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TRANSFUSION

Whole blood donor behavior and availability after deferral: Consequences of a new ferritin monitoring policy

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Abstract

Background: To prevent (negative consequences of) temporary deferral due to low hemoglobin, the Dutch national blood service Sanquin introduced a ferritin monitoring policy in 2017. Ferritin is measured after the donation (as opposed to before donation for hemoglobin), and low ferritin levels lead to deferral of 6 (ferritin 15-30 ng/mL) or 12 months (ferritin <15 ng/mL). We explored the consequences of this policy on donor behavior and availability.

Study Design and Methods: We included all Dutch whole blood donors who made a donation (attempt) between 13 November and 31 December 2017. At that point, the ferritin monitoring policy was randomly implemented in 8 of 29 regional clusters of collection centers. We extracted information from Sanquin's donor database about donors' deferrals, subsequent donation attempts, and donation cessation (up to 31 December 2019). Donors deferred for low ferritin were compared to those deferred for low hemoglobin or other reasons, as well as to donors who were not deferred.

Results: A total of 55 644 donors were included (11% deferred). For donor behavior, we found that donors deferred for low ferritin less often unsubscribed and switched to other donation types, yet also made fewer donations in the follow-up period. For availability, we found they were less often deferred, yet they were unavailable to donate for a longer period.

Conclusion: Results suggest that the implementation of a ferritin monitoring policy may lead to a decrease in donor availability and reduced donations. However, the policy is successful in retaining more donors and reducing low hemoglobin deferrals.

KEYWORDS

blood donor, deferral, donor behavior, ferritin, hemoglobin

1 | INTRODUCTION

Sanquin, the national blood service in the Netherlands, currently applies multiple deferral criteria that may result

Abbreviations: ANCOVA, analysis of covariance; MANCOVA, multivariate analysis of covariance.

in temporary or permanent deferral. However, temporary deferral may result in donor loss and complicates an adequate blood supply.[1] The duration of a temporary deferral can range from a single day up to 3 years. The most common reason for temporary deferral is low hemoglobin.[2–4] In The Netherlands, approximately 10% of all donation attempts are deferred on-site (ie, at the donation center),[5] 40% of whom are deferred for low hemoglobin.[6] Of these donors deferred on-site for hemoglobin, the large majority (82%) is female.[7] Measurement of hemoglobin levels before donation assures adequate hemoglobin levels in collected blood,[8] prevents anemic blood donors from donating blood, and decreases the risk of health problems after donation.[9] However, on-site low hemoglobin deferral policies also lead to higher donor loss, longer time to first return, and reduced frequency of donation compared to donors who are not deferred,[3] thereby threatening the blood supply due to lower donor availability.

In an attempt to protect whole blood donors from developing anaemia *and* reduce the deferral rate for low hemoglobin levels (and its associated consequences), Sanquin initiated an eligibility screening policy in 2017. This policy includes ferritin measurements for each new donor and at every fifth whole blood donation. Ferritin measurements are tied to actual donation frequency and after implementation of the new ferritin policy, ferritin was measured from donors' 5th, 10th, and 15th, donation and so on. Donors with ferritin levels between 15-30 ng/mL are deferred for 6 months, and donors with ferritin levels below 15 ng/mL are deferred for 12 months.[7] Ferritin levels are measured 1 to 2 days after the blood donation takes place or after blood samples are drawn (in the case of new donors). Further details about the ferritin monitoring policy can be found in Sweegers et al.[7] In case of low ferritin levels, donors receive a letter or email with information regarding the deferral. These donors are not advised to make any changes to their daily habits and are only advised to visit their general practitioner in the case of iron deficiency–related complaints. After the deferral for low ferritin levels has ended, donors' ferritin levels are remeasured (either from blood taken during the next donation, or—when a donor has been deferred for low ferritin before—from blood samples drawn for this dedicated purpose). When ferritin is <30 ng/mL again, the ferritin level is remeasured after 6 or 12 months' deferral, before the donor is allowed to donate. These ferritin deferrals are different from most other deferrals because the deferrals takes place *after* the donor has donated. This may influence the experience of the deferral. For instance, it may lead to fewer negative emotions compared to on-site deferrals such as low hemoglobin.[10] Additionally, these ferritin deferrals are longer in duration than many other deferrals (eg, the standard deferral time for low hemoglobin is 3 months in the Netherlands[7]). Therefore, the implementation of the new ferritin monitoring policy may have altered donor return behavior. We aimed to investigate the consequences of the new ferritin monitoring policy by comparing donor behavior and availability of donors deferred for low ferritin levels to those of donors deferred for low hemoglobin levels or other criteria, using data from Dutch whole blood donors.

2 | METHOD

2.1 | Participants

We included all whole blood donors who provided consent for their information to be used for medical scientific research, and who made a donation (attempt) between 13 November and 31 December 2017. We included both donors who donated at a collection center that had implemented the ferritin monitoring policy at that time and donors who donated at a different centre. The ferritin monitoring policy was implemented according to a stepped wedge cluster randomized design and only 8 (of 29) regional clusters had implemented the policy on 13 November 2017. The ferritin monitoring policy was implemented at the other regional clusters throughout the follow-up period (see Sweegers et al[7] for a detailed explanation of the implementation).

