Original article

Surveillance of blood donors detects an exceptional Parvovirus B19 outbreak in Switzerland in 2023/2024

Mauro Serricchio[1], Peter Gowland[1], Nadja Widmer[1], Martin Stolz[1], Sophie Waldvogel[2], Jutta Thierbach[3], Andreas Buser[4], Franziska Suter-Riniker[5], Christoph Niederhauser[1,5]

[1]*Interregional Blood Transfusion SRC, Bern, Switzerland;*
[2]*Blood Transfusion Service SRC, Geneva, Switzerland;*
[3]*Blood Transfusion Service SRC Nordostschweiz, St. Gallen, Switzerland;*
[4]*Blood Transfusion Service SRC Beider Basel, Basel, Switzerland;*
[5]*Institute for Infectious Diseases, University of Bern, Bern, Switzerland*

Background - Human Parvovirus B19 is a common human pathogen that causes fifth disease that can be severe for immunocompromised people and unborn children. Blood donations are routinely screened for the presence of Parvovirus B19 DNA to release plasma for the fractionation industry.

Materials and methods - Voluntary, unremunerated blood donations from six regions of Switzerland were tested by Interregional Blood Transfusion Swiss Red Cross since 2008. Individual blood donations with viral titers exceeding 10^3 IU/mL are removed from the blood supply and the viral genotype, viral titers, and serological status were determined.

Results - From 2008 until September 2024, 2,789,113 blood donations were tested for the presence of Parvovirus B19 DNA, of which 271 were considered positive. Two small outbreaks in the years 2013 and 2017 and an unprecedented massive outbreak in winter/spring 2023/2024 were detected. The incidence in the 2023/2024 outbreak was 15.1 per 10,000 donations and thus about ten times higher than in the previous outbreaks with 1.6 and 1.2 positive cases per 10,000 donations, respectively. Of the genotyped cases from the 2023/2024 outbreak all were caused by Parvovirus B19 of genotype 1a2. Viral titers reached maximum values of 3×10^{12} IU/mL. Serological data show an inverse correlation between viral titers and presence of protective IgG antibodies.

Discussion - Similar to the situation in other European countries, Switzerland was struck with an unprecedented Parvovirus B19 outbreak in 2023/2024. The outbreak follows a two-year stretch with no positive Parvovirus B19 cases. It is likely that the measures implemented in 2020 to confine the spread of SARS-CoV-2 had a strong impact on other infectious diseases like Parvovirus B19.

Keywords: *Parvovirus B19, blood transfusion, outbreak, nucleic acid testing, blood donations.*

©SIMTIPRO Srl

INTRODUCTION

Human Parvovirus B19 is a common human pathogen that causes a variety of diseases. These include erythema infectiosum in children, aplastic crisis, chronic pure red blood cell aplasia, fetal hydrops, and spontaneous abortion. In most cases infections are

Arrived: 6 March 2025
Revision accepted: 20 June 2025
Correspondence: Christoph Niederhauser
e-mail: christoph.niederhauser@itransfusion.ch

© SIMTIPRO Srl
Published under a CC BY-NC-ND license

asymptomatic or mild. Severe outcomes may occur in immunocompromised or hematologic patients, where severe prolonged anemia may arise[1].

Parvovirus B19 is a small non-enveloped DNA virus with three genotypes that infect humans[2]. Parvovirus B19 can be transmitted via the respiratory route, vertically from mother to fetus and through blood and blood products via transfusion or transplantation. Transfusion-transmissions have been reported[3], but it seems to be quite rare with red blood cells concentrates and platelet concentrates[4], and it is assumed that the greatest concern for patient safety is the cumulative effect of plasma pooling. Contamination of plasma derivatives with Parvovirus B19 has led to widespread use of Parvovirus B19 screening of initial and recovered plasma donations to screen out high titer viremic products prior to pooling and fractionation[5-7]. Parvovirus B19 infections follow a cyclical course in many regions of the world, with increased case numbers every 3-5 years[8-10].

Viremia occurs approximately one week after infection and persists at high titers in plasma for approximately 5 days[11]. Immunoglobulin (Ig)M antibodies develop at approximately 12 days after infection. IgG antibodies follow in the proceeding days, and their appearance coincides with a sharp drop in plasma viremia. In general, viremia disappears within weeks. Nevertheless, even in immunocompetent individuals viraemia can persist for months or even years, but in these cases, it is often associated with a low-level viremia[12] and may be related to the release of naked, non-infectious DNA from tissues[13]. IgM antibodies become undetectable after several months, whereas IgG antibodies persist life-long and are thought to convey immunity to reinfection.

In Switzerland, testing of blood donations for Parvovirus B19 is not mandatory, except for the release of products for the plasma fractionation industry. In the Interregional Blood Transfusion Swiss Red Cross (IRB SRC) all blood donations have been tested for Parvovirus B19 since 2008. Mild Parvovirus B19 outbreaks among blood donors were detected in the years 2013 and 2017; an extraordinary outbreak occurred in winter/spring 2023/2024. Here, we summarize characteristics of the 2023/2024 outbreak and report viral titers, incidences, serological data, and viral genotypes of positive Parvovirus B19 blood donations detected from January 2008 until September 2024.

