

# Effect of a National Disaster on Blood Supply and Safety

## The September 11 Experience

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**T**HE OUTPOURING OF COMMUNITY support following the terrorist attacks on September 11, 2001, was unprecedented. Food, clothes, and cash donations poured in and many expressed their desire to help by giving blood.<sup>1,2</sup> Although a strong community response has been observed after national disasters,<sup>3-6</sup> the nature of the September 11 attacks and subsequent mass appeals and blood drives<sup>5</sup> led to the collection of 572 000 units more than usually collected in September, October, and November.<sup>7,8</sup> This countrywide surge in blood donations was larger than those observed during the Persian Gulf War<sup>1</sup> or after the 1995 bombing of the Murrah Federal Building in Oklahoma City, Okla.<sup>6</sup>

Although the short-term increase in blood donations following national disasters has been well documented,<sup>3-5</sup> less is known about the long-term impact on the blood supply. Gimble et al<sup>9</sup> noted that disasters and accidents usually have short-term effects on blood donation. Hence, the impetus to donate following disasters may be short lived. Donors, especially those giving for the first

**Context** An understanding of characteristics of blood donors donating in times of crisis may help predict blood supply safety and donor return patterns.

**Objectives** To characterize the volume of donations and prevalence of infectious disease markers in blood donated by US donors responding to the September 11, 2001, terrorist attacks, and to evaluate return rates in those who donated for the first time.

**Design** Cross-sectional survey data from the National Heart, Lung, and Blood Institute Retrovirus Epidemiology Donor Study for 4 weeks before and 4 weeks starting with September 11, 2001, and the corresponding 8-week period in 2000.

**Setting and Participants** A total of 327 065 volunteer blood donors making 373 628 allogeneic donations at 5 large regional US blood centers.

**Main Outcome Measures** Changes in number of donations overall and by first-time and repeat status, prevalence of infectious disease markers, estimated risks of transfusion-transmitted viral infections, and first-time donor return rates.

**Results** About 20 000 allogeneic donations were collected weekly in the 4 weeks preceding September 11, whereas  $\approx$ 49 000 (2.5-fold increase) and  $\approx$ 26 000 to 28 000 (1.3-fold to 1.4-fold increases) donations were made per week in the first and in the second through fourth weeks starting with September 11, respectively. All demographic groups donated more than usual after the attacks, and after adjusting for seasonal and annual variation there was a 5.2-fold (95% confidence interval, 5.0-5.4) increase in the number of first-time donations vs a 1.5-fold (1.4-1.5) increase in the number of repeat donations made in the first week starting on September 11 vs the 4 weeks before. The weekly proportion of repeat donors returning after not donating for 10 or more years increased from 2% before September 11 to 6% in the first week starting with September 11. Donations confirmed positive for human immunodeficiency virus (HIV), hepatitis C virus (HCV), and hepatitis B surface antigen nearly tripled between 1 week before September 11 (0.1%) and 1 week after the attacks (0.3%), largely explained by the increase in first-time and lapsed repeat donors. Estimated viral residual risks increased slightly after the attacks (HIV, 1/1.5 million vs 1/1.8 million donations; HCV, 1/1.3 million vs 1/1.6 million; hepatitis B virus, 1/140 000 vs 1/170 000). First-time donor 12-month return rates for 2000 and 2001 were similar,  $\approx$ 28% ( $P = .37$ ) for donors in the first week starting with September 11 (or September 12, 2000) and 30% ( $P = .69$ ) for the second to fourth weeks.

**Conclusions** The September 11 events resulted in an influx of first-time donors without substantial increase in absolute risk of transfusion-transmissible viral infections. First-time donor return rates were equally relatively low before and after the attacks, suggesting that those donating in times of crisis have return behaviors similar to those of other first-time donors. Their relatively low return rates reinforce the need for education about the importance of donating regularly.

JAMA. 2003;289:2246-2253

www.jama.com

**Author Affiliations, Members of the Retrovirus Epidemiology Donor Study (REDS Study Group), and Financial Disclosures** are listed at the end of this article.

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time, may not realize that blood is a perishable product and that regular donations are needed to continuously replenish the blood supply. It is also possible that the widely reported high rate of collections that were discarded after September 11<sup>8,10</sup> confused and angered donors. Disenchantment with the blood system could result in a decrease in donor return that could exacerbate potential blood shortages in a system already strained by the May 2002 implementation of the variant Creutzfeldt-Jakob disease European travel deferral criteria.<sup>11</sup>

It is also unclear if the large influx of donations after September 11 could have adversely affected blood safety. Many more people donate for the first time after national disasters,<sup>3,4</sup> and first-time donors have higher incidence rates of transfusion-transmissible viral infections (TTVIs) than repeat donors.<sup>12,13</sup> Donors who feel compelled to donate when confronted with a catastrophe may or may not have the same risk profiles as those who donate at other times. A large number of first-time blood donors were reported to test positive for TTVIs after September 11, thereby raising concern about the relative safety of new donors giving in response to disasters.<sup>14</sup> Finally, increased TTVI prevalence and the increased burden on laboratories resulting from the larger number of collections needing to be processed may lead to increased rates of false-negative errors in routine laboratory screening tests.