2.2 | Setting

The Dutch donor population consists of voluntary non-remunerated donors, and when eligible, men are allowed to donate whole blood a maximum of five times a year (minimum interval of 56 days) and women a maximum of three times a year (minimum interval of 122 days). Whole blood donors receive an invitation via (postal) mail to visit one of the collection centers during a 2-week walk-in period. Even though some blood groups may be invited more frequently than others based on demand for their blood type, Sanquin strives that all donors donate at least once a year (for more information about the donor population and its characteristics, see Timmer et al[11]). The wording in the invitation is exactly the same for all donors, so previously deferred donors are invited in the same way as donors who made a successful donation previously. To reduce disappointment for both the donor and the blood bank as a result of showing up needlessly, donors are encouraged to complete a short version of the donor health questionnaire online before visiting one of the collection centers for a whole blood donation. This questionnaire includes questions related to general health, recent

visits abroad, pregnancy, medical treatment, tattoos or piercings, acupuncture, sexual behavior, dental visits, and specific diseases. Based on the responses, a donor may be temporarily deferred before visiting one of the collection centers (ie, off-site self-deferral). All donors who visit a collection center are checked for eligibility to donate using the full version of the donor health questionnaire and measurements of hemoglobin levels and blood pressure. Based on the physical examination, donors are allowed to donate if hemoglobin levels are >7.8 mmol/L (125 g/L) for women or >8.4 mmol/L (135 g/L) for men, diastolic blood pressure is 50 to 100 mm Hg, and systolic blood pressure is 90 to 180 mm Hg. Any reason for deferral that comes to light during this process is referred to as on-site deferral. Because deferral due to low ferritin levels takes place after the donation (and thus, the donor was deemed eligible to donate at the time), this kind of donation can be referred to as postdonation deferral.

2.3 | Data extraction

Each donor's first whole blood donation attempt in the period 13 November to 31 December 2017 was referred to as their index donation (attempt). For these donors, we extracted information about donor characteristics, past donation frequency, information about the index donation, and information about subsequent visits to blood collection centers (including deferrals influencing whole blood donation and whether the donor unsubscribed) up to 31 December 2019 from the donor database (eProgesa, 5.03; Mak-system, Paris, France). Based on the predonation screening and ferritin measurement (if available) of the index donation, every donor was categorized into one of the following index donation categories: (a) eligible to donate (no deferral), (b) deferred due to low hemoglobin levels (<7.8 mmoL/L and 8.4 mmoL/L for women and men, respectively), (c) deferred due to ferritin <15 ng/mL, (d) deferred due to ferritin 15-30 ng/mL, or (e) deferred for other reasons. Because the ferritin monitoring policy was not implemented at all donation centers at the time of the index donation (attempt), the low-ferritin groups consisted only of donors who donated at a donation center within the eight regional clusters that had implemented the policy at that time. For donations in the follow-up period, we considered only whole blood donation attempts, as the method of inviting donors is different for other donation types. Hence, we checked whether donors switched to another donation type. Sanquin Blood Bank recruits plasma donors from active whole blood donors, and these donors are asked to make an appointment for their next donation when they present at the donation center. Generally, if a donor switches to plasma donation, a donor does not switch back to whole blood donation. Thus, donors who made a plasma donation during the follow-up period were considered as switched donors. For other donation types, such as thrombocytapheresis, erythrocytes, or a therapeutic blood draw, donors are often personally invited after careful selection and tissue typing, and it is possible to switch temporarily and resume donating whole blood. Therefore, we considered a donor switched if three or more subsequent donations were registered for another donation type, without a subsequent whole blood donation.

2.4 | Data analyses

Descriptive statistics are presented (mean and SD or SE, or median and interquartile range) for all included donors. Age was calculated from date of birth at the time of the index donation. Hemoglobin (mmol/L; Hemocue AB, Ängelholm, Sweden) was measured at the time of the index donation. Donor behavior was operationalized as switching from whole blood to a different donation type, the frequency of whole blood donations, the ratio between the number of donations and the number of invitations, and donation cessation. Donation cessation is considered to be the case when Sanquin no longer actively invites the donor for donation. This may be either donor or Sanquin initiated (eg, due to medical reasons). Donors who do not respond to invitations but are still actively invited are thus not considered to be ceased donors. We categorized these donors into five donation cessation categories: (a) no contact (ie, donors that Sanquin is not able to reach and can be considered lost, such as donors who have not responded to five invitations to donate); (b) medical (ie, donors who are not allowed to donate anymore due to a medical condition or feel unfit to donate); (c) unable to donate (ie, donors who can no longer donate due to external factors, such as moving abroad or passing the upper age limit); (d) too many deferrals (eg, donors who are repeatedly deferred for low hemoglobin); (e) other (all other reasons, all of whom are provided by the donor, such as "personal reasons," being unsatisfied with blood bank policy, or inconvenient opening times). Donor availability was operationalized as the number of deferrals in the follow-up period and the ratio between the total number of days in the follow-up and the number of days deferred during that period. To investigate differences on measures of donor behavior and donor availability between index donation categories (ie, eligible donors, donors deferred for low hemoglobin levels, donors deferred for ferritin <15 ng/mL, donors deferred for ferritin 15 to 30 ng/mL, and donors deferred for other reasons), we used χ^2 tests for categorical outcome measures

and (multivariate) analyses of covariance (MANCOVA/ANCOVA) for continuous outcome measures. In the MANCOVA/ANCOVA, we entered age, the number of donations in the 2 years before the index donation, and the donation interval since the last donation (in days) into the model as covariates because they correlated significantly with our outcome measures. For our analyses, we used information from whole blood donations only, and results are presented separately for men and women. We applied Bonferroni correction for multiple testing wherever we used pairwise comparisons to compare specific index donation categories.

3 | RESULTS

Between 13 November and 31 December 2017, 55 864 whole blood donors visited a donation center. Of these, 16 795 donors (30%) visited a donation center within one of the eight regional clusters that had implemented the new ferritin policy. Based on the index donation, we excluded 189 donors who were permanently deferred, four donors who received a postdonation deferral due to additional confirmation tests or other medical reasons, and 27 donors for whom data was insufficient to determine whether the donor was deferred. Of the total 55 644 donors (48.3% female) included in the data set, 4473 were deferred during the predonation screening. Of them, 2262 (4.1%) were deferred for low hemoglobin and 2211 (4.0%) were deferred for other reasons. Ferritin was measured for 2814 out of the 51 171 donors who made a donation, resulting in 599 (1.1%) donors deferred due to ferritin levels <15 ng/mL and 916 donors (1.6%) donors deferred due to ferritin levels 15 to 30 ng/mL. Thus, 49 656 donors (89.2%) made a successful donation without any on-site deferral or postdonation ferritin deferral. Donor characteristics for the different index donation categories are presented in Table 1.

3.1 | Donor behavior

3.1.1 | Donation cessation

A total of 4054 donors (7.3%) ended their donor career, with an even split between females and males. We calculated differences for the total number of donors ceasing their donor career between index donation categories. Descriptives of the reasons why donors ended their donor career and results of pairwise comparisons of the total

TABLE 1 Donor characteristics

	No deferral	Hb < 8.4 mmol/L	Ferritin <15 ng/mL	Ferritin 15-30 ng/mL	Other deferral
Male donors, N	26 204	762	274	509	1025
Age, y, median (IQR)	52 (37-60)	55 (44-62)	53 (38-60)	53 (42-61)	53 (36-61)
Hemoglobin, mmol/L, median (IQR)	9.3 (8.9-9.7)	8.1 (7.9-8.2)	8.8 (8.5-9.2)	9.2 (8.8-9.7)	9.3 (8.9-9.9)
Ferritin, ng/mL, median (IQR)	52 (39-76)	n/a[a]	12 (10-13)	22 (18-25)	n/a
Number of whole blood donations in past 2 years, median (IQR)	6 (3-8)	7 (5-9)	8 (6-9)	7 (5-9)	5 (2–7)
Time since last whole blood donation, d, median (IQR)	90 (70-132)	77 (64-105)	77 (65-103)	84 (70-112)	104 (74-161)
	No deferral	**Hb < 7.8 mmol/L**	**Ferritin <15 ng/mL**	**Ferritin 15–30 ng/mL**	**Other deferral**
Female donors, N	23 452	1500	325	407	1186
Age, y, median (IQR) Postmenopausal, %	43 (27-55) 53	35 (24-49) 35	41 (27-51) 42	46 (31-56) 54	40 (27-56) 45
Hemoglobin, mmol/L, median (IQR)	8.5 (8.1-8.9)	7.5 (7.3-7.6)	8.2 (7.8-8.6)	8.5 (8.2-8.8)	8.5 (8.1-8.9)
Ferritin, ng/mL, median (IQR)	48 (37-62)	n/a[a]	10 (8-13)	23 (19-26)	n/a
Number of whole blood donation in past 2 years, median (IQR)	3 (1-5)	3 (2-5)	4 (3-5)	4 (3-5)	3 (1-4)
Time since last whole blood donation, d, median (IQR)	151 (132-208)	140 (128-175)	139 (127-175)	151 (133-196)	159 (133-236)

[a]Sanquin's policy prescribes that ferritin is only measured among donors deferred for low hemoglobin when there is an explicit reason to do so, such as recurring low hemoglobin deferrals. Hence, ferritin levels were only measured for 11 male and 15 female donors deferred for low hemoglobin. Therefore, ferritin levels are not an adequate representation for this group and, hence, left out of the table.

number of donors ceasing their donor career are presented in Table 2.

For male donors, we found a significant difference between index donation categories in the number of donors ending their donor career (χ^2 (4) = 78.03; $P < .001$). Focusing on the ferritin categories, we see that donors in both the ferritin <15 ng/mL and in the ferritin 15 to 30 ng/mL categories (3.8% and 3.1%, respectively) unsubscribed significantly fewer compared to donors deferred for hemoglobin (10.7%) and other reasons (12.4%; (χ^2's(1) > 10, *P's* < .02). The ferritin 15 to 30 ng/mL category also unsubscribed significantly fewer compared to the no deferral category (6.8%; χ^2 (1) = 78.03; $P = .01$).

For female donors, we also found a significant difference between index donation categories in the number of donors ending their donor career (χ^2 (4) = 160.32; $P < .001$). We see a similar pattern for female donors compared to male donors in the ferritin-deferred categories. The ferritin <15 ng/mL category (3.0%) and the ferritin 15 to 30 ng/mL category (6.2%) unsubscribed significantly fewer compared to both the hemoglobin deferral category (13.9%) and the deferral for other reasons category (12.9%; χ^2's (1) > 13, *P*'s < .01). No significant differences were found between the ferritin categories and the no deferral category (6.9%; χ^2's (1) < 6; *P*'s > .1).

3.1.2 | Switch to other donation types

A total of 2266 donors (4.1%) switched from being whole blood donor to a different donation type during the follow-up period (see Table 3), about half of whom were men (49%). For male donors, we found no differences between the index donation categories in the number of donors switching to other donation types ($P = .21$). For female donors, we found a significant difference between index donation categories in terms of the number of donors who switched to a different donation type (χ^2 (4) = 9.60; $P = .048$). Particularly female donors deferred for low ferritin were significantly less likely to switch (2.2% switched in both ferritin categories) compared to the hemoglobin deferral category (4.6%) and the other reason deferral category (5.0%; χ^2's (1) > 4; *P*'s = .05). In total, 649 of the donors

TABLE 2 Descriptives and χ^2 comparisons[a] of donation cessation in the follow-up period per index donation category (Bonferroni correction for multiple comparisons applied)

	No deferral	Hb < 8.4 mmol/L	Ferritin <15 ng/mL	Ferritin 15-30 ng/mL	Other deferral
Male donors, N	26 204	776	260	509	1026
No contact, N (%)	950 (53.0)	24 (28.9)	3 (30.0)	6 (37.5)	59 (46.5)
Medical, N (%)	404 (22.6)	20 (24.1)	2 (20.0)	4 (25.0)	38 (29.9)
Unable to donate, N (%)	95 (5.3)	4 (4.8)	1 (10.0)	1 (6.3)	4 (3.2)
Too many deferrals, N (%)	4 (0.2)	3 (3.6)	0 (0.0)	0 (0.0)	0 (0.0)
Other, N (%)	338 (18.9)	32 (38.6)	4 (40.0)	5 (31.3)	26 (20.5)
Total, N (%)	1791 (6.8)[c, e, f]	83 (10.7)[b, d, e]	10 (3.8)[c, f]	16 (3.1)[b, c, f]	127 (12.4)[b, d, e]
	No deferral	**Hb < 7.8 mmol/L**	**Ferritin <15 ng/mL**	**Ferritin 15-30 ng/mL**	**Other deferral**
Female donors, N	23 452	1563	265	405	1188
No contact, N (%)	825 (50.8)	87 (40.1)	3 (37.5)	6 (24.0)	80 (52.3)
Medical, N (%)	238 (14.7)	53 (24.4)	4 (50.0)	8 (32.0)	29 (19.0)
Unable to donate, N (%)	148 (9.1)	9 (4.2)	0 (0.0)	3 (12.0)	6 (3.9)
Too many deferrals, N (%)	6 (0.4)	7 (3.2)	0 (0.0)	0 (0.0)	2 (1.3)
Other, N (%)	407 (25.1)	61 (28.1)	1 (12.5)	8 (32.0)	36 (23.5)
Total, N (%)	1624 (6.9)[c, f]	217 (13.9)[b, d, e]	8 (3.0)[c, f]	25 (6.2)[c, f]	153 (12.9)[b, d, e]

Note: Superscript denotes statistically significant differences from groups b-f ($P < .05$).

[a]Only the total number of ceased donors is compared, as too little data was available to compare the different reasons for donor cessation.

[b]Significantly different from the no deferral group ($P < .05$).

[c]Significantly different from the low hemoglobin deferral group ($P < .05$).

[d]Significantly different from the ferritin <15 ng/mL deferral group ($P < .05$).

[e]Significantly different from the ferritin 15-30 ng/mL deferral group ($P < .05$).

[f]Significantly different from the other deferral group ($P < .05$).

(40% male) who switched to other donation types did so immediately after the index donation, so these donors did not have any opportunity to return for further whole blood donations. Therefore, these 649 donors are left out of the following analyses.

3.1.3 | Number of donations

We also tested whether the total number of whole blood donations during the follow-up period differed between the index donation categories (see Table 4). Male donors donated, on average, 6.2 times (SD, 2.75) during the follow-up, while female donors donated 4.0 times (SD, 1.68) during that period.

For male donors, we found a univariate difference between index donation categories on the number of donations made in the follow-up period (F [4, 26 995] = 423.68; $P < .001$, $\eta_p^2 = .06$). Results of pairwise comparisons of estimated marginal means showed that all deferral categories differed significantly from one another in terms of the number of whole blood donations made during the follow-up period. Especially donors deferred for ferritin made many fewer donations on average (2 and 3.6 for donors deferred for ferritin <15 ng/mL and ferritin 15 to 30 ng/mL, respectively) compared to the other index donation categories.

For female donors, we also found significant univariate effects on the number of donations in the follow-up period (F [4, 23 060] = 229.05; $P < .001$, $\eta_p^2 = .04$). Again, we observed that both ferritin categories led to significantly fewer donations during the follow-up period (1.9 and 3.1 for the ferritin <15 ng/mL and the 15-30 ng/mL categories, respectively) compared to the other.

3.1.4 | Ratio donations/invitations

Next, we looked at the ratio between donations and invitations. Because a whole blood donation (attempt) is always preceded by an invitation at Sanquin, we looked only at the last invitation and checked whether this was followed by a whole blood donation attempt. If a donation attempt was registered after the last invitation, this ratio is 1, as the donor responded to all invitations. A lower score indicates that the last invitation was not followed by a donation attempt in the follow-up period (and the ratio is influenced by the total number of donations made during the follow-up period). Results for both male and female donors are shown in Table 5.

TABLE 3 χ^2 comparisons of the number of donors switched from whole blood to other donation types in the follow-up period per index donation category (Bonferroni correction for multiple comparisons applied)

	No deferral	Low hemoglobin	Ferritin <15 ng/mL	Ferritin 15-30 ng/mL	Other deferral
Male donors, N (%)	1013 (3.9)	22 (2.9)	6 (2.2)	20 (4.0)	48 (4.7)
Female donors, N (%)	1013 (4.3)[c]	69 (4.6)[b,c]	7 (2.2)[a,d]	9 (2.2)[a,d]	59 (5.0)[b,c]

Note: Superscript denotes statistically significant differences from groups a-d ($P < .05$).
[a]Significantly different from the low hemoglobin deferral group ($P < .05$).
[b]Significantly different from the ferritin <15 ng/mL deferral group ($P < .05$).
[c]Significantly different from the ferritin 15-30 ng/mL deferral group ($P < .05$).
[d]Significantly different from the other deferral group ($P < .05$).

TABLE 4 Estimated marginal means for the total number of whole blood donations in the follow-up period per index donation category, adjusted for covariates at their mean value (Bonferroni correction for multiple comparisons applied)

	No deferral	Low hemoglobin	Ferritin <15 ng/mL	Ferritin 15-30 ng/mL	Other deferral
Male donors, estimated marginal mean (SE)	6.42 (0.2)[b,c,d,e]	5.40 (0.09)[a,c,d,e]	2.00 (0.14)[a,b,d,e]	3.63 (0.11)[a,b,c,e]	5.99 (0.08)[a,b,c,d]
Female donors, estimated marginal mean (SE)	4.13 (0.01)[b,c,d]	3.77 (0.04)[a,c,d,e]	1.87 (0.09)[a,b,d,e]	3.09 (0.08)[a,b,c,e]	4.05 (0.05)[b,c,d]

Note: Superscript denotes statistically significant differences from groups a-e ($P < .05$).
[a]Significantly different from the no deferral group ($P < .05$).
[b]Significantly different from the low hemoglobin deferral group ($P < .05$).
[c]Significantly different from the ferritin <15 ng/mL deferral group ($P < .05$).
[d]Significantly different from the ferritin 15-30 ng/mL deferral group ($P < .05$).
[e]Significantly different from the other deferral group ($P < .05$).

For male donors, we found significant univariate differences between the index donation categories on the response rate (F [4, 26 995] = 20.38; $P < .001$, $\eta_p^2 = .003$). Pairwise comparisons of estimated marginal means showed that the response rate was highest among donors who were not deferred and lowest among donors deferred for ferritin <15 ng/mL or for other reasons.

For female donors, we also found a univariate difference between the index donation categories (F [4, 23 060] = 19.65; $P < .001$; $\eta_p^2 = .003$). This time, however, we found that the response was highest among donors who were not deferred or deferred for ferritin 15 to 30 ng/mL, whereas the response rate was significantly lower among donors deferred for low hemoglobin, for ferritin <15 ng/mL, and for other reasons.

3.2 | Donor availability

3.2.1 | Number of deferrals

To investigate differences in the number of deferrals during the follow-up period, we looked at differences between the index donation categories on the number of deferrals due to hemoglobin, ferritin <15 ng/mL, ferritin 15 to 30 ng/mL, and other reasons, as well as the total number of deferrals during the follow-up period. Results for both male and female donors are presented in Table 6.

For male donors, we found a significant multivariate difference between the index donation categories (Wilk's $\lambda = .97$; F [16, 82 462.56] = 56.13; $P < .001$; $\eta_p^2 = .008$). Univariate tests showed differences of index donation category for each of the individual deferrals ($F's > 15$; $P's < .001$; range, $\eta_p^2 = .002$-.02). Pairwise comparisons of estimated marginal means showed that the average total number of deferrals and the number of deferrals for other reasons in the follow-up period was significantly lower among donors deferred for low ferritin (both <15 and 15-30 ng/mL) than the other categories. Additionally, we found that the donors in the low hemoglobin category on average received more ferritin-related deferrals in the follow-up period than any of the other categories.

For female donors, we also found a significant multivariate difference between index donation categories (Wilk's $\lambda = .95$; F [16, 70 440.94] = 81.23; $P < .001$; $\eta_p^2 = .01$). Univariate tests showed differences for each of the individual deferrals ($F's > 15$, $P's < .001$; range $\eta_p^2 = .003$-.04). Similar to male donors, we found that female donors in the ferritin <15 ng/mL category received significantly fewer total deferrals and deferrals for other reasons during the follow-up period. In contrast to male donors, we found that the number of ferritin-related deferrals (both <15 and 15-30 ng/mL) was higher among the ferritin index donation categories than the other categories. The number of hemoglobin deferrals was lower among the ferritin categories compared to the other categories. At the same time, donors in the hemoglobin index donation category received significantly more hemoglobin deferrals during the follow-up period in comparison to the other categories.

3.2.2 | Deferral rate

Finally, we looked at differences between the index donation categories in the deferral rate during the follow-up period. The deferral rate was operationalized as the ratio between the number of days a donor was deferred vs the total follow-up time (in days). A deferral rate of 1 thus means that the donor was deferred for the entire time in the follow-up period and, hence, unavailable to donate, while lower values indicate higher availability of the donor. Table 7 shows the results for both male and female donors.

TABLE 5 Estimated marginal means for the response rate (ratio of number of donations vs number of invitations) in the follow-up period per index donation category, adjusted for covariates at their mean value (Bonferroni correction for multiple comparisons applied)

	No deferral	Low hemoglobin	Ferritin <15 ng/mL	Ferritin 15-30 ng/mL	Other deferral
Male donors, estimated marginal mean (SE)	0.92 (0.001)[b,c,e]	0.90 (0.004)[a]	0.89 (0.01)[a]	0.91 (0.01)[e]	0.89 (0.004)[a,d]
Female donors, estimated marginal mean (SE)	0.89 (0.001)[b,c,e]	0.87 (0.004)[a,d]	0.85 (0.01)[a,d]	0.90 (0.01)[b,c,e]	0.86 (0.01)[a,d]

Note: Superscript denotes statistically significant differences from groups a-e ($P < .05$).
[a]Significantly different from the no deferral group ($P < .05$).
[b]Significantly different from the low hemoglobin deferral group ($P < .05$).
[c]Significantly different from the ferritin <15 ng/mL deferral group ($P < .05$).
[d]Significantly different from the ferritin 15-30 ng/mL deferral group ($P < .05$).
[e]Significantly different from the other deferral group ($P < .05$).

For male donors, a significant univariate effect of deferral category was found (F [4, 26 995] = 799.44; $P < .001$; $\eta_p^2 = .11$). Results of pairwise comparisons for estimated marginal means showed that male donors deferred for ferritin <15 ng/mL had a significantly higher deferral rate than all other index donation categories,

TABLE 6 Estimated marginal means for number of deferrals during the follow-up period per index donation category, adjusted for covariates at their mean value (Bonferroni correction for multiple comparisons applied)

	No deferral	Low hemoglobin	Ferritin <15 ng/mL	Ferritin 15-30 ng/mL	Other deferral
Male donors, N	24 544	751	273	501	934
Total deferrals, mean (SE)	1.65 (0.01)[b,c,d,e]	2.03 (.05)[a,c,d,e]	.58 (.09)[a,b,e]	.83 (.07)[a,b,e]	1.80 (.05)[a,b,c,d]
Hemoglobin deferrals, mean (*SE*)	.22 (0.004)[b,c,d,e]	.63 (.02)[a,c,d,e]	−.03 (.03)[a,b,e]	.002 (.03)[a,b,e]	.16 (.02)[a,b,c,d]
Ferritin <15 deferrals, mean (SE)	.11 (0.002)[b]	.22 (.01)[a,c,d,e]	.14 (.02)[b]	.08 (.02)[b]	.10 (.01)[b]
Ferritin 15–30 deferrals, mean (SE)	.24 (0.003)[c,d,e]	.22 (.02)[d]	.13 (.03)[a]	.12 (.02)[a,b]	.16 (.02)[a]
Other deferrals, mean (SE)	1.08 (0.01)[c,d,e]	.96 (.05)[c,d,e]	.34 (.08)[a,b,d,e]	.62 (.06)[a,b,c,e]	1.38 (.04)[a,b,c,d]
	No deferral	**Low hemoglobin**	**Ferritin <15 ng/mL**	**Ferritin 15–30 ng/mL**	**Other deferral**
Female donors, N	20 034	1351	299	382	1002
Total deferrals, mean (SE)	1.58 (0.01)[b,c,e]	2.01 (0.04)[a,c,d,e]	1.06 (0.08)[a,b,d,e]	1.41 (0.07)[b,c,e]	1.80 (0.4)[a,b,c,d]
Hemoglobin deferrals, mean (SE)	0.19 (0.004)[b,c,d]	0.59 (0.01)[a,c,d,e]	0.02 (0.03)[a,b,e]	0.05 (0.03)[a,b,e]	0.16 (0.02)[b,c,d]
Ferritin <15 deferrals, mean (SE)	0.12 (0.003)[b,c,d,e]	0.20 (0.01)[a,c,d,e]	0.36 (0.02)[a,b,e]	0.31 (0.02)[a,b,e]	0.08 (0.01)[a,b,c,d]
Ferritin 15–30 deferrals, mean (*SE*)	0.15 (0.003)[b,d,e]	0.09 (0.01)[a,c,e]	0.20 (0.02)[b,e]	0.25 (0.02)[a,b,e]	0.11 (0.01)[a,c,d]
Other deferrals, mean (SE)	1.13 (0.01)[c,d,e]	1.13 (0.03)[c,d,e]	0.48 (0.07)[a,b,d,e]	0.81 (0.06)[a,b,c,e]	1.44 (0.04)[a,b,c,d]

Note: Superscript denotes statistically significant differences from groups a-e ($P < .05$).
[a]Significantly different from the no deferral group ($P < .05$).
[b]Significantly different from the low hemoglobin deferral group ($P < .05$).
[c]Significantly different from the ferritin <15 ng/mL deferral group ($P < .05$).
[d]Significantly different from the ferritin 15-30 ng/mL deferral group ($P < .05$).
[e]Significantly different from the other deferral group ($P < .05$).

TABLE 7 Estimated marginal means for the deferral rate (ratio of time deferred vs total time in the follow-up) per index donation category, adjusted for covariates at their mean value (Bonferroni correction for multiple comparisons applied)

	No deferral	Low hemoglobin	Ferritin <15 ng/mL	Ferritin 15–30 ng/mL	Other deferral
Male donors, estimated marginal mean (SE)	0.18 (0.001)[b,c,d,e]	0.44 (0.01)[a,c,d,e]	0.61 (0.01)[a,b,d,e]	0.37 (0.01)[a,b,c,e]	0.31 (0.01)[a,b,c,d]
Female donors, estimated marginal mean (SE)	0.18 (0.001)[b,c,d,e]	0.44 (0.01)[a,c,d,e]	0.72 (0.01)[a,b,d,e]	0.52 (0.01)[a,b,c,e]	0.32 (0.01)[a,b,c,d]

Note: Superscript denotes statistically significant differences from groups a-e ($P < .05$).
[a]Significantly different from the no deferral group ($P < .05$).
[b]Significantly different from the low hemoglobin deferral group ($P < .05$).
[c]Significantly different from the ferritin <15 ng/mL deferral group ($P < .05$).
[d]Significantly different from the ferritin 15-30 ng/mL deferral group ($P < .05$).
[e]Significantly different from the other deferral group ($P < .05$).

followed by donors in the low hemoglobin category and donors in the ferritin 15 to 30 ng/mL category. Donors in the no deferral index donation category had the lowest deferral rate and thus the highest availability.

For female donors, we found significant univariate differences between index donation categories (F [4, 23 059] = 1221.43; $P < .001$; $\eta_p^2 = .18$). Similar to male donors, we found that deferral rate was highest among the group of donors who were deferred for ferritin <15 ng/mL, followed by donors deferred for ferritin 15 to 30 ng/mL, and donors deferred for low hemoglobin.

4 | DISCUSSION

In this study, we sought to investigate the consequences of a new ferritin monitoring policy on whole blood donor behavior and availability. For donor behavior, we found that donors deferred for low ferritin were retained better in terms of fewer donors ending their donor career and fewer donors switching to other donation types. However, we also found that these donors donated fewer times during the follow-up period and had a somewhat lower response rate to donation invitations, especially among donors deferred for ferritin <15 ng/mL. For donor availability, we found that donors deferred for low ferritin were deferred less often during the follow-up period, but nevertheless were not available to donate for longer periods of time.

A little over 10% of donors included were deferred on-site at the start of our study. In line with previous findings, the most common cause of deferral was low hemoglobin.[4,8,9] The new ferritin monitoring policy was initiated to reduce the high rates of hemoglobin deferral *and* protect whole blood donors from developing anemia. While we did not investigate the impact of the new policy on ferritin levels or health among donors, our results suggest the new policy is successful in reducing the deferral rate for low hemoglobin levels. In accordance with previous research, donors in our ferritin categories had fewer deferrals for low hemoglobin in the follow-up period.[12] However, the difference in duration of deferrals (standard periods ranging from 3 months for low hemoglobin to 12 months for ferritin <15 ng/mL) may have played a role in the reduction of deferrals during the follow-up period.

Unsurprisingly, in light of the longer deferral period, ferritin deferral appears to have had a negative effect on donor availability. Previous research has shown that deferred donors make fewer donations, and this was the case in our study as well.[1,3] Donors in all deferral categories donated fewer times compared to donors in the nondeferred category, and this difference was most evident in the ferritin categories, particularly the ferritin <15 ng/mL category. This finding is in line with the findings from a study that also used a 2-year follow-up period after ferritin measurement, as Goldman and colleagues[13] also found that donors with low ferritin (<25 μg/L) made fewer donations during the follow-up period. It seems plausible that the longer deferral period also plays a salient role in the lower number of whole blood donations made by donors in the ferritin categories. Such long periods of donor unavailability are a risk for blood collection agencies and require recruitment of new donors. Otherwise, blood collection agencies might put an unnecessary strain on donors currently not deferred for ferritin, thereby depleting their ferritin levels, and risk negating the beneficial effects of the ferritin monitoring policy. Donors in all deferral categories, except the ferritin 15 to 30 ng/mL category, were less likely to return for their next donation after receiving an invitation to donate compared to nondeferred donors. Donors in the ferritin 15 to 30 ng/mL category fared better, especially female donors who showed a higher response rate compared to the other deferral categories. This suggests that ferritin-related deferral does not necessarily lower the motivation to donate compared to other deferrals. In fact, donors whose donation has been deferred for low ferritin receive a letter stating that their ferritin will be measured again at their next visit to the donation center, which in itself may be a motivator for these donors to return.

The results indicate a positive effect of the new policy on donation cessation as donors deferred for low ferritin were the least likely to cease their donor career. This is surprising as the lower return rate of deferred donors is well documented.[1,6,14–16] The lower number of deferrals and shift from on-site deferral to deferral *after* the donor has donated (ie, postdonation deferral) might be responsible for this reduced cessation. Our study provides additional evidence that deferral length is not a critical factor for ceasing a donor career,[7] as the deferral categories with the longest duration of deferral (ie, the ferritin deferral categories) were the least likely to end their donor career.

Even though we followed the behavior of the donors for a crucial 2-year period, it is possible that longer-term effects might be present that we are currently unable to detect. For example, availability and donations may increase long term due to fewer deferrals and healthier donors as a result of increasing ferritin levels.

When introducing new policies such as the ferritin monitoring policy, consequences can be far-reaching and evaluation is necessary. Vinkenoog and colleagues[12] show promising results of the policy for donor ferritin levels and postulate two other important evaluation criteria: the effect on donor health and on the blood

supply. While further research on the effect of the new policy on ferritin levels and donor health is being conducted,[11] this study investigated the effects on donor behavior and availability primarily for possible consequences of the policy for the blood supply. Policies aimed at protecting whole blood donors often conflict with goals for the blood supply.[17] Initial results suggest that other blood collection agencies considering a similar ferritin policy can expect a decrease in donor availability and reduced donations. However, results show that the policy is effective in reducing deferrals for low hemoglobin and donation cessation. More research with longer follow-up periods will be necessary to assess the impact of the ferritin monitoring policy on the blood supply and examine if the long-term promise of the new ferritin policy will be fulfilled.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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REFERENCES

1. Custer B, Chinn A, Hirschler NV, Busch MP, Murphy EL. The consequences of temporary deferral on future whole blood donation. Transfusion. 2007;47:1514–1523.
2. Iqbal H, Tameez Ud Din A, Tameez Ud Din A, FMD C, Younas M, Jamil A. Frequency and causes of deferral among blood donors presenting to combined military hospital Multan. Cureus. 2020;12:e6657.
3. Hillgrove T, Moore V, Doherty K, Ryan P. The impact of temporary deferral due to low hemoglobin: future return, time to return, and frequency of subsequent donation. Transfusion. 2011;51:539–547.
4. Shrivastava M, Shah N, Navaid S, Agarwal K, Sharma G. Blood donor selection and deferral pattern as an important tool for blood safety in a tertiary care hospital. Asian J Transfus Sci. 2016;10:122–126.
5. De Kort W, van den Burg P, Geerligs H, Pasker-de Jong P, Marijt-van der Kreek T. Cost-effectiveness of questionnaires in preventing transfusion-transmitted infections. Transfusion. 2014;54:879–888.
6. Spekman MLC, van Tilburg TG, Merz E-M. Do deferred donors continue their donations? A large-scale register study on whole blood donor return in the Netherlands. Transfusion. 2019;59:3657–3665.
7. Sweegers MG, Zalpuri S, Quee FA, et al. Ferritin measurement IN donors—effectiveness of iron monitoring to diminish iron deficiency and low haemoglobin in whole blood donors (FIND'EM): study protocol for a stepped wedge cluster randomised trial. Trials. 2020;21:823.
8. World Health Organization. Blood Donor Selection: Guidelines on Assessing Donor Suitability for Blood Donation. World Health Organization: Luxembourg, 2012. https://apps.who.int/iris/bitstream/handle/10665/76724/9789241548519_eng.pdf
9. Boulton F. Evidence-based criteria for the care and selection of blood donors, with some comments on the relationship to blood supply, and emphasis on the management of donation-induced iron depletion. Transfus Med. 2008;18:13–27.
10. Gemelli CN, Thijsen A, Van Dyke N, Masser BM, Davison TE. Emotions experienced when receiving a temporary deferral: perspectives from staff and donors. ISBT Sci Ser. 2018;13:394–404.
11. Timmer TC, de Groot R, Habets K, et al. Donor InSight: characteristics and representativeness of a Dutch cohort study on blood and plasma donors. Vox Sang. 2019;114:117–128.
12. Vinkenoog M, van den Hurk K, van Kraaij M, van Leeuwen M, Janssen MP. First results of a ferritin-based blood donor deferral policy in the Netherlands. Transfusion. 2020;60:1785–1792.
13. Goldman M, Uzicanin S, Osmond L, Yi Q-L, Scalia V, O'Brien SF. Two-year follow-up of donors in a large national study of ferritin testing. Transfusion. 2018;58:2868–2873.
14. Halperin D, Baetens J, Newman B. The effect of short-term, temporary deferral on future blood donation. Transfusion. 1998;38:181–183.
15. Zou S, Musavi F, Notari EP, Rios JA, Trouern-Trend J, Fang CT. Donor deferral and resulting donor loss at the American red Cross blood services, 2001 through 2006. Transfusion. 2008;48:2531–2539.
16. Custer B, Schlumpf KS, Wright D, Simon TL, Wilkinson S, Ness PM. Donor return after temporary deferral. Transfusion. 2010;51:1188–1196.
17. Busby H, Kent J, Farrell A-M. Revaluing donor and recipient bodies in the globalised blood economy: transitions in public policy on blood safety in the United Kingdom. Health (London). 2014;18:79–94.

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