MATERIALS AND METHODS

Parvovirus B19 nucleic acid testing (NAT) and titer quantification

From 2008 to 2022, blood donations from six regional Swiss blood donation services (Basel, Bern, Geneva, St. Gallen, Valais, Vaud) were tested in pools of up to 480 samples for the presence of Parvovirus B19 DNA with an in-house NAT detecting the Parvovirus B19 subtypes 1, 2 and 3[14]. Viral DNA was extracted from these pools with an automated extraction system on a Tecan pipetting robot using the QIAamp 96 Virus BioRobot kit from Qiagen (Hombrechtikon, Switzerland). Until 2013, amplification and detection of Parvovirus B19 DNA was performed with a validated quantitative in-house test on an ABI 7700 Sequence Detection System and afterwards on an ViiA7 Sequence Detection System, both from Applied Biosystems (Thermo Fisher Scientific, Basel, Switzerland). The test uses specific dual labelled probes detecting Parvovirus B19 specific sequences in the ns-1 region of genotype 1 to 3 and an internal control sequence from a different species origin. Quantification was done on a serial dilution of a Parvovirus B19 reference plasmid, calibrated against the WHO reference standard 99/800 (NIBSC). The sensitivity of the in-house test is 32.7 IU/mL. Data management, pool resolution and identification of positive samples were all performed with the NADIS Software from Grawunder Software GmbH (Kassel, Germany). Since 2023, pools of 96 samples are being analyzed with the cobas® DPX test on a Cobas® 8800 system (Roche Diagnostics GmbH, Rotkreuz, Switzerland). Positive pools were resolved by pool deconstruction and single sample testing. Single samples are considered positive if the titer exceeds 10^3 IU/mL. Quantitative analysis on viral titers were done with the Parvovirus B19 quantitative in-house test described above.

Serology

From 2008 until 2023, Parvovirus B19 IgG and IgM ELISA was manually performed with commercial assays (Diasorin Ireland Ltd., Dublin, Ireland; MIKROGEN GmbH, Neuried, Germany) according to the manufacturer`s instructions. From 2023, Biotrin Parvovirus B19 IgG and IgM was performed according to the package insert on the Liaison XL analyzer (Diasorin, Saluggia, Italy).

©SIMTIPRO Srl

Phylogenetic analysis

Viral DNA from 500 µL plasma was extracted using the Qiagen Virus BioRobot 9604 kit (Qiagen) modified for a Tecan pipetting robot (Tecan AG, Männedorf, Switzerland) and eluted in 80 µL Qiagen elution buffer. Nested PCR using HotStarTaq DNA Polymerase (Qiagen) was performed to create an 945 bp DNA sequence encompassing regions of VP1 and NS1 with primers PVB1, PVB3, B19SR[15]. The forward and reverse primers were used for sanger sequencing (Mycrosynth GmbH, Balgach, Switzerland). An 882 bp long nucleotide sequence was phylogenetically analyzed using Parvovirus B19 reference strains. Sequences were aligned using MUSCLE and a Maximum Likelihood Tree with 1,000 bootstrap replicates were created using the RAxML model (MegAlign Pro software from DNASTAR, Inc. [Madison, WI, USA], version: 17.5.0).

RESULTS

Surveillance of Parvovirus B19 in Swiss blood donors

From January 2008 until September 2024, a total of 2,789,113 blood donations from six regional blood donation services in Switzerland (Basel, Bern, Geneva, St. Gallen, Valais, Vaud) were tested for the presence of Parvovirus B19 DNA. Of these, 271 samples were confirmed positive with viral titers in the individual donation of >10^3 IU/mL (**Figure 1**). In this period of more than 16 years, the yearly incidence fluctuated between 0 and 2.5 cases per 10,000 donations (**Figure 1**, *upper panel*). Minor Parvovirus B19 outbreaks were detected in the years 2013 and 2017 with yearly incidences of 1.6 and 1.2 per 10,000 donations, respectively. A steep increase in Parvovirus B19-contaminated blood donations was recorded in November 2023, which reached a peak in February 2024 and faded to baseline in July 2024 (**Figure 1**, *lower panel*). During this outbreak, the incidence

©SIMTIPRO Srl

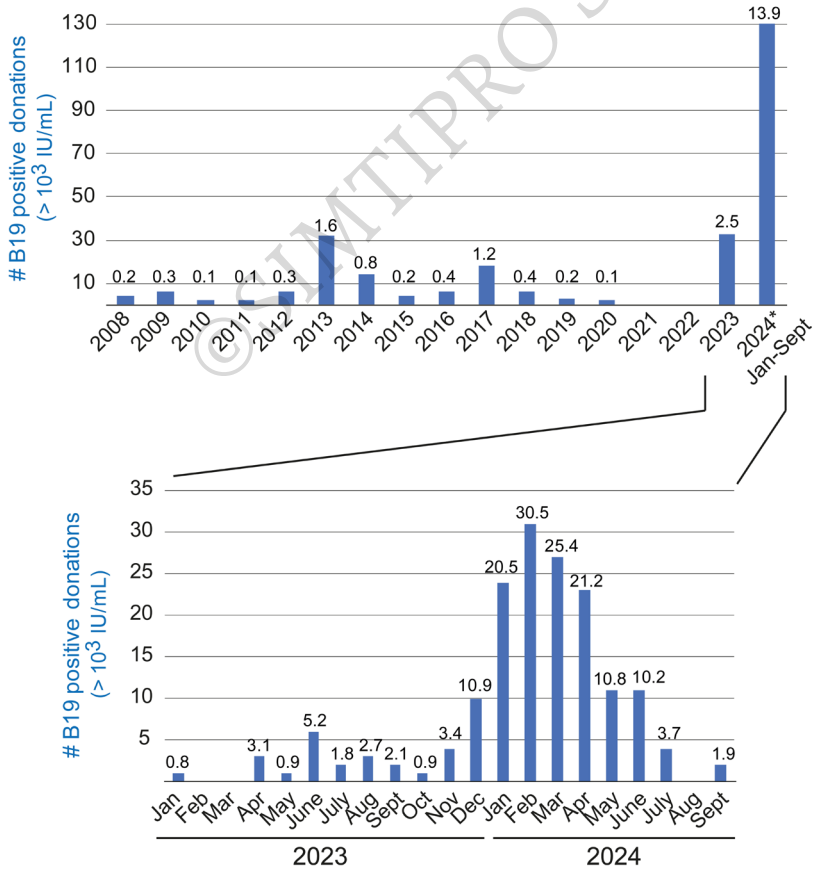


Figure 1 - Parvovirus B19-positive blood donations since 2008
Cases per year are shown in the upper panel, while the lower zoomed-in panel shows the monthly cases from January 2023 until September 2024. Bars show the number of positive blood donations and the numbers above the bars indicate incidences per 10,000 donations.

Table I - *Viral titers of parvovirus B19-positive blood donations from 2008 until September 2024*

Viral load (IU/mL)	No. donations	Percentage	
10^3 - 10^4	19	7.2	40.7
10^4 - 10^5	38	14.4	
10^5 - 10^6	50	19.0	
10^6 - 10^7	45	17.1	30.4
10^7 - 10^8	18	6.8	
10^8 - 10^9	17	6.5	
10^9 - 10^{10}	13	4.9	28.9
10^{10} - 10^{11}	19	7.2	
10^{11} - 10^{12}	19	7.2	
10^{12} - 10^{13}	25	9.5	
Total	263		

Viral titers of 263 positive blood donations were determined with an in-house quantitative PCR.

Table II - *Serological data of parvovirus B19-positive blood donations*

IgM/IgG	No. donations	Percentage
–/–	97	37
+/–	33	13
–/+	4	2
+/+	130	49
Total	264	

Numbers and percentage of IgM and IgG negative and positive blood donations are shown.

increased to 15.1 per 10,000 donations. Of all 271 Parvovirus B19-positive donations recorded since 2008, 145 (54%) occurred in the period from November 2023-July 2024. Focusing on the 2023/2024 outbreak, the incidence rate of Parvovirus B19 was 1: 662 donations; in contrast to the mean rate of 1: 10,292 when considering the entire time since the introduction of Parvovirus B19 testing in 2008.

Viral titers, antibodies, and genotypes

Viral loads of positive donations were determined with a validated in-house quantitative PCR[14] and ranged from 10^3 to 3×10^{12} IU/mL (**Table I**) with a median titer of 3.8×10^6 IU/mL and a mean titer of 2.1×10^{11} IU/mL. 107 (41%) of positive donations had viral titers below 10^6 IU/mL.

Anti-parvovirus B19 IgM and IgG antibodies were analyzed in positive plasma samples. 37% (97) of Parvovirus B19-positive donors were IgM/IgG negative, 13% (33) had only IgM antibodies while 51% (134) seroconverted and were IgG positive (**Table II**). When comparing viral titers of serologic naïve and seroconverted donors, we observed that IgG-negative donors had higher viral loads than seroconverted donors (**Figure 2**).

The median age of Parvovirus B19-positive donors was 39.4 years (95% CI 37.8-40.9), with 67% of the infected blood donors being male. This is slightly below the mean and median age of our general blood donor population (mean age 42.1 years; median age 42 years). Sequencing of part of Parvovirus B19 NS1 and VP1