To examine and characterize the impact of the September 11 attacks on blood availability and safety, we evaluated and compared the donor demographics, infectious disease marker rates, and number of allogeneic donations collected during 4 weeks starting on September 11, 2001, with those collected during 4 weeks prior to September 11 and during corresponding 4-week periods 1 year earlier at 5 US blood centers taking part in the National Heart, Lung, and Blood Institute's Retrovirus Epidemiology Donor Study (REDS). Furthermore, we estimated the impact of September 11 on the probability of releasing potentially infectious dona-

tions for the major TTVIs. We also compared donor return between first-time donors giving before and after the September 11 attacks to assess whether donors who gave for the first time in response to the September 11 events were as likely to continue donating as donors who had first given blood for other reasons. In contrast to earlier reports evaluating the impact of the September 11 attacks on blood supply and safety,<sup>5-8,15,16</sup> we quantified the excess number of donations observed after the September 11 events not attributable to annual or seasonal variation, and estimated TTVI residual risks. Furthermore, access to the 1991-2002 REDS donor longitudinal data set allowed us not only to evaluate first-time donor return rates before and after the September 11 attacks but also to characterize lapsed or infrequent repeat donor donation behavior in times of disaster and associated infectious disease marker rates.

## METHODS

Information on donation type, donation dates, demographic characteristics (age, sex, race/ethnicity, education level, country of birth), first-time or repeat donor status, and screening and confirmatory tests that are routinely conducted at all blood centers has been collected by the REDS program continuously since 1991 at 5 blood centers: American Red Cross Blood Services Greater Chesapeake and Potomac Region (Baltimore, Md, and Washington, DC), American Red Cross Blood Services Southeastern Michigan Region (Detroit), and American Red Cross Blood Services Southern California Region (Los Angeles); Blood Centers of the Pacific (San Francisco); and the Sylvan N. Goldman Oklahoma Blood Institute (Oklahoma City). The REDS program compiles information on approximately 8% of all US allogeneic collections. The REDS protocol was approved by the institutional review board at each center.

We compared the number of allogeneic (whole blood community or directed and apheresis) donations made in the 4 weeks beginning with September 11 to October 8, 2001, to those ob-

tained in the preceding 4 weeks (August 14 to September 10, 2001) and corresponding periods in 2000 (September 12 to October 9, 2000; and August 15 to September 11, 2000). For each of these 4 periods, we determined the number of allogeneic donations given at each center, by each demographic group, and by first-time or repeat status. To allow for comparisons, we assessed the proportion of donations in each week that screened reactive for antibodies to human immunodeficiency virus (HIV) types 1 and 2, human T-cell lymphotropic virus (HTLV) types I and II, hepatitis C virus (HCV), hepatitis B core antigen, syphilis, or hepatitis B surface antigen (HBsAg), or that had elevated levels of alanine aminotransferase (ALT).

Reactivity tests used for HIV were Abbott HIVAB HIV-1/HIV-2 (rDNA) EIA (Abbott Laboratories, Abbott Park, Ill) (3 centers) or Genetic Systems HIV-1/HIV-2 Peptide EIA (BioRad Laboratories, Redmond, Wash) (2 centers); tests for HTLV were Vironostika HTLV I/II MicroElisa (Organon Teknika Corp, Durham, NC), either alone (1 center) or followed by Abbott HTLV-I/HTLV-II EIA (Abbott Laboratories) (4 centers); the test for HCV was Ortho HCV Version 3.0 ELISA Test System (Ortho-Clinical Diagnostics Inc, Raritan, NJ) (5 centers); the test for hepatitis B core antigen was Ortho HbC ELISA Test System (Ortho-Clinical Diagnostics Inc) (5 centers); the test used for syphilis was the Olympus PK TP System (Olympus America Inc, Melville, NY; manufactured for Olympus by Fujirebio Inc, Tokyo, Japan) (5 centers); and the tests used for HBsAg were Ortho Antibody to HBsAg ELISA Test System 2 (Ortho-Clinical Diagnostics Inc), either alone (2 centers) or followed by Auzyme Monoclonal (Abbott Laboratories) (3 centers). The tests for ALT included the Roche/Hitachi system ALT Kinetic Assay using Pyridoxal 5 Phosphate (Roche Diagnostics, Basel, Switzerland) (4 centers) or Abbott Aeroset Alanine Aminotransferase (Abbott Laboratories) (1 center).

Because adequate samples could not be obtained from some qualified potential donors at the time of venipuncture,

marker results were not available for an average of 4% of donations for 4 of the REDS centers that reported this information (the fifth center [contributing about 11% of donations collected by the 5 centers] does not provide information on donations unless marker test results are available). Analyses involving demographics and changes in the overall volume of donations included donors without marker information. Analyses of screening test reactivity rates, prevalence of HIV, HCV, and HBsAg, and donor return rates excluded donations without marker test results.

Prevalence of HIV, HCV, and HBsAg was also calculated for each week by dividing the number of confirmatory positive results (for any of these 3 markers) for each week by the number of donations that were screened in the same week (HTLV was not included because confirmatory test results were not available at all centers). The confirmatory tests used for HIV were Cambridge Biotech HIV-1 Western Blot (Calypte Biomedical Corp, Berkeley, Calif) (3 centers), Genetic Systems HIV-1 Western Blot (BioRad Laboratories) (1 center), or EPIblot HIV-1 Western Blot (EpiTope Inc, Beaverton, Ore) (January 2000-June 2001) followed by Genetic Systems HIV-1 Western Blot (BioRad Laboratories) (June 2001 forward) (1 center). The confirmatory test used for HCV was Chiron RIBA HCV 3.0 Strip Immunoblot Assay (Chiron Corporation, Emeryville, Calif), for confirmation of Ortho 3.0 ELISA-reactive donations (5 centers). The confirmatory test used for HBsAg was Monoclonal Neutralization Assay (Abbott Laboratories) (5 centers).

A simple comparison between 4-week periods of the total numbers of donations obtained may be misleading because donation counts fluctuate from day to day, week to week, and year to year. We conducted log-linear models<sup>17</sup> using the PROC CATMOD feature in SAS version 8.2<sup>18</sup> to quantify the excess number of donations (overall and within each demographic group) observed starting on September 11 that was not attributable to annual or seasonal variation. The log-linear models

included variables identifying the day, the week, the year (2000 or 2001), and the center where the donation was given, a binary group variable representing the subgroups of interest (eg, first-time vs repeat donations), and interaction terms. The “year” variable accounted for annual variation (the difference in number of donations between 2000 and 2001). The “nweek” variable accounted for the seasonal variation (the difference in number of donations over the weeks within August, September, and early October). An interaction term between the year variable and the nweek variable was used to assess the excess number of donations starting on September 11 after adjusting for annual and seasonal variation. A 3-way interaction term involving the year, nweek, and subgroup (ie, first-time vs repeat donations) variables was used to assess the excess number of donations after the September 11 events specific to each level of the subgroup. These models then yielded odds ratio (OR) estimates and Wald-type 95% confidence intervals (CIs) to assess the relative increase in donations given in the first week and in the second to fourth weeks after the September 11 attacks that could not be explained by seasonal and annual variation. Evidence from previous REDS research indicated that demographics of first-time and repeat donors have changed over time<sup>19,20</sup>; thus, a year as close as possible to year 2001 was chosen for comparison to reduce the “year” effect when evaluating changes in first-time or repeat status and demographics.

To better evaluate post-September 11 changes in screening reactivity (infectious disease markers) and confirmatory (HIV, HCV, or HBsAg) rates, we conducted logistic regressions to obtain ORs and Wald 95% CIs comparing the odds of having a reactive or confirmatory positive test result in the first week (or second to fourth weeks) starting with September 11, 2001, to the odds of having a reactive or confirmatory positive test result in the 4 weeks preceding September 11, unadjusted and adjusted for seasonal and annual variation.

The logistic models were then adjusted for first-time/repeat donor status to assess how much of the change in reactivity or confirmatory rates could be explained by the relatively larger number of first-time donors donating after the September 11 events, because first-time donors are known to have a higher prevalence of TTVI than repeat donors. We also assessed whether lapsed or infrequent repeat donors were more or less likely to donate after the September 11 attacks by comparing the length of the last interdonation intervals in repeat donors giving before and after the September 11 events and calculating the pre- and post-September 11 proportion of repeat donors who returned after not donating for 10 or more years.

We then applied the incidence/window period model to estimate the change in TTVI residual risks after the September 11 attacks.<sup>21</sup> In this model, the probability of having a potentially infectious donation released in the blood supply (ie, residual risk) is obtained by multiplying the incidence in the donor population by the window period.<sup>21</sup> If the window period is assumed to be the same before or after September 11, then the residual risk will vary as a function of the underlying incidence in the donor population. If we assume that first-time donor TTVI incidence is about twice that of repeat donors based on HIV and HCV data<sup>12,13</sup> and that repeat donor incidence is known,<sup>13,21</sup> then the incidence in the overall donor population can be calculated as  $(FT\% \times 2 \times \text{repeat donor incidence}) + (RPT\% \times \text{repeat donor incidence})$ , where FT% and RPT% indicate the proportions of first-time and repeat donations, respectively.

Finally, we evaluated the 12-month return rates of those who had donated blood for the first time on or after September 11, 2001, comparing the rates for the first and for the second to fourth weeks (because of attenuation in activity in the 2- to 4-week period after September 11, these weeks were analyzed in aggregate) and compared these rates with those obtained for donors who had given for the first time on or after September 12, 2000 (starting with the same

day of the week vs calendar number because of day-to-day variation of donations) using  $\chi^2$  tests. These return-rate calculations only included those whose donated blood screened negative for all infectious disease markers because donors with a positive marker are deferred from donation.

## RESULTS

### Donation Frequencies and Demographics

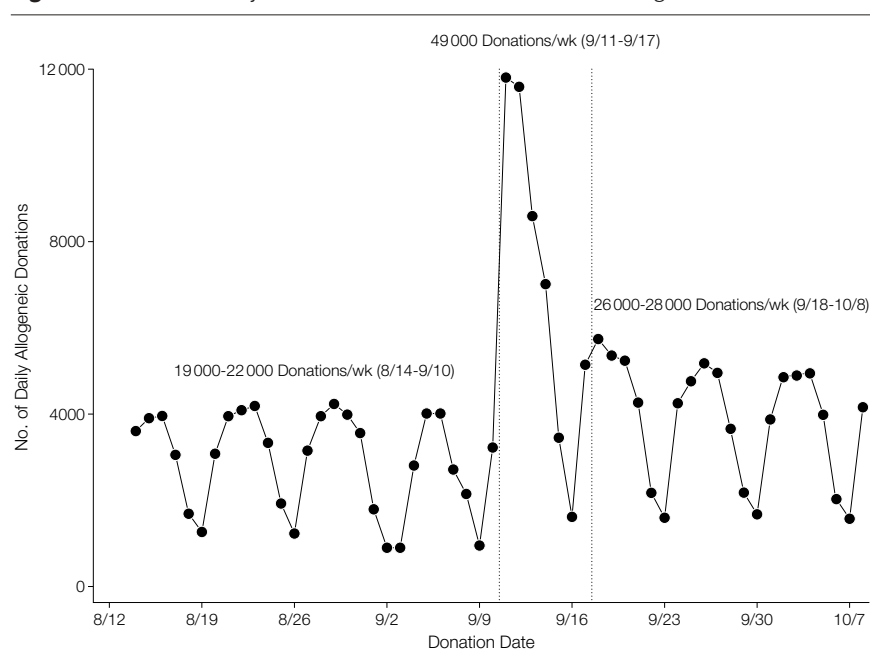
During the 16-week study period (8 weeks in both 2000 and 2001), 327 065 donors gave 373 628 allogeneic donations at the 5 REDS centers. For comparison purposes, we first examined donation frequencies 1 year prior to the September 11 attacks. The number of weekly allogeneic donations varied between about 17 000 and 21 000 from August 15 to September 11, 2000, and between about 21 000 and 23 000 from September 12 to October 9, 2000. Slightly more donations were made in the 4 weeks preceding September 11, 2001 (from about 19 000 to 22 000 per week, FIGURE 1) than in the corresponding period in 2000. As expected, marked day-to-day variation in collections occurred with a trough observed on Sundays and a peak midweek (Figure 1). In marked contrast, about 49 000 (a 2.5-fold increase) and 26 000 to 28 000 (1.3-fold to 1.4-fold increases) donations per week were given in the first and in the second to fourth weeks following the September 11 events, respectively (Figure 1). The increase in donations starting on September 11 occurred at all centers (S.A.G., unpublished data, 2003).

We observed a marked increase in the proportion of first-time donors (FIGURE 2) giving blood on and after September 11, 2001. There were about 22 700 first-time donations given the first week starting on September 11 compared with about 4000 donations per week in the 4 weeks preceding September 11, whereas repeat donors gave about 26 400 donations the first week after the September 11 events compared with a weekly average of about 16 400 in the prior 4 weeks. Hence, while 20% of donations were made by first-time do-

nors prior to September 11, that proportion increased to 46% in the first week thereafter. After adjusting for seasonal and annual variation, we observed a 5.2-fold (95% CI, 5.0-5.4) increase in the number of first-time donations compared with a 1.5-fold (95% CI, 1.4-1.5) increase in the num-

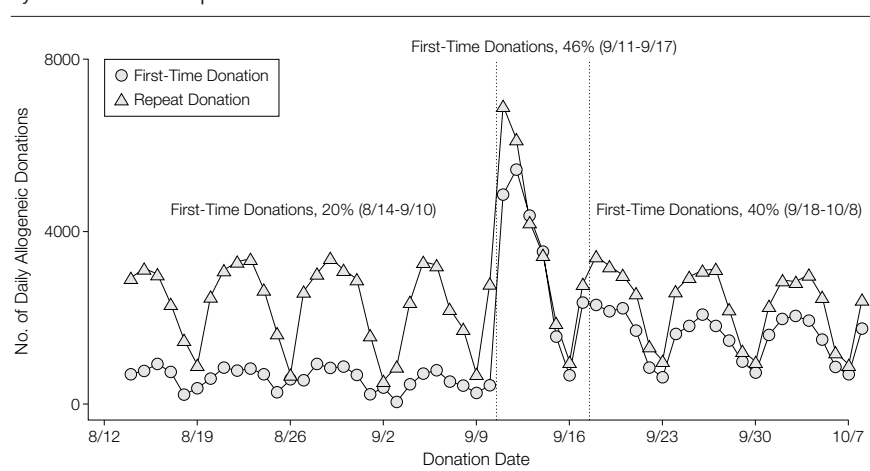
ber of repeat donations made the first week after the September 11 attacks compared with the prior 4 weeks. First-time donors continued to make more donations than usual in the second to fourth weeks after September 11, albeit at a lower level than in the preceding week (1.9-fold increase). Repeat do-

**Figure 1.** Number of Daily Donations at the 5 REDS Centers From August to October 2001



REDS indicates Retrovirus Epidemiology Donor Study.

**Figure 2.** Number of Daily Donations at the 5 REDS Centers From August to October 2001 by First-Time and Repeat Status



REDS indicates Retrovirus Epidemiology Donor Study.

nors gave slightly less in the second through fourth weeks after September 11 than in the 4 weeks prior to September 11 (0.9-fold increase).

In the first week starting with September 11, donors from all demographic groups (characterized by age, sex, race/ethnicity, education level, or country of birth) donated 1.8 to 3.0 times more frequently than in the prior 4 weeks. The increase in the number of female donors (2.6-fold increase in the first week after the September 11 events) was more pronounced than the increase in the number of male donors (1.9-fold increase,  $P < .001$ ). Hence, in contrast to the 4 weeks prior to September 11, more than 50% of donations (26033/49044) given the first week after the September 11 attacks were from female donors. In

2000, 54% of allogeneic donations were collected from male donors.

**Screening Reactivity Rates and Prevalence of HIV, HCV, or HBsAg**

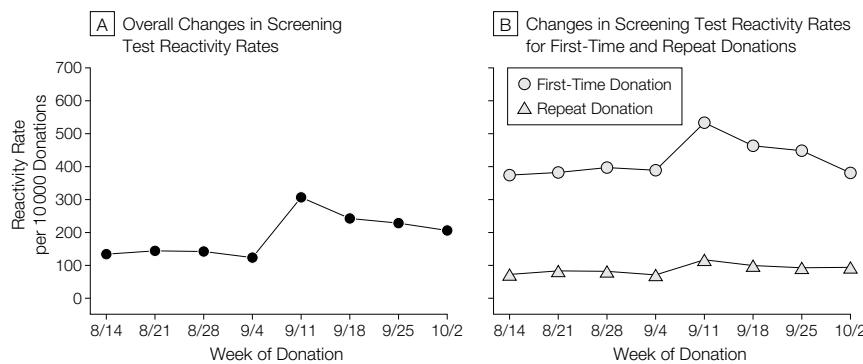
FIGURE 3A and 3B illustrate the changes in screening reactivity rates for HIV types 1 and 2, HTLV types 1 and II, HCV, hepatitis B core antigen, HBsAg, syphilis, and ALT observed after September 11, overall and by first-time/repeat status. Screening reactivity rates increased from 1.2% to 1.4% per week in the 4 weeks preceding September 11 to 3.1% in the first week starting with September 11, and decreased to 2.4% to 2.1% per week in the second through fourth weeks thereafter (Figure 3A). Similarly, the number of donations that were confirmed positive for HIV, HCV,

or HBsAg nearly tripled after the September 11 events (from 0.1% in the week before September 11 to 0.3% in the week following) and remained elevated in the 3 weeks thereafter (0.2%, FIGURE 4A). As shown in Figure 4A, the increase in HIV, HCV, or HBsAg prevalence after the September 11 attacks appeared to be driven by an increase in HCV prevalence (0.07%-0.09% per week in the 4 weeks before September 11 to 0.1%-0.2% after) rather than changes in HIV (0%-0.01% before September 11 to 0%-0.02% after) or HBsAg prevalence (0.02%-0.06% before September 11 to 0.05%-0.10% after).

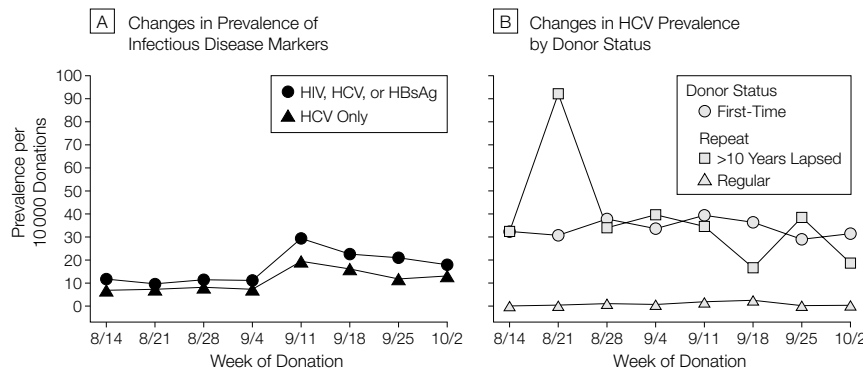
Most of the post-September 11 increase in screening reactivity or confirmatory rates was explained by the increase in first-time donors who have a higher prevalence of TTVIs than repeat donors. The odds of being confirmatory positive for HIV, HCV, or HBsAg were not significantly different in first-time donors before and after the attacks (OR, 1.20 [95% CI, 0.90-1.59] and OR, 0.98 [95% CI, 0.74-1.29], comparing the first and the second to fourth weeks starting on September 11 to the prior 4 weeks, respectively). These ORs remained similar after adjustment for seasonal and annual variation (OR, 1.17 [95% CI, 0.88-1.56] and OR, 0.96 [95% CI, 0.73-1.27], respectively). Similarly, HCV prevalence in first-time donors did not differ before or after the attacks (Figure 4B).

Although not statistically significant, repeat donations appeared more likely to be positive for HIV, HCV, or HBsAg in the first week starting with September 11 than in the prior 4 weeks (OR, 2.26 [95% CI, 0.92-5.57]) but not in the second to fourth weeks after September 11 (OR, 1.23 [95% CI, 0.50-3.02]). These ORs remained similar after adjustment for seasonal and annual variation (2.09 [95% CI, 0.85-5.17] and 1.20 [95% CI, 0.49-2.95], respectively). The apparent increase in HIV, HCV, or HBsAg prevalence in repeat donations was driven by an increase in HCV prevalence from 0.01% to 0.02% per week in the 4 weeks before September 11 to 0.03% in each of

**Figure 3.** Weekly Infectious Disease Marker Reactivity Rates Between August 14 and October 8, 2001



**Figure 4.** Weekly Infectious Disease Marker Prevalence Between August 14 and October 8, 2001



HBsAg indicates hepatitis B surface antigen; HCV, hepatitis C virus; HIV, human immunodeficiency virus.

the first 2 weeks after, then decreasing to 0.01% and 0.007% in the third and fourth weeks, respectively; there was no increase in HIV per week (0% before and after September 11) or HBsAg prevalence (0%-0.01% before and after).

Because this slight increase in HCV prevalence could potentially be explained by an influx of lapsed or infrequent repeat donors, we evaluated time since last donation in repeat donors donating before and after the September 11 events. The median time since last donating was 4 to 5 months (interquartile range [IQR], 2-12 months) for repeat donors giving in 2000 or in the 4 weeks before September 11, whereas repeat donors donating in the first and in the second through fourth weeks starting with September 11 had median times of 10 (IQR, 4-31) and 6 to 7 (IQR, 3-22) months, respectively. Furthermore, a larger proportion of repeat donors who had not donated at the same center in at least a decade returned to donate after the September 11 events (6% in the first week and 3%-4% in the second to fourth weeks after September 11, compared with 2% for each week in 2000 and in the 4 weeks pre-September 11, 2001).

Finally, we evaluated HCV prevalence in repeat donors who had or had not lapsed donating in at least 10 years. Ten-year lapsed repeat donors were expected to have similar HCV prevalence as first-time donors since they probably had never been screened for HCV (HCV EIA 1.0 was implemented in 1991, after their last donation). As shown in Figure 4B, estimates of HCV prevalence were similar in 10-year lapsed repeat donors and first-time donors, whereas estimates of HCV prevalence in repeat donors who had been donating in the last 10 years were at least 10 times lower. Furthermore, estimates of HCV prevalence did not significantly differ before or after the September 11, 2001, events in either group of repeat donors (OR, 0.67 [95% CI, 0.20-2.20] for 10-year lapsed donors and OR, 3.93 [95% CI, 0.66-23.49] for nonlapsed repeat donors, comparing the week starting with September 11 to the prior 4 weeks), suggesting that the apparent increase in

HCV prevalence in repeat donations after the September 11 attacks was largely explained by the larger proportion of lapsed repeat donors returning on and after that date.

#### TTVI Residual Risks

Using American Red Cross repeat donor incidence data from 2000 and 2001,<sup>13</sup> we estimated that for HIV about 1 in 1.5 million donations could have been potentially infectious in the first week starting with September 11 vs 1 in 1.8 million before September 11; for HCV, 1 in 1.3 million vs 1 in 1.6 million; and for hepatitis B virus, 1 in 140 000 vs 1 in 170 000.

#### Twelve-Month Donor Return

The 12-month return rate for those donating for the first time in the week beginning September 11 was 28.3% compared with 27.6% ( $P = .37$ ) in the corresponding period in 2000, whereas 30.2% and 30.4% ( $P = .69$ ) of donors giving for the first time in the second to fourth weeks after September 11 and in the corresponding weeks in 2000, respectively, returned to donate within 12 months.

#### COMMENT

The 2- to 3-fold increase in number of donations collected by the 5 REDS centers in the first week after the September 11, 2001, terrorist attacks was similar to other blood centers' experiences across the United States.<sup>15,16</sup> This large increase in donations beginning September 11 was driven by the increased number of donors who spontaneously came to donate rather than the result of special recruitment efforts. Although all demographic groups donated more than usual after the September 11 events, most striking was the large increase in the number of people who decided to donate for the first time. First-time donations usually represent one fifth of all allogeneic donations at the REDS centers (S.A.G., unpublished data, 2003), but after the September 11 events accounted for nearly one half of all collections. Busch et al<sup>4</sup> noted that 40% to 45% of donations made in San Fran-

cisco and Los Angeles after the 1989 San Francisco Bay Area earthquake were given by first-time donors (compared with 26% before the earthquake) and Schmidt and Bayer<sup>3</sup> reported a similar phenomenon after the 1981 partial collapse of the Hyatt Regency Hotel in Kansas City, Mo. We also found that a higher proportion of donors were women after the September 11 attacks, similar to observations following the 1989 San Francisco earthquake.<sup>4</sup>

The dramatic increase in first-time donations after a national disaster and subsequent relatively low return rates warrant further consideration.<sup>4-6</sup> It is clear that a large population of eligible donors can be mobilized after a national disaster and that, in the United States, most eligible people do not regularly donate. Studies have identified several motivators for blood donation: altruism (ie, a general desire to help others such as friends, relatives, or those affected by disaster); awareness of need for blood in the community; a sense of social obligation or duty; personal social pressure; need to replace blood used by a friend or relative; and increased self-esteem.<sup>22-25</sup> Conversely, fear, inconvenience, perceived medical disqualification, being too busy, not being asked, and apathy (ie, "never thought about it") have been identified as impediments to blood donation.<sup>22-24,26</sup> The response observed after a national disaster demonstrates that, in those situations, the donors perceive that the benefits associated with giving blood (for example, knowing that one has helped those affected by a disaster or has performed his or her civic duty) clearly outweigh the costs (ie, the fear or inconvenience).

In the months following September 11, several REDS centers conducted telephone, e-mail, or postal mail recruitment campaigns aimed both at attracting potential donors who because of excess supply were asked not to donate immediately after September 11 but for whom contact information was collected, and at retaining the September 11 first-time donors. These centers were often disappointed by the seemingly low response obtained. We observed that the

12-month return rate of post–September 11 first-time donors was similar to historical return rates. If we assume these donors gave only in response to the disaster, getting them to return again at the observed rate (in the absence of another disaster) could actually be viewed as a recruitment success. Furthermore, the high proportion of first-time donors giving after the attacks translates into an increase in the absolute number of donors returning after the September 11 events vs before; hence, at the 5 REDS centers, more than 14 500 eligible donors giving for the first time in the month starting with September 11 returned within 12 months compared with approximately 5800 donors who had given for the first time in the same month in 2000. However, it is clear that, in light of the critically low margin that exists between the demand for blood components and blood collections,<sup>27</sup> the return of more first-time donors is crucial. One step in that direction is to ensure that the public and the media are aware of the continuous need for blood and the importance of donating regularly. The Advisory Committee on Blood Safety and Availability has recognized this need and has recommended that the Department of Health and Human Services identify blood donors as a critical national resource and promote blood donations as a national service.<sup>28</sup>

It is also important to assess the impact of a large influx of first-time donors on blood safety. The increases we observed in screening reactivity test results and in HIV, HCV, or HBsAg prevalence appeared to be primarily explained by the large number of donors giving for the first time after the September 11 attacks, since previously un-screened donors have a higher TTVI prevalence than repeat donors. Hence, the 3-fold increase in the number of non-transfusable donations after the attacks (due to reactive screening tests) was probably not caused by an influx of high-risk donors, but rather by the increase in reactive donations resulting from more first-time donations being screened. We found that HIV, HCV, or HBsAg prevalence did not appear to dif-

fer in first-time donors who had given before or after the attacks. These findings are similar to those of Dodd et al,<sup>16</sup> who compared viral prevalence in first-time donations that were collected by the American Red Cross for 20 days before and 20 days after the September 11 events and found no significant differences. The similar prevalence of infectious disease markers in pre- vs post-September 11 first-time donors suggests that behavioral screening (ie, the donor history questionnaire) was probably as effective in detecting people with a high-risk profile after the September 11 attacks (in a large-volume situation) as it was before. Furthermore, the nonsignificant increase in HCV prevalence observed in repeat donors appeared to be largely explained by an influx of donors who had not donated in at least 10 years. Hence, we believe that people who successfully donated after the September 11 events at the 5 REDS centers probably did not have higher viral risks than donors with similar donation history characteristics who give in noncrisis times.

However, the comparability of prevalence rates stratified by donation history does not imply that TTVI risks were identical before and after the September 11 attacks. The greatest threat to the blood supply is the donation of blood by seronegative donors (and those testing negative by nucleic acid amplification) in the infectious window period.<sup>21</sup> We estimated that the large influx of first-time donors observed for the first month starting with September 11 probably resulted in a small increase in TTVI risks in that period at the 5 REDS centers. However, considering the short-lived nature of the surge in first-time donors and the small magnitude of these risks (in particular for HIV and HCV), we suggest that this small increase in risks probably did not have a significant impact on blood safety. The higher TTVI prevalence observed after the September 11 events, however, could have increased the probability of making a false-negative error in screening. It also is probable that error rates increased after the September 11 events because of the

sheer volume of collections that needed to be processed.<sup>8</sup> However, although difficult to quantify, we think that the increase in false-negative errors probably would have a negligible impact on risk because, at least for HIV and HCV, these errors appear to be occurring in fewer than 6 units per billion.<sup>29</sup>

It is important to note that our analysis is based on data collected at 5 blood centers that collect about 8% of the US blood supply. Although similar shifts in demographics (increase in female donors) and first-time/repeat status (increase in first-time donations) have been observed after other national disasters, our findings are restricted to 5 centers and may not apply to other blood centers. We also were unable to evaluate whether the number of potential donors who were deferred for high-risk behaviors increased after the September 11 attacks because deferral data were not available. Similarly, we did not measure the rate at which donors failed to report a high-risk behavior at the time of screening. The level of unreported deferrable risk, estimated to be 2% to 3% in the United States before September 11,<sup>30,31</sup> could have increased after the attacks if more people felt pressured to donate. Furthermore, while the ratio between first-time and repeat donor incidence has been estimated for HIV and HCV,<sup>12,13</sup> these data are unavailable for hepatitis B virus. Hence, our assumption that the incidence of hepatitis B virus in donations from first-time donors is about 2 times that of repeat donors is more uncertain. Finally, it is possible that the TTVI incidence of donors giving for the first time after the attacks may have been different from that of first-time donors giving previously.

These data suggest that, in response to a national disaster, persons representing a number of demographic groups rally to help others and donate blood. Because 12-month return rates were similar before and after the September 11 events, the large influx of first-time donors observed after these events resulted both in a short-term increase in donations (probably without a concomitant significant change in

TTVI risks) and in an increase in the absolute number of donors returning to donate a year later. Although people who successfully donate in times of crisis appear to have return behaviors similar to other first-time donors, the relatively low yearly return rates before or after the attacks reinforce the need for education about the importance of regular blood donation. Additionally, improving understanding of both motivating and deterrent factors associated with donating blood will enhance the ability to ensure the adequacy of the blood supply.

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**Financial Disclosures:** Dr Glynn owned stock in Biotechnology General, Cephalon, Genentech, Human Genome Sciences, iFlow, Medimmune, and Novartis. Dr Busch received research grants or funding from the National Heart, Lung, and Blood Institute (NHLBI grant NO1-HB-47114) and from the Retrovirus Epidemiology Donor Study (REDS); received honoraria from Abbott Laboratories, Chiron, Gen-Probe Inc, Ortho Diagnostics Systems, and Roche Molecular Systems; consulted for Acrometrix, Gambro BCT/Navigator, Haemonetics, Ortho Diagnostics Systems (Ortho blood advisory committee member), Roche Molecular Systems (global advisory board member), and VI Technologies (Vitek) (scientific advisory board member); had lecture sponsorships from Abbott, Cambridge Healthtech Institute, Cerus Corp, DiaMed, Emory University, Johns Hopkins University, University of California, San Diego, US Centers for Disease Control and Prevention, US Food and Drug Administration (FDA), National Institutes of Health, National Cancer Institute, and NHLBI; was an advisor for Canadian Blood Services (scientific, technical, research, and advisory committee member), US Department of Health and Human Services Advisory Committee on Blood Safety and Availability (former member), FDA Blood Policy Advisory Committee (former member), University of California, San Francisco, AIDS Research Institute (executive committee member), University of California, San Francisco/Berkeley, Institute for Global Health (affiliated faculty member), American Society of Hematology (Scientific Committee on Transfusion Medicine member), America's Blood Centers (scