 2020 at HRTN. Regarding HMOB, a partial yet constant downward trend was observed in 2017 and 2019. Finally, there was a partial stable trend between 2018 and 2019, followed by a sharp decline in 2020 and 2021 at HMDCC. In the time series of blood transfusion rates per hospitalization, what stands out is the upward trend between 2008 and 2010, stability between 2011 and 2014, a sharp decline in 2015, an increase in 2016, followed by a constant decline between 2017 and 2021 at HRTN; a partial downward trend was observed between 2009 and 2011, stability between 2012 and 2017, followed by an upward trend between 2018 and 2021 at HMOB; and a partial sharp decline between 2020 and 2021 at HMDCC.

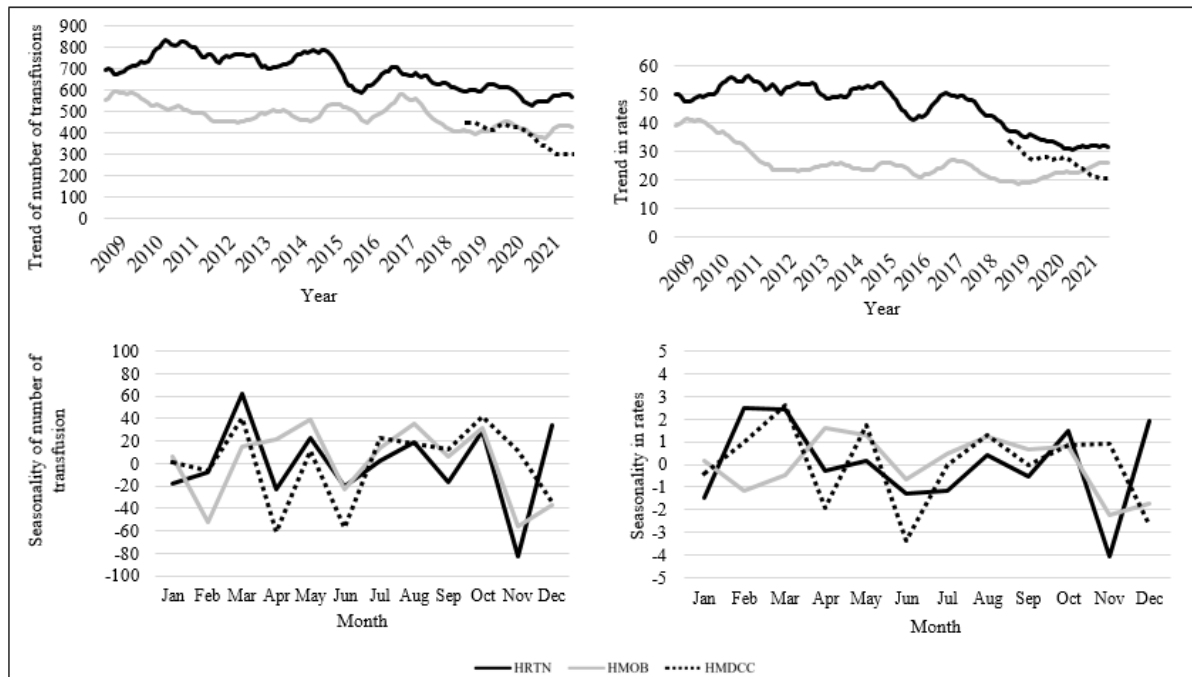


Figure 3 – Components of trend and seasonality of the time series of blood transfusions and blood transfusion rates per hospitalization between 2008 and 2021. HRTN: Hospital Risoleta Tolentino Neves; HMOB: Hospital Metropolitano Odilon Behrens; HMDCC: Hospital Metropolitano Dr. Célio de Castro

Among the results found for the component of seasonality in the series of blood transfusions, what stood out was a 12-month seasonality with a peak in March and a low point in November for HRTN; low points in February, June, November, and December for HMOB; and peaks in March and May and low points in April, June, and December for HMDCC. As regards the time series of blood transfusion rates per hospitalization, we found a 12-month seasonality with peaks in February, March, and December and a low point in November for HRTN; a peak in April and low points in November and December for HMOB; and a peak in February and low points in April, June, and December for HMDCC.