©SIMTIPRO Srl

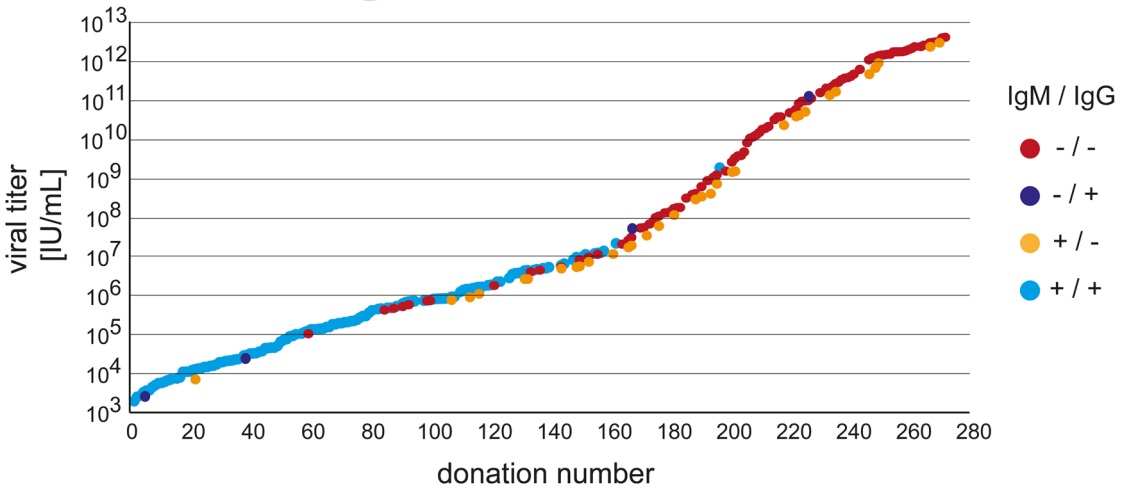


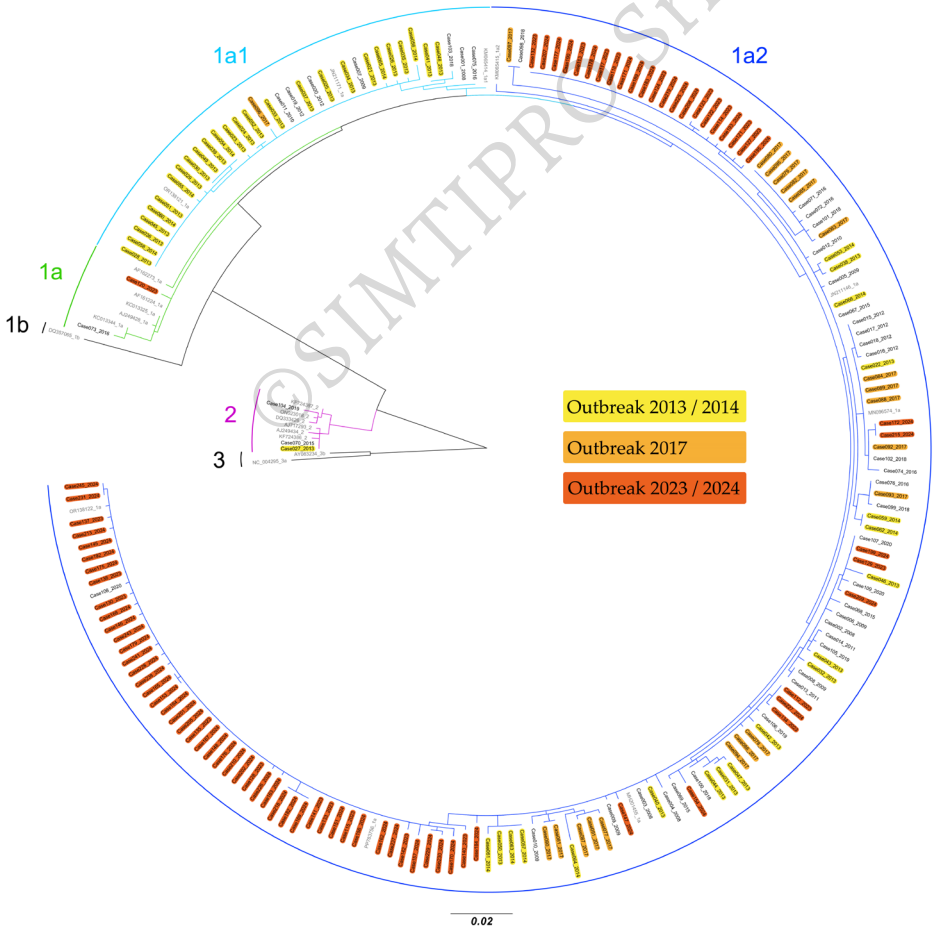
Figure 2 - Viral titers of serologic naïve and seroconverted blood donors
The figure shows viral titers (IU/mL) of IgG-negative and seroconverted blood donors, color-coded by IgM/IgG status. Each point represents a blood donation.

Table III - *Parvovirus B19 genotypes detected in positive blood donations from 2008 until September 2024*

Genotype	No. donations	Percentage	
1a1	34	17.7	98.4
1a2	154	80.2	
1a	1	0.5	
2	3	1.6	
Total	192		

DNA after PCR amplification unveiled that genotype 1a (98.4%) is the most prevalent in Switzerland, with very rare appearances of genotype 2 (1.6%) (**Table III**). Within genotype 1a, we detected the two sub-genotypes 1a1 and 1a2, that have a 98-100% identity within the sequenced 882 bp stretch. Sub-genotype 1a2 has been more frequent with 154 cases (80%) as compared to 1a1 (34 cases, 18%) (**Table III**). While in previous outbreaks (2013 and 2017) both genotypes 1a1 and 1a2 were detected, in the 2023/2024 outbreak, the B19 genotype 1a2 was the only one detected in the samples which were analyzed (**Figure 3**).

Although all blood products are discarded if Parvovirus B19 virus titer is above 10^3 IU/mL, some blood components like platelet concentrates might already be transfused by the time the quantification is performed. Despite pathogen-reduction treatment of platelet concentrates with Amotosalen® (INTERCEPT Blood System, Cerus, Amersfoort, the Netherlands), transfusion-transmissions of Parvovirus B19 have been discovered in previous years[14], including one confirmed transmission during the 2024 outbreak in Switzerland.



©SIMTIPRO Srl

Figure 3 - Phylogenetic representation of detected parvovirus B19 genotypes
With a very few exceptions, all genotypes detect were of genotypes 1a. Positive donations during the three outbreaks 2013, 2017 and 2023/2024 are colored in the phylogenetic tree. Reference sequences for all genotypes are shown in grey.

DISCUSSION

In adults, acute Parvovirus B19 infections often cause no symptoms. If symptoms occur, mild, non-specific signs like a common cold or flu may occur [16]. Therefore, one significant risk for blood transfusion recipients is the potential transmission of Parvovirus B19 from asymptomatic but infected blood donors. During the acute phase of Parvovirus B19 infection, viral titers in the blood can reach very high levels of up to 10^{14} IU/mL. Blood products collected during this period significantly increase the risk of transfusion transmitted infections (TTI)[17,18]. The risk of a Parvovirus B19 TTI is determined by two factors: the infectivity of the Parvovirus B19-containing blood product and the susceptibility of the recipient. Regarding the infectivity of blood products, plasma derivates prepared from pools with Parvovirus B19 DNA levels below 10^4 IU/mL are considered safe and un-pooled labile blood components with Parvovirus B19 below 10^6 IU/mL seem to be safe too, even for recipients who did not acquire immunity through Parvovirus B19 infection in the past[19]. Several studies reported that transfusion transmission of Parvovirus B19 occurs at DNA levels that exceed 10^5 IU/mL[12,19-22], however, exceptions with transfusion transmission occurring with lower viremia are documented[23]. Moreover, after an acute infection, the donated blood presumably also contains neutralising antibodies which could play a protective role for the recipient of the contaminated donation. As far un-pooled labile blood components are concerned, Parvovirus B19 DNA levels lower than 10^4 IU/mL might not be clinically significant while the transfusion of labile blood components with Parvovirus B19 titres greater than 10^7 IU/mL has been associated with TTI of Parvovirus B19[24].

Regarding the low susceptibility of the recipients, possible reasons are that i) a considerable proportion of transfusion recipients are immune to Parvovirus B19, ii) Parvovirus B19 infection usually does not cause a serious illness even in non-immune adults but results only in a deleterious outcome in a small proportion of patients with specific conditions such as hematologic malignancy or hemolytic diseases, iii) passive immunization by the transfer of neutralizing anti-Parvovirus B19 antibodies often occurs with concurrent transfusion and iv) the risk factors that increase susceptibility of recipients to severe Parvovirus B19 disease, and the signs and symptoms of a transfusion-transmitted Parvovirus B19 infection, are not well recognized among physicians. Nevertheless, a blood donor with a recent asymptomatic Parvovirus B19 infection may be highly viraemic, with Parvovirus B19 levels of up to 10^{14} IU/mL, and therefore poses a potential threat for patients with certain risk factors.

In the present study, 41% (107 donors) had viral loads below 10^6 IU/mL in the individual donation, and 59% (156) above 10^6 IU/mL; 29% (76) had a viral load above 10^9 IU/mL (**Table I**). These values agree with a recently published study from Germany, where 26% were also highly viraemic with viral loads higher than 10^9 IU/mL[25].

NAT screening of plasma donations collected in Central Europe, with a sample size of more than 9 million and a resolution down to the level of the individual plasma donation, confirms that a Parvovirus B19 resurgence in healthy adults could be observed with up to a 33-fold increased Parvovirus B19 incidence[26]. This Europe-wide outbreak also had an impact on the safety of blood and plasma products[26]. Similar data was recently reported from France, where Parvovirus B19 NAT plasma pool testing also indicated a marked increase in Parvovirus B19 incidence pre- versus post-COVID-19[27]. This outbreak showed an unusual seasonality which was observed in autumn/winter 2023/2024, as normal outbreaks are usually restricted to spring and early summer[9,27]. Moreover, reports from Israel describe a Parvovirus B19 outbreak where the previously existing seasonality has largely disappeared[28,29]. In Germany, an unexpected high incidence of Parvovirus B19 was detected in blood donors in winter/spring of 2023/2024[25]. Overall, the Parvovirus B19 outbreak from 2023/2024 was not a locally confined event. Many European[26] and Middle Eastern countries have reported unusually high numbers of Parvovirus B19 infections in 2023/2024: France[9,27], England[30], the Netherlands[8], Denmark[31], Germany[25], Italy[13,32], and Israel[28].

During roughly the same period, a comparable Parvovirus B19 outbreak was observed in Switzerland. The incidence rate of Parvovirus B19 infections among blood donors in the 2023/2024 outbreak was 1: 662 donations, while in the preceding Swiss outbreaks in 2013 and 2017, incidences were 1: 6,367 and 1: 8,512 donations, respectively. The described outbreak follows a 2-year stretch during

©SIMTIPRO Srl

which no Parvovirus B19 contaminated blood donations were recorded. It has been speculated that the unusual increase in Parvovirus B19 infections that followed the SARS-CoV-2 pandemic was enhanced due to the implemented SARS-CoV-2 restrictions that left a larger than usual cohort of individuals with no previous contact to Parvovirus B19[8,9,26,27,33]. Such a rebound outbreak resulting from low immunity as a reaction to the low infection rates during the COVID-19 pandemic has already been postulated by Russcher and colleagues[8]. In line with this, it has been found that the Parvovirus B19 DNA-positive donors (mean age 30.4 years) were on average slightly younger than the overall donor average (mean age 33.8 years).

Due to the significantly increased rates of infection in blood donors, blood donation services were faced with certain logistical problems, particularly regarding the release of un-pooled labile blood components. The following issues were affected: i) the increased workload, ii) the financial burden due to more testing of sub-pools and individual tests, and iii) the delayed release of labile blood components due to pool resolution testing. The observed incidence per se was still so low that the basic supply of blood products was never at risk. However, it should be mentioned that some donations were only released hours later than usual, which could be critical for the availability of, for example, platelet concentrates (PT) (short shelf-life) or red blood cell concentrates (RBC) with rare blood group combinations. Colleagues from Germany calculated that their testing strategy (pools of 96 donations) is still the most appropriate given the current epidemiological parameters. However, they stated that this strategy must be regularly re-evaluated and, if necessary, adjusted if the number of infections continues to rise, for example by reducing the pool sizes[25].

The global genotype distribution for Parvovirus B19 differs with genotype 1 occurring in Europe, North America and China and genotype 3 being common in Africa, next to genotype 1[34-36]. Not only was the seasonality of the latest outbreak unusual. While previous outbreaks recorded in Switzerland in 2013 and 2017 were caused by genotypes 1a1 and 1a2, the 2023/2024 outbreak was caused by Parvovirus B19 of genotype 1a2 only (**Figure 3**). The data represented here for the 2023/2024 outbreak are in line with other European countries[37-39].

Furthermore, Parvovirus B19 DNA-positive donations came from 33% female and 67% male donors. It should be noted here that because men are allowed to donate more frequently, the ratio of donations made by female to male does not correspond to the sex distribution in the Swiss blood donor population (43% female - 57% male).

CONCLUSIONS

Normally, Parvovirus B19 circulates at a rather low incidence, so that only a few transmissions have occurred through transfusions of labile blood components. In addition, since the introduction of Parvovirus B19 NAT, to our knowledge no TTIs through pathogen-reduced, industrially manufactured plasma derivatives have been published. Europe-wide data including the present study show that after the removal of protective interventions against the SARS CoV-2 pandemic, Parvovirus B19 DNA-positive donations increased drastically in 2023/2024.

DATA AVAILABILITY STATEMENT

The sequence data presented in the study are openly available from the National Center for Biotechnology Information at https: //www.ncbi.nlm.nih.gov/, with accession numbers LT632618 to LT632687 and OZ078671 to OZ078794. Sequences of the 2023/2024 outbreak have accession numbers OZ078728 to OZ078782 and OZ078784 to OZ078794.

ETHICAL CONSIDERATION

The data presented in the article are data from voluntary blood donors, and the analysis conducted on their blood is part of the mandatory routine blood testing performed on all blood donations. As this is a screening test used for all voluntary donations in Switzerland, to which the donors give written consent, no ethics vote was required, and this study was therefore not subject to authorization.

FUNDING

The article summarizes data from mandatory blood testing from voluntary blood donations. No funding was required to conduct the study.

ACKNOWLEDGEMENTS

We thank all the blood transfusion services and their corresponding directors for suppling us with additional material, where required, and information about the donors confirmed positive.

©SMITRO GT

AUTHORS' CONTRIBUTIONS

MSe, PG, NW, MSt, SW, JT, AB, and FSR collected data. MSe, PG, NW, MSt and CN analyzed and discussed data. MSe and CN wrote the manuscript. All Authors revised the manuscript.

The Authors declare no conflicts of interest.

REFERENCES

1. Young NS, Brown KE. Parvovirus B19. N Engl J Med. 2004; 350(6): 586-597. doi: 10.1056/NEJMra030840.
2. Servant A, Laperche S, Lallemand F, Marinho V, De Saint Maur G, Meritet JF, et al. Genetic diversity within human erythroviruses: identification of three genotypes. J Virol. 2002; 76(18): 9124-9134. doi: 10.1128/jvi.76.18.9124-9134.2002.
3. Parsyan A, Candotti D. Human erythrovirus B19 and blood transfusion - an update. Transfus Med. 2007; 17(4): 263-278. doi: 10.1111/j.1365-3148.2007.00765.x.
4. Yu MY, Alter HJ, Virata-Theimer ML, Geng Y, Ma L, Schechterly CA, et al. Parvovirus B19 infection transmitted by transfusion of red blood cells confirmed by molecular analysis of linked donor and recipient samples. Transfusion. 2010; 50(8): 1712-1721. doi: 10.1111/j.1537-2995.2010.02591.x.
5. Brown K. Anaemia, parvovirus, and malaria. Lancet. 2006; 368(9537): 714-716. doi: 10.1016/S0140-6736(06)69265-9.
6. Wu CG, Mason B, Jong J, Erdman D, McKernan L, Oakley M, et al. Parvovirus B19 transmission by a high-purity factor VIII concentrate. Transfusion. 2005; 45(6): 1003-1010. doi: 10.1111/j.1537-2995.2005.04387.x.
7. Brown KE, Young NS, Alving BM, Barbosa LH. Parvovirus B19: implications for transfusion medicine. Summary of a workshop. Transfusion. 2001; 41(1): 130-135. doi: 10.1046/j.1537-2995.2001.41010130.x.
8. Russcher A, van Boven M, Beninca E, Verweij E, Molenaar-de Backer MWA, Zaaijer HL, et al. Changing epidemiology of parvovirus B19 in the Netherlands since 1990, including its re-emergence after the COVID-19 pandemic. Sci Rep. 2024; 14(1): 9630. doi: 10.1038/s41598-024-59582-7.
9. d'Humieres C, Fouillet A, Verdurme L, Lakoussan SB, Gallien Y, Coignard C, et al. An unusual outbreak of parvovirus B19 infections, France, 2023 to 2024. Euro Surveill. 2024; 29(25): 2400339. doi: 10.2807/1560-7917.ES.2024.29.25.2400339.
10. Vukovic V, Patic A, Ristic M, Kovacevic G, Hrnjakovic Cvjetkovic I, Petrovic V. Seroepidemiology of Human Parvovirus B19 Infection among the Population of Vojvodina, Serbia, over a 16-Year Period (2008-2023). Viruses. 2024; 16(2): 180. doi: 10.3390/v16020180.
11. Corcoran A, Doyle S. Advances in the biology, diagnosis and host-pathogen interactions of parvovirus B19. J Med Microbiol. 2004; 53(Pt 6): 459-475. doi: 10.1099/jmm.0.05485-0.
12. Juhl D, Hennig H. Parvovirus B19: What Is the Relevance in Transfusion Medicine? Front Med (Lausanne). 2018; 5: 4. doi: 10.3389/fmed.2018.00004.
13. Candura F, Pati I, De Fulvio L, Massari MS, Piccinini V, Pupella S, et al. Comprehensive analysis of parvovirus B19 infection in blood donors: epidemiological trend and implications for transfusion safety and management strategies in Italy. Blood Transfus. 2025; 23(2): 168-175. doi: 10.2450/BloodTransfus.894.
14. Gowland P, Fontana S, Stolz M, Andina N, Niederhauser C. Parvovirus B19 passive transmission by transfusion of Intercept® Blood System-treated platelet concentrate. Transfus Med Hemother. 2016; 43(3): 198-202. doi: 10.1159/000445195.
15. Candotti D, Etiz N, Parsyan A, Allain JP. Identification and characterization of persistent human erythrovirus infection in blood donor samples. J Virol. 2004; 78(22): 12169-12178. doi: 10.1128/JVI.78.22.12169-12178.2004.
16. Woolf AD, Campion GV, Chishick A, Wise S, Cohen BJ, Klouda PT, et al. Clinical manifestations of human parvovirus B19 in adults. Arch Intern Med. 1989; 149(5): 1153-6. PMID: 2541666.
17. Healy K, Aulin LBS, Freij U, Ellerstad M, Bruckle L, Hillmering H, et al. Prevalence of Parvovirus B19 viremia among german blood donations and the relationship to ABO and Rhesus blood group antigens. J Infect Dis. 2023; 227(10): 1214-1218. doi: 10.1093/infdis/jiac456.
18. Jia J, Zhang M, Ma Y, Zhang J. Human parvovirus B19 research concerning the safety of blood and plasma derivatives in China. Annals of Blood 2019; 4. doi: 10.21037/aob.2019.
19. Kleinman SH, Glynn SA, Lee TH, Tobler LH, Schlumpf KS, Todd DS, et al. A linked donor-recipient study to evaluate parvovirus B19 transmission by blood component transfusion. Blood. 2009; 114(17): 3677-3683. doi: 10.1182/blood-2009-06-225706.
20. Hourfar MK, Mayr-Wohlfart U, Themann A, Sireis W, Seifried E, Schrezenmeier H, et al. Recipients potentially infected with parvovirus B19 by red blood cell products. Transfusion. 2011; 51(1): 129-136. doi: 10.1111/j.1537-2995.2010.02780.x.
21. Juhl D, Ozdemir M, Dreier J, Gorg S, Hennig H. Look-back study on recipients of Parvovirus B19 (B19V) DNA-positive blood components. Vox Sang. 2015; 109(4): 305-311. doi: 10.1111/vox.12295.
22. Juhl D, Gorg S, Hennig H. Persistence of Parvovirus B19 (B19V) DNA and humoral immune response in B19V-infected blood donors. Vox Sang. 2014; 107(3): 226-32. doi: 10.1111/vox.12162.
23. Satake M, Hoshi Y, Taira R, Momose SY, Hino S, Tadokoro K. Symptomatic parvovirus B19 infection caused by blood component transfusion. Transfusion. 2011; 51(9): 1887-1895. doi: 10.1111/j.1537-2995.2010.03047.x.
24. Blumel J, Burger R, Drosten C, Groner A, Gurtler L, Heiden M, et al. Parvovirus B19 - Revised. Transfus Med Hemother. 2010; 37(6): 339-350. doi: 10.1159/000322190.
25. Plumers R, Dreier J, Knabbe C, Vollmer T. Unexpected high incidence of parvovirus B19 nucleic acid detection in German blood donors in the winter/spring season 2023/2024. J Med Virol. 2024; 96(9): e29878. doi: 10.1002/jmv.29878.
26. Farcet MR, Karbiener M, Aberham C, Powers N, Aue D, Kreil TR. Parvovirus B19 rebound outbreak 2024 and implications for blood- and plasma-product safety. Transfusion. 2024; 64(12): 2218-2221. doi: 10.1111/trf.18032.
27. Guillet M, Bas A, Lacoste M, Ricard C, Visse C, Barlet V, et al. New atypical epidemiological profile of parvovirus B19 revealed by molecular screening of blood donations, France, winter 2023/24. Euro Surveill. 2024; 29(21). PMID: 38785091.
28. Patalon T, Saciuk Y, Trotzky D, Pachys G, Ben-Tov A, Segal Y, et al. An outbreak of Parvovirus B19 in Israel. Viruses. 2023; 15(11): 2261. doi: 10.3390/v15112261.
29. Mor O, Wax M, Arami SS, Yitzhaki M, Kriger O, Erster O, et al. Parvovirus B19 outbreak in Israel: retrospective molecular analysis from 2010 to 2023. Viruses. 2024; 16(3): 480. doi: 10.3390/v16030480.
30. Williams S, Ratcliff J, Nguyen D, Simmonds P, Harvala H. Detection frequencies and viral load distribution of parvovirus B19 DNA in blood and plasma donations in England. Transfus Med. 2022; 32(5): 402-409. doi: 10.1111/tme.12893.
31. Nordholm AC, Trier Moller F, Fischer Ravn S, Flink Sorensen L, Moltke-Prehn A, Elskaer Mollerup J, et al. Epidemic of parvovirus B19 and disease severity in pregnant people, Denmark, January to March 2024. Euro Surveill. 2024; 29(24): 2400299. doi: 10.2807/1560-7917.ES.2024.29.24.2400299.
32. Tassis B, Testa L, Pampo F, Boito S, Tiso G, Accurti V, et al. The 2024 outbreak of Parvovirus B19 as a global obstetrical threat insights from an Obstetrics Referral Center in Northern Italy. J Med Virol. 2024; 96(11): e70046. doi: 10.1002/jmv.70046.
33. Drews SJ, Charlton C, O'Brien SF, Burugu S, Denomme GA. Decreasing parvovirus B19 and hepatitis A nucleic acid test positivity rates in Canadian plasma donors following the initiation of COVID-19 restriction in March 2020. Vox Sang. 2024; 119(6): 624-629. doi: 10.1111/vox.13616.
34. Hubschen JM, Mihneva Z, Mentis AF, Schneider F, Aboudy Y, Grossman Z, et al. Phylogenetic analysis of human parvovirus b19 sequences from eleven different countries confirms the predominance of genotype 1 and suggests the spread of genotype 3b. J Clin Microbiol. 2009; 47(11): 3735-3738. doi: 10.1128/JCM.01201-09.
35. Jia J, Ma Y, Zhao X, Huangfu C, Zhong Y, Fang C, et al. Existence of various human parvovirus B19 genotypes in Chinese plasma pools: genotype 1, genotype 3, putative intergenotypic recombinant variants and new genotypes. Virol J. 2016; 13(1): 155. doi: 10.1186/s12985-016-0611-6.
36. Jiang H, Qiu Q, Zhou Y, Zhang Y, Xu W, Cui A, et al. The epidemiological and genetic characteristics of human parvovirus B19 in patients with febrile rash illnesses in China. Sci Rep. 2023; 13(1): 15913. doi: 10.1038/s41598-023-43158-y.
37. Beligni G, Alessandri G, Cusi MG. Genotypic characterization of human Parvovirus B19 circulating in the 2024 outbreak in Tuscany, Italy. Pathogens. 2025; 14(2): 121. doi: 10.3390/pathogens14020121.
38. Creuzet E, Pulby W, Archimbaud C, Brebion A, Chabrolles H, Mirand A, et al. Insights into the clinical and molecular epidemiology of an infections outbreak of human parvovirus B19 in France, 2023-2024. J Clin Virol. 2025; 178: 105798. doi: 10.1016/j.jcv.2025.105798.
39. Veyrenche N, Fourgeaud J, Burgard M, Allali S, Toubiana J, Pinhas Y, et al. Virological characterization of Parvovirus B19 isolated during the atypical 2023-2024 outbreak in France. J Infect. 2025; 90(2): 106409. doi: 10.1016/j.jinf.2025.106409.

©SIMTIPRO Srl