Original Article

Effect of the COVID-19 Pandemic on Blood Donations and Transfusions in Nigeria – A Multi-Facility Study of 34 Tertiary Hospitals

A Oreh[1], T Bozegha[1,2,3,4], A Ihimekpen[1], F Biyama[1], C Irechukwu[1], S Aliu[1], D Oshiame[1], A Nnabuihe[1], A Ndanitsa[1], O Nnachi[5], A Ogbenna[6], S Abubakar[7], F Olupitan[8], A Akinkunmi[9], C Ogunlade[10], T Abayomi[11], U Omokaro[12], C Sylvester[1,13], U Igiebor[14], B Wokoma[1,15], S Ebophni[16], B Adewuyi[17], R Dachi[18], H Muhammad[19], M Abubakar[20], J Mgbang[1,21,22,23], A Chineke[24], O Ogbuabor[24], G Fakai[1,25,26], B Hashim[27], N Adeluwoye[1,28], D Olanrewaju[29,30], E Agahiu[31], E Etim[32], S Alabi[33], I Akinbola[34], C Anibueze[35], O Awogbami[1,36], G Edowhorhu[28], T Adekoya-Benson[36], S Bello[1,36], Y Ojuade[2], O Amedu[1]

[1]National Blood Service Commission, [2]National Hospital Abuja, [3]Federal Medical Centre Asaba, [4]Delta State University Teaching Hospital, [5]Alex Ekwueme Federal University Teaching Hospital, Abakaliki, [6]University of Lagos Teaching Hospital (LUTH), [7]Federal Medical Centre, Azare, [8]Lagos State University Teaching Hospital (LASUTH), [9]National Orthopaedic Hospital Dala, Kano, [10]National Orthopaedic Hospital Igbobi, Lagos, [11]Federal Medical Centre, Owo, [12]University of Benin Teaching Hospital, [13]Prof. Kelsey Harrison Hospital Port Harcourt, [14]Igbinedion University Teaching Hospital, Okada, [15]University of Port Harcourt Teaching Hospital, [16]Braithwaite Memorial Specialist Hospital, Port Harcourt, [17]Olabisi Onabanjo University Teaching Hospital, [18]Abubakar Tafawa Balewa University Teaching Hospital, [19]University of Maiduguri Teaching Hospital, [20]Federal Medical Centre, Birnin Kudu, Jigawa, [21]University of Uyo Teaching Hospital, [22]University of Calabar Teaching Hospital, [23]Federal Medical Centre Yenagoa, [24]Enugu State University Teaching Hospital, Parklane Enugu, [25]Ahmadu Bello University Teaching Hospital, [26]Usman Dan Fodio University Teaching Hospital, [27]Federal Medical Centre, Birnin Kebbi, [28]Bowen University Teaching Hospital, [29]Ambrose Alli University, Ekpoma, [30]Irrua Specialist Hospital, [31]Nisa Premier Hospital Abuja, [32]Federal Medical Centre, Yola, [33]University of Ilorin Teaching Hospital, [34]Ladoke Akintola University of Technology (LAUTECH) Teaching Hospital, Ogbomoso, [35]University of Abuja Teaching Hospital, Gwagwalada, [36]Ekiti State University Teaching Hospital

Address for correspondence: Dr. A Oreh, Head of Department of Planning, Research and Statistics, National Blood Service Commission, 39 Abidjan Street, Wuse Zone 3 Abuja, Nigeria. E-mail: azoreh@yahoo.com

Received: 19-Apr-2021;
Revision: 04-Jul-2021;
Accepted: 30-Dec-2021;
Published: 16-Jun-2022

Access this article online

Quick Response Code:

Website: www.njcponline.com

DOI: 10.4103/njcp.njcp_1437_21

ABSTRACT

Background: The coronavirus disease 2019 (COVID-19) pandemic affected blood supplies globally. Mobile blood drive campaigns halted, and voluntary blood donations reduced, challenging available blood supplies. Furthermore, fears of virus transmission led to deferrals of elective surgeries and non-urgent clinical procedures with noticeable declines in blood donations and transfusions. **Aims:** We aimed to assess the effect of the COVID-19 pandemic on the number of blood donations and transfusions across the country by blood product type across various hospital departments. **Materials and Methods:** A retrospective descriptive study was conducted to determine the impact of the COVID-19 pandemic on blood services in 34 tertiary hospitals in Nigeria, comparing January to July 2019 (pre-COVID-19) to January to July 2020 (peri-COVID-19). Data were collected from the country's web-based software District Health Information System, Version 2 (DHIS2). **Results:** A 17.1% decline in numbers of blood donations was observed over the study period, especially in April 2020 (44.3%), a 21.7% decline in numbers of blood transfusions, especially in April 2020 (44.3%). The largest declines in transfusion were noted in surgery department for fresh frozen plasma (80.1%) [p = 0.012] and accident and emergency department transfusion of platelets (78.3%) [p = 0.005]. The least decline of statistical significance was observed in internal medicine transfusions of whole blood (19.6%) [p = 0.011]. **Conclusions:** The COVID-19 pandemic significantly affected the numbers of blood donations and transfusions in Nigeria. Strengthening blood services to provide various blood components and secure safe blood supplies during public health emergencies is therefore critical.

KEYWORDS: *Blood collection, blood components, donors, transfusion medicine (in general)*

How to cite this article: Oreh A, Bozegha T, Ihimekpen A, Biyama F, Irechukwu C, Aliu S, *et al.* Effect of the COVID-19 pandemic on blood donations and transfusions in Nigeria – A multi-facility study of 34 tertiary hospitals. Niger J Clin Pract 2022;25:786-93.

Introduction

Coronavirus disease 2019 (COVID-19) is a highly transmissible respiratory illness caused by a new strain of coronavirus which was first reported by the World Health Organization (WHO) in December 2019.[1] Infected people may be asymptomatic, while others may develop symptoms, including fever, cough, shortness of breath, sore throat, and a loss of sense of taste or smell. The infection may lead to severe breathing difficulties, leading to hospitalization, admission to intensive care or death.[2]

Following the outbreak report from Wuhan, China, the virus rapidly spread to other countries, and many national governments across the world put in place lockdown measures as a strategy to limit its spread. Severe restrictions on individual movements affected many aspects of life including voluntary blood donation, thus leading to a sizeable decrease in the number of blood donors.[3] This generated anxiety globally on the availability of blood for transfusion, especially in African countries that were already challenged by low rates of voluntary blood donation.[4,5]

After the report of Nigeria's first COVID-19 case on February 27, 2020, the Nigerian Presidential Task Force against COVID-19 mandated lockdowns and physical distancing measures including restrictions of mass gatherings from 30 March 2020. This led to the cessation of voluntary blood donation drives across the country. Early in the pandemic, the Pan American Health Organization had warned of impending shortages in safe blood supplies due to reduced numbers of voluntary blood donors in response to COVID-19 preventive measures.[6,7]

Nigeria is currently one of five countries in the world where a woman is most likely to die from causes related to pregnancy and childbirth, and nearly a quarter of these deaths are due to hemorrhage.[8-10] Additionally, the country has the highest burden of sickle cell disease in the world with about 70–90% of affected children dying before the age of five.[11] For these reasons and others such as malaria, cancer, trauma from road traffic accidents, conflict, insurgency and various surgical needs, available and sustainable supplies of safe blood and blood products are critical to saving lives, regardless of the COVID-19 pandemic. Blood shortages would therefore jeopardize the lives of many leading to deaths and needless suffering.

Blood transfusion services in Nigeria are coordinated and regulated by the National Blood Service Commission (NBSC), with blood collection activities decentralized among both public and private blood centers spread across the country and hospital-based blood bank facilities. Component separation is carried out in select public and private blood establishments.

This study thus aimed to assess the effect of the COVID-19 pandemic on the number of blood donations and transfusions across tertiary hospitals in Nigeria, disaggregated by blood product type across different departments. This was done to generate evidence and recommendations for effective planning, motivation of safe voluntary donation, and optimal management of blood supplies to avoid blood shortages, recognizing that infection prevention measures could create enormous gaps in safe blood supplies. This research would prove useful in the present pandemic, and during other potentially similar public health emergencies in future.

Materials and Methods

Study design, period, and settings

We conducted a retrospective analysis of routinely collected hospital blood services data in Nigeria, performed to determine the impact of the COVID-19 pandemic on blood services in 34 tertiary hospitals across the country which had complete blood safety data entries on the District Health Information System, Version 2 (DHIS2), comparing the months of January to July 2019 (pre-COVID-19) to the months of January to July 2020 (peri-COVID-19).

Nigeria is administratively divided into 36 states plus the Federal Capital Territory (FCT), which are zoned across six geopolitical areas: South-South; South-West; South-East; North-East; North-West, and North-Central. During the peri-COVID-19 study period, 36 states including the FCT had reported confirmed COVID-19 cases, and national lockdown measures were in place.

Thirty-four tertiary hospitals were involved in this study, cutting across the country's six geo-political zones [Figure 1]. With a cumulative bedspace of 15,311 (ranging from 100 to 910 beds), each of the hospitals provides blood services to their respective states and regionally, for both urban-based patients and those referred from rural settings in addition to undergraduate and postgraduate medical training.

Ethical approval

Ethical approval for this study was obtained from the NBSC Research Ethics Committee. The investigation was not considered to be research on human subjects. Therefore, individual consent from blood donors and recipients was not sought, as personal individual data was not used in this study, only global data from routinely recorded departmental registers.

Data source and collection

The District Health Information System, Version 2 (DHIS2), is a real-time web-based software on the platform for the National Health Management Information System that has been in use since 2010. In 2018, NBSC with support from WHO Nigeria Country Office adopted and customized DHIS2 as its primary digital platform for collecting blood services data from hospitals across the country. All data generated through DHIS2 is owned by the Federal Ministry of Health, processed, and stored in a central server at the headquarters in Abuja, Nigeria.

Blood donation and transfusion data from the hospitals were retrieved from DHIS2, where hospital data on blood services have been routinely collected since 2019. Data tabulated on a spreadsheet included number of blood donations, number of whole blood transfusions, number of red blood cell (RBC) transfusions, number of fresh frozen plasma transfusions, and number of platelet transfusions across the following hospital departments – accident and emergency, obstetrics and gynecology, pediatrics, surgery, and internal medicine.

Data analysis

Hospital data on blood donations and transfusions by department were organized, reviewed, and analyzed using Microsoft Excel and Statistical Package for Social Sciences (SPSS) version 25, IBM Armonk, New York, USA. The Shapiro–Wilk test of normality was used to determine the distribution of data, and correlation analysis done to ascertain the relationship between 2019 data and 2020 data. The *P* values were generated from t-test analysis, and a *P* value of < 0.05 was considered statistically significant.

Results

The District Health Information System, Version 2 (DHIS2) routinely captures information on blood donations and transfusions in several tertiary hospitals in Nigeria. A total of 69,287 blood units were donated in the months of January to July of 2020, compared to 83,570 units donated in the same period in 2019, signifying a decline of approximately 17.1%. Out of these, 5,564 blood units were donated by voluntary unpaid blood donors in 2020

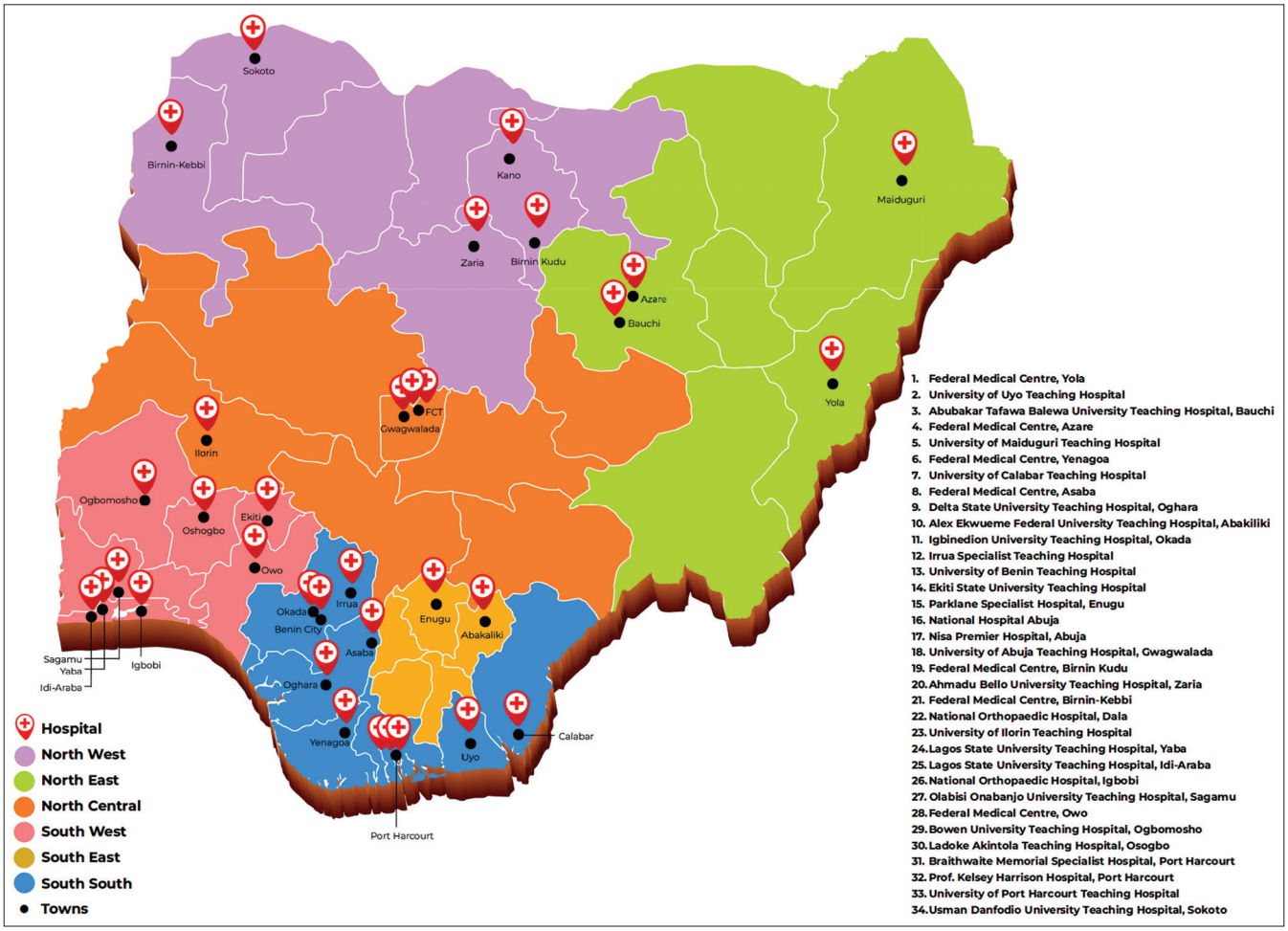

Figure 1: Distribution of the 34 tertiary hospitals in Nigeria according to geopolitical zone

compared to 6,269 blood units in 2019 [Table 1] and [Figure 2]. For family replacement donations, 63,723 blood donations were given in the 2020 study period, compared to 77,301 donations in 2019. In the month of April 2020, the number of blood donations was 6,630 compared to 11,748 in April 2019, thus accounting for a 44.3% drop in blood donations across the studied hospitals. All blood donations took place in the hospital blood banks. The mean (± standard deviation) number of blood units donated at tertiary hospitals in the months of January to July 2019 before COVID-19 was 11,939 ± 399 units per month while the mean (± standard deviation) number of blood units collected over the same period in 2020 was 9,898 ± 1,703 units per month. This 17.1% decrease in total blood donations was statistically significant with $P = 0.032$ [Table 1] and [Figure 3].

Table 1: Total number of blood donations in January to July 2019 and 2020

Total number of blood donations			
	2019	2020	Effect (% change)
January	11586	11222	-3%
February	11531	10070	-12.7%
March	11499	9714	-15.5%
April	12499	6962	-44.3%
May	12210	8972	-26.5%
June	12038	12370	2.8%
July	12207	9977	-18.3%
Total	83570	69287	-17.1%
t-test statistic	2.786		
P	0.032*		

*significant at $P<0.05$

Table 2: Number of blood transfusions in January to July 2019 and 2020

Total number of blood transfusions			
	2019	2020	Effect (% change)
January	13917	13872	-0.3%
February	13297	12763	-4.0%
March	13818	12870	-6.9%
April	15607	8699	-44.3%
May	15048	10021	-33.4%
June	14142	9296	-34.3%
July	14582	11126	-23.7%
Total	100411	78647	-21.7%
t-test statistic	3.111		
P	0.021*		

*significant at $P<0.05$

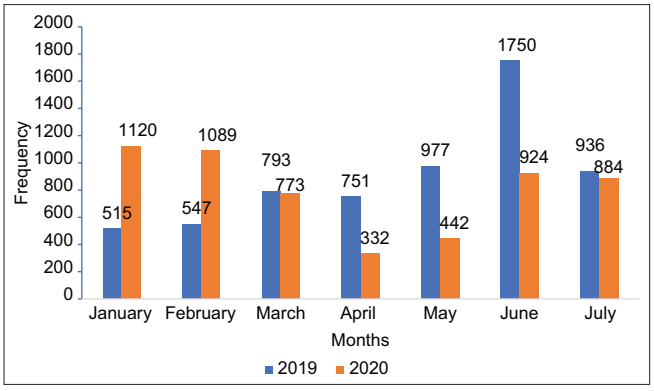

Figure 2: Effect of COVID-19 on voluntary non-remunerated blood donations (VNRD) in 34 tertiary hospitals in Nigeria

All donated blood units were screened and processed before release to various hospital departments for transfusion. The month of April 2020 was the most affected with a 44.3% decline in blood transfusions compared to 2019 with only 7,410 whole blood transfusions compared to 12,666 in April 2019 [Table 2]. The mean (± standard deviation) amount of blood transfused in the months of January to July 2019 before COVID-19 was 14,344 ± 790 units per month, while the mean (± standard deviation) amount of blood transfused in January to July 2020 was 11235 ± 1985 units per month. This 21.7% decrease in blood transfusion, was statistically significant at $P = 0.021$ [Table 2] and [Figure 3].

In the departments of obstetrics and gynecology, a 53.5% decline was observed in the transfusion of platelets over the study period ($p = 0.041$). For the pediatrics departments, declines ranged from 6.9% to 22.0%, but were not found to be statistically significant. Internal medicine departments reported declines of up to 48.1% in red cell transfusions ($p = 0.014$).

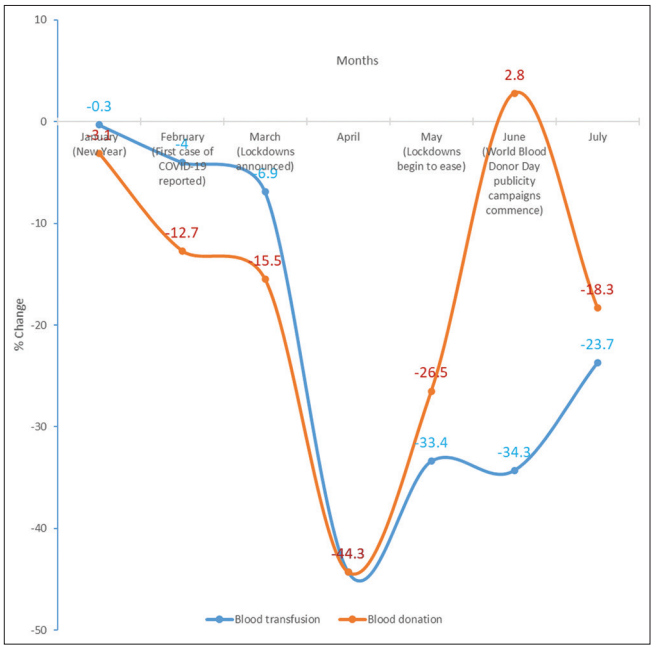

Figure 3: Effect of COVID-19 (percentage change) on numbers of blood donations and transfusions according to month in 34 tertiary hospitals in Nigeria

Table 3: Effect of COVID-19 on blood transfusions by hospital department

Blood product transfused	2019	2020	% change	Correlation (*r*)	*P*
Obstetrics and Gynecology					
Whole blood	22144	17057	-23.0	-0.383	0.008*
Red cells	1164	1433	23.1	-0.736	0.634
Platelets	294	72	-75.5	-0.299	0.103
Fresh frozen plasma	187	87	-53.5	0.042	0.041*
Pediatrics					
Whole blood	10936	9388	-14.2	0.709	0.147
Red cells	2108	1644	-22.0	-0.676	0.392
Platelets	515	479	-6.9	0.778	0.822
Fresh frozen plasma	118	95	-19.5	-0.355	0.622
General Surgery					
Whole blood	14886	11191	-24.8	-0.411	0.012*
Red cells	1418	1183	-16.6	-0.790	0.695
Platelets	147	143	-2.7	-0.566	0.968
Fresh frozen plasma	433	86	-80.1	-0.428	0.012*
Accident and Emergency					
Whole blood	16787	14525	-13.5	-0.533	0.077
Red cells	3440	2323	-32.5	-0.227	0.009*
Platelets	304	66	-78.3	0.426	0.005*
Fresh frozen plasma	238	94	-60.5	0.353	0.051
Internal Medicine					
Whole blood	9609	7730	-19.6	-0.108	0.011*
Red cells	3203	1662	-48.1	0.875	0.014*
Platelets	757	454	-40.0	-0.690	0.299
Fresh frozen plasma	248	105	-57.7	-0.108	0.149
Other Departments[#]					
Whole blood	8226	792	-21.5	-0.571	0.123
Red cells	1713	679	-60.4	0.349	0.007*
Platelets	1051	1105	5.1	-0.593	0.873
Fresh frozen plasma	485	591	21.9	0.049	0.324

*-significant at $P<0.05$ [#]*Other departments – Anesthesia, Ophthalmology, Orthopedics, Otorhinolaryngology*

The highest declines in blood transfusions for the entire study period by hospital department and blood product were observed in surgery department transfusions of fresh frozen plasma (80.1%) ($p = 0.012$) and accident and emergency department transfusions of platelets (78.3%) ($p = 0.005$). The least decline was observed in surgery department platelet transfusions (2.7%), although this finding was not statistically significant. Increased transfusions of red cells over the study period were however observed in obstetrics and gynecology departments (23%). However, this increase was not found to be statistically significant [Table 3]. Data on numbers of different types of blood donations, and blood products transfused over the study period are provided in Supplementary Tables 1 and 2.

Discussion

Over the years, many lower- and middle-income countries (LMICs) especially in Africa have been challenged by an insufficiency of safely screened blood to meet country needs, and Nigeria has not been an exception.[5,12,13] The COVID-19 pandemic, coupled with the government-led preventive measures that curtailed movements and mass gatherings therefore threatened already strained blood supplies.[6,14]

Blood and blood components are critical aspects of emergency preparedness, with limitations to how long they can be kept viable in storage, varying from as high as 42 days (RBCs), to as little as five days (platelets).[15,16] Frequent maintenance of stocks of safe blood supplies is therefore vital to ensuring the availability of blood for transfusion even during pandemics.

In this study, blood donations and blood transfusions were analyzed across 34 tertiary hospitals in Nigeria over the months of January to July 2019 and compared to the same period in 2020. In 2019, the blood units donated were collected in hospital blood banks and during voluntary blood donor campaigns. Increased sensitization and campaigns for voluntary blood donations led to an increase in numbers of voluntary blood donors

observed in January and February 2020 compared to 2019. However, between April and July 2020, all blood units collected were in only hospital blood banks due to COVID-19 restrictions and cancellations of blood drives. A 44.3% decline in blood donations at the peak of the pandemic in Nigeria is less than that reported from China, where only one-third of pre-COVID-19 blood donations were collected.[17] However, our finding is closer to that reported from Saudi Arabia (39.5%), but substantially more than recorded in Iran (29.5%).[18,19] Similarly to Saudi Arabia, strategies such as phone calls directly to registered blood donors may have been responsible for closing blood donation gaps.

A majority of the donors recorded were family replacement donors (FRDs), accounting for 92% of hospital blood donations in both 2019 and 2020. This finding correlates with reports from Egypt and India which revealed FRDs to be 87% and 45% of blood donors, respectively.[20,21] However, our study finding is worrisome given evidence that places FRDs to be more likely infected with transfusion-transmissible infections than voluntary non-remunerated donors.[20,22] Several Nigerian studies also corroborate this huge gap between FRDs and VNRDs in the country.[23-26]

The months of April and May 2020 were hit the hardest following national lockdowns announced by the government on the March 30, 2020 with substantial reductions in numbers of blood donations. These declines were more marked in voluntary blood donations than family replacement donations. It is likely that FRDs are motivated to donate for known relatives in need of blood, and thus proceeded to do so despite the fears of the COVID-19 pandemic and lockdown measures in place. Another perspective worth considering is the fact that in limited-resource environments, many families call on commercial blood donors who make themselves available to donate blood as "family replacement donors".[21,27] The economic fall-out of COVID-19 preventive measures, which disproportionately affected informal sector workers may have also increased the tendency toward paid blood donations in the guise of FRD.

Typically, in the New Year, there are observed declines in hospital admissions as families return from Christmas and New Year celebrations. These are observed in the reduced numbers of transfusions in January–February 2020 even before Nigeria reported its first case of COVID-19. Subsequent peri-COVID-19 declines in blood transfusion observed were due to reduced demand owing to closures of outpatient departments, less patient admissions, and suspension of elective surgeries, similar strategies employed in various countries like India.[28] These helped hospitals cope with the reduced numbers of blood donations, and not having to turn away patients due to blood unavailability. Early in 2020, improved apheresis availability led to increases in numbers of red cells and platelets transfusions. These however declined with the pandemic. Overall, the impact of the pandemic on blood transfusions was minimal, as all available blood units donated were processed and made available for departmental use, limiting blood units on reserve. This differs from reports from Italy, however, where hospital blood strategic reserves remained untouched for emergency purposes.[29] The impact of the pandemic on blood services in obstetrics and gynecology is significant, considering Nigeria's high maternal death rates.[8] As antenatal care services were shut down in many hospitals, more incidences of bleeding are likely to have occurred with patients in the communities who were unable to access maternal care services over the period.[8-10] The minimal impact of the pandemic on pediatric blood services emphasizes the emergency nature of pediatric transfusions in conditions such as malaria and sickle cell disease; especially as emergency services continued uninterrupted over the period. Whereas numbers of family replacement blood donations increased in June 2020, likely due to campaigns surrounding the World Blood Donor Day celebrations, the numbers of voluntary blood donations and transfusions remained reduced. This calls for an exploration of the nature and design of such campaigns to better target voluntary blood donors.

Findings from this study clearly reveal that the COVID-19 pandemic negatively affected the numbers of blood donations and blood transfusions in Nigerian hospitals. This is in consonance with past outbreaks of other coronaviruses.[30-33] As the current COVID-19 pandemic rages on, and infectious diseases outbreaks are predicted to be frequent occurrences in the future,[34] it is vital that adequate planning and implementation of strategies to strengthen national blood supplies are prioritized to meet country needs.[35]

Lessons from past infectious disease outbreaks illustrate the need for innovation in maintaining stable and adequate blood supplies. Collaborations between hospitals, state, regional, and national blood transfusion centers would enhance safe blood mobilization during emergencies. Furthermore, collation and regular monitoring of data on regional and local blood needs and available supplies including protocols for needs-based distribution of safe blood between regions and facilities are expedient. In addition, increasing voluntary blood donations through public sensitization, setting up appointment systems, and safely holding small blood drives in donors' communities are also necessary.[18,29,30]

Finally, optimizing available blood supplies would necessitate adherence to guidelines on appropriate clinical use of blood. Blood conservation methods such as patient blood management; and the deferment of elective and non-urgent surgeries must be deployed to make special provision for emergency conditions.[18,31,36]

Conclusions

This study revealed the negative impact of the COVID-19 pandemic on blood donations and transfusions in Nigeria, largely evident in the numbers of voluntary blood donations and blood transfusions in departments of surgery, trauma and in obstetrics and gynecology. The overall effect was that despite the repressive effect of the pandemic on demand and supply, the demand was still less than the available supply of blood and its products. The prevalent phobia of presenting to the hospitals and being infected with COVID-19 could have been responsible for this.

To mitigate the effects of pandemics, blood services need to be strengthened, and blood supply shortages efficiently managed. This can be achieved by implementing public enlightenment strategies to motivate regular voluntary blood donations while ensuring donor and staff safety. We also recommend the enhancement of communication and collaborations with blood transfusion centers and developing protocols to ensure continuity of operations and ease of distribution of safe blood and blood products to facilities based on need.

Acknowledgements

The authors thankfully acknowledge all blood donors who volunteered even during lockdowns to donate their blood to save the lives of those in need. The authors would also like to thank the programmers at the Health Information System Program, Nigeria, who provided the initial codes for the DHIS2 Blood safety Module and customised the dashboard for the NBSC and each tertiary facility. Our special thanks go to Aluka Terpase and Henry Okoli for their support with DHIS2 in this study.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. World Health Organization. Health Topics – Coronavirus. Geneva: World Health Organization; 2020. Available from: https://www.who.int/health-topics/coronavirus#tab=tab_1. [Last accessed on 2020 Sep 23].
2. Piechotta V, Chai KL, Valk SJ, Doree C, Monsef I, Skoetz N, *et al*. Convalescent plasma or hyperimmune immunoglobulin for people with COVID-19: A living systematic review. Cochrane Database Syst Rev 2020;7:CD013600.
3. Raturi M, Kusum A. The blood supply management amid the COVID-19 outbreak. Transfus Clin Biol 2020;27:147–51.
4. Barrett CL. Obstetric anaemia in Africa in the time of COVID-19: A call to action. ISBT Sci Ser 2020;15:398-402.
5. Aneke J, Okocha C. Blood transfusion safety; Current status and challenges in Nigeria. Asian J Transfus Sci 2017;11:1-5.
6. World Health Organization. PAHO Warns of Potential Blood Shortages During the COVID-19 Pandemic. Geneva: World Health Organization; 2020. Available from: https://www.paho.org/en/news/10-4-2020-paho-warns-potential-blood-shortages-during-covid-19-pandemic. [Last accessed on 2020 Sep 28].
7. Congressional Research Service: The US Blood Supply and the COVID-19 Response. Washington: United States Congress; 2020. Available from: https://fas.org/sgp/crs/misc/R46375.pdf. [Last accessed on 2020 Oct 21].
8. World Health Organization: Trends in Maternal Mortality 2000 to 2017: Estimates by WHO, UNICEF, UNFPA and World Bank Group. Geneva: World Health Organization; 2019. Available from: https://www.who.int/reproductivehealth/publications/maternal-mortality-2000-2017/en/. [Last accessed 2020 Oct 21].
9. Galadanci H, Dongarwar D, Künzel W, Shittu O, Yusuf M, Salihu HM, *et al*. Cesarean section and maternal-fetal mortality rates in Nigeria: An ecological lens into the last decade. Int J MCH AIDS 2020;9:128-35.
10. Ntoimo LF, Okonofua FE, Ogu RN, Galadanci HS, Gana M, Okike ON, *et al*. Prevalence and risk factors for maternal mortality in referral hospitals in Nigeria: A multicenter study. Int J Womens Health 2018;10:69-76.
11. Fraiwan A, Hasan MN, An R, Rezac AJ, Kocmich NJ, Oginni T, *et al*. Advancing healthcare outcomes for sickle cell disease in Nigeria using mobile health tools. Blood 2019;134:2173.
12. Osaro E, Adias T. The challenges of meeting the blood transfusion requirements in Sub-Saharan Africa: The need for the development of alternatives to allogenic blood. J Blood Med 2011;2:7-21.
13. Oreh AC. Is COVID-19 plasma an option for Africa? Africa Sang 2020;22:1-2.
14. Sayedahmed AM, Ali KA, Ali SB, Ahmed HS, Shrif FS, Ali NA. Coronavirus disease (COVID-19) and decrease in blood donation: A cross-sectional study from Sudan. ISBT Sci Ser 2020;15:381-5.
15. Cancelas JA, Dumont LJ, Maes LA, Rugg N, Herschel L, Whitley PH, *et al*. Additive solution-7 reduces the red blood cell cold storage lesion. Transfusion 2015;55:491-8.
16. Kaplan C. Toddy for chilled platelets? Blood 2012;119:1100-2.
17. Wang Y, Han W, Pan L, Wang C, Liu Y, Zheng X, *et al*. Impact of COVID-19 on blood centres in Zhejiang province China. Vox Sang 2020;115:502-6.
18. Yahia AI. Management of blood supply and demand during the COVID-19 pandemic in King Abdullah Hospital, Bisha, Saudi Arabia. Transfus Apher Sci 2020;59:102836.
19. Maghsudlu M, Eshghi P, Amini Kafi-Abad S, Sedaghat A, Ranjbaran H, Mohammadi S, *et al*. Blood supply sufficiency and safety management in Iran during the COVID-19 outbreak. Vox Sang 2021;116:175-80.
20. Abdel Messih IY, Ismail MA, Saad AA, Azer MR. The degree of safety of family replacement donors versus voluntary non-remunerated donors in an Egyptian population: A comparative study. Blood Transfus 2014;12:159-65.
21. Jain R, Gupta G. Family/friend donors are not true voluntary donors. Asian J Transfus Sci 2012;6:29-31.

22. World Health Organization. Universal Access to Safe Blood Transfusion. Geneva: World Health Organization; 2008. Available from: https://apps.who.int/iris/bitstream/handle/10665/69747/WHO_EHT_08.03_eng.pdf?sequence=1&isAllowed=y&ua=1. [Last accessed on 2020 Oct 21].
23. Ahmed SG, Ibrahim UA, Hassan AW. Adequacy and pattern of blood donations in north-eastern Nigeria: The implications for blood safety. Ann Trop Med Parasitol 2007;101:725–31.
24. Jeremiah ZA, Koate B, Buseri F, Emelike F. Prevalence of antibodies to hepatitis C virus in apparently healthy Port Harcourt blood donors and association with blood groups and other risk indicators. Blood Transfus 2008;6:150–5.
25. Buseri FI, Muhibi MA, Jeremiah ZA. Sero-epidemiology of transfusion-transmissible infectious diseases among blood donors in Osogbo, south-west Nigeria. Blood Transfus 2009;7:293-9.
26. Okocha EC, Aneke JC, Ezeh TU, Ibeh NC, Nwosu GA, Onah CE, *et al*. The epidemiology of transfusion-transmissible infections among blood donors in Nnewi, South-East Nigeria. African J Med Heal Sci 2015;14:125-9.
27. Allain JP. Moving on from voluntary non-remunerated donors: Who is the best blood donor? Br J Haematol 2011;154:763–9.
28. Dhiman Y, Patidar GK, Arora S. Covid-19 pandemic- response to challenges by blood transfusion services in India: A review report. ISBT Sci Ser 2020;15:365-73.
29. Franchini M, Farrugia A, Velati C, Zanetti A, Romanò L, Grazzini G, *et al*. The impact of the SARS-CoV-2 outbreak on the safety and availability of blood transfusions in Italy. Vox Sang 2020;115:603-5.
30. Shander A, Goobie SM, Warner MA, Aapro M, Bisbe E, Perez-Calatayud AA, *et al*. Essential role of patient blood management in a pandemic: A call for action. Anesth Analg 2020;131:74-85.
31. Teo D. Blood supply management during an influenza pandemic. ISBT Sci Ser 2009;4:293-8.
32. Shan H, Zhang P. Viral attacks on the blood supply: The impact of severe acute respiratory syndrome in Beijing. Transfusion 2004;44:467-9.
33. Kim KH, Tandi TE, Choi JW, Moon JM, Kim MS. Middle East respiratory syndrome coronavirus (MERS-CoV) outbreak in South Korea, 2015: Epidemiology, characteristics and public health implications. J Hosp Infect 2017;95:207-13.
34. Frandsen MV. Pandemics are here to stay. Here's how to prepare for the next one Davos: World Economic Forum; 2020. Available from: https://www.weforum.org/agenda/2020/06/pandemics-are-here-to-stay-heres-how-we-should-prepare-for-the-next-one/. [Last accessed on 2020 Oct 21].
35. World Health Organization. Maintaining a Safe and Adequate Blood Supply during the Pandemic Outbreak of Coronavirus Disease (COVID-19). Interim Guidance. Geneva: World Health Organization; 2020. Available from: https://www.who.int/publications/i/item/WHO-2019-nCoV-BloodSupply-2021-1. [Last accessed on 2020 Oct 21].
36. Sadana D, Pratzer A, Scher LJ, Saag HS, Adler N, Frank SM, *et al*. Promoting high-value practice by reducing unnecessary transfusions with a patient blood management program. JAMA Intern Med 2018;178:116-22.