DISCUSSION

The present study showed that packed red blood cells were the blood component most frequently used in transfusions in the three hospitals, in accordance with national literature¹¹⁻¹⁴. Considering the other blood components, the second and third most commonly used were fresh plasma and packed platelets, diverging from national literature^{11-14,19,20}, in which packed platelets and fresh plasma were the second and third most used blood components, respectively. By contrast, the proportional decrease in the use of packed platelets, found in the three hospitals, is not in line with the results from the study by Jordan et al., who found an increase in the use of packed platelets²¹.

The decrease in the transfusion of packed platelets may be related to changes due to billing and to the kind of product associated with this type of procedure. The Hemominas Foundation gradually substituted the supply of random platelets for a pool of platelets and plateletpheresis, which usually corresponds to five/six units of random platelets. The data obtained by HIS-SUS makes it impossible to conclude if the billing presented by HIS-SUS corresponds to the reality in terms of the real billing performed by the hospitals.

The blood transfusion rates observed at HRTN, HMDCC, and HMOB (45.5%, 26.9%, and 26.3%, respectively) are close to the rates observed in national and international studies. Bastos et al.¹⁹ found a blood transfusion rate per hospitalization of 35.9%, while Mafirakureva et al.²² found a 48.1% estimate for this rate. Oliveira's study found rates of 22% and 38.9% in the two private hospitals analyzed in Belo Horizonte²³. Warner et al. found a 40.5% rate in a hospital network²⁴.

The comparison with Oliveira's study²³ would indicate the need for the local public hospital network of Belo Horizonte to adjust to the reality of public health in Brazil, in which blood components are considered to be scarce inputs, associated with high costs and risks, especially at HRTN, which showed a blood transfusion rate per hospitalization that was significantly higher than the two other hospitals and similar to rates observed in intensive care units^{25,26}. On the other hand, the variation in blood transfusion rates per hospitalization was approximately 20% between 2011 and 2019 at HMOB, while in 2021, at HMDCC, it was below that observed in the literature, which defines rates between 20% and 50%^{19,20,22-24}. Those rates must be undergo a more in-depth study, especially in comparison to the medical care profile and the demand profile of the hospitalized patients, so that they can be used as a reference indicators to evaluate excess or reduction in the three studied hospitals.

The downward trend in the blood transfusion rates per hospitalization goes against what is observed in the literature, which indicates an increase in blood transfusions^{7,20,21}, and against the results from a similar study conducted in a network of private hospitals in Belo Horizonte, which identified an upward trend in all of the hospitals analyzed in the study²³.

The trend curves of the time series of blood transfusion rates per hospitalization are similar to the trend curves of blood transfusions in general, suggesting that hospitalization has a minimal influence on the variable in the trend component in relation to the behavior of the time series. The downward trend in the number of blood transfusions and in blood transfusion rates observed in the three hospitals can be considered as a positive result of the activities developed and the criteria/routines established in the hospitals and in the city of Belo Horizonte, which seek to reduce the total number of blood transfusions²³.

Such a reduction can be intensified in the three hospitals with the adoption of more restrictive criteria towards the blood transfusions, such as the introduction of Programs for the Management of Patient Blood (PBM, in Portuguese) and the dissemination of information regarding the importance of reducing the use of blood components by healthcare services^{5,6,24,27}.

By contrast, the decline in the number of blood transfusions performed in the three hospitals in 2020 and the drop in blood transfusion rates per hospitalization observed at HRTN and HMDCC in 2020 can be explained by the Covid-19 pandemic, which changed the care profile in the three hospitals. However, over the course of the pandemic, the hospitalizations for Covid-19 treatment were associated with the use of blood components, especially in the most serious cases, in which the patients might develop anemia, severe hemorrhage, coagulopathies, thrombosis, and septic shock²⁰. Therefore, even though an increase may have been observed in the three hospitals in 2020, the decrease in blood transfusion rates, in comparison to previous years, differs from what was expected in the current study and should be analyzed in future studies. In this sense, the declines observed in our study can be explained by a possible lack of supply of blood components, especially in the most acute phase of the pandemic; by the low proportion of serious disease cases among the hospitalized patients; and by the decrease in elective surgeries that require blood transfusions. In this light, the differences observed between HRTN and the other two hospitals may be related to the fact that the hospital does not conduct elective surgeries, only urgent and emergency surgeries, and that, since the hospital is an emergency hospital with a large number of patients from the northern region of Belo Horizonte, it did not show a decline in the volume of surgeries.

The significant decrease in the average number of blood transfusions per hospitalization in 2015 at HRTN may be related to a change in the management processes of the hospital's blood bank, which began to be managed directly by the Hemominas Foundation in October 2014.

The plausible justification for the difference observed in the three hospitals during the last three years of the time series may be explained by the care models provided by the three hospitals analyzed in this study. HRTN and HMOB are hospitals with open doors in terms of patient care, whereas HMDCC is defined as a backup hospital, receiving patients from other hospitals and primary care units. Moreover, HMDCC does not offer emergency care services and thus provides an admission profile that is different from those in the other two hospitals. By contrast, the blood transfusion agency from HMOB also takes care of a primary care unit (UPA) next to the hospital, which differentiates it from the other two hospitals in terms of hospitalization profile and hospitalization accounting, since some patients submitted to blood transfusions at HMOB have authorizations for hospitalization associated with the UPA and not with HMOB and their hospital billing procedures. In this sense, the different care model may justify the differences observed in the monthly number of transfusions per hospitalization when comparing HRTN/HMDCC and HMOB.

The 12-month seasonality observed in the time series of blood transfusions per hospitalization is similar to what was found in Oliveira's study²², which also observed a 12-month seasonality for blood transfusions rates per hospitalization. Unlike the trend component, seasonality is altered by the addition of the hospitalization variable. In the time series of blood transfusions, the peaks were observed in the months of March, May, and October, while in the series of blood transfusions, peaks were observed in February, March, October, and December. The peak observed for the months of October are in line with findings from Oliveira²³, who also identified a peak in October²³. By contrast, the peaks found for the three hospitals in reference to the time series of blood transfusions and blood transfusion rates per hospitalization differ from what is commonly mentioned in the media, which indicates that June and January are the months with the highest increases in the number of blood transfusions due to the vacation periods.

The differences in the average number of blood transfusions per hospitalization observed at HRTN, HMOB, and HMDCC may also be explained by the type of care offered to the population and by their location in the city. Hospital blood transfusions are associated with trauma procedures, surgeries, and anemia treatment. HMOB is located in the center of Belo Horizonte, and provides care together with other medium and large hospitals, run by the state, by the federal government, and by philanthropic hospitals. In this sense, the demand for that type of care is naturally smaller at HMOB in relation to the demand for care at HRTN, which is located in the northern regions of the city and is characterized as the main reference in the region. It is important to mention that the same phenomenon cannot be attributed to HMDCC during the period of this study. Therefore, studies regarding this theme related to the three hospitals must consider the nature of the hospitalization, the blood transfusion rates related to the hospitalization services, and the quantity and kinds of blood components provided to each patient.

The management model at HMDCC (public-private partnership) is different from the management model at HRTN and HMOB (public hospitals)⁸. However, this study found no significant differences among the hospitals that could be explained by different management models. In this sense, it is necessary to observe the time series of blood transfusion rates at HMDCC for a longer period of time in order to identify possible differences related to the management models.

It was not possible to identify the number of patients who received blood transfusions nor the quantity of blood transfusions per patient in the data provided by HIS-SUS. Given the reality observed for blood transfusions, there may well have been patients who received blood transfusions of two or more blood components. Therefore, the results found in this study indicate the need, in future

studies, to investigate blood transfusion rates per hospitalization in a manner that is more closely linked to reality, in which the information regarding blood transfusions and hospitalizations can be obtained directly from the hospitals. Therefore, the blood transfusion rates per hospitalization will have, as a numerator and a denominator, the quantity of patients who received blood transfusions and the number of patients hospitalized during the same period, respectively. Moreover, we also suggest that future studies of this nature analyze the hospital complexes in an individualized manner, given the specificities observed in this study related to the providing and management of services, demand profiles, the proportion of emergency care versus elective procedures, infrastructure, location, and hospitalization billing and accounting, all of which may have contributed directly to the discrepancy among the hospitals in terms of the results found in this study.

CONCLUSION

The time series analysis showed a significant decrease in the number of blood transfusions during the period of study, which also had their dynamics affected by the Covid-19 pandemic. This fact should be seen as a positive event in terms of public health, since a decrease in blood donations rates was also observed.

Factors, such as management models, the proportion of urgent versus elective procedures, the providing of services, and other specificities by each hospital may have contributed to the discrepancies observed among the hospitals. Therefore, the current study indicates the need for new studies in each hospital unit, with data collected directly from the hospitals, which will contribute to a better understanding of the use of blood components in the local public hospital network of the city of Belo Horizonte.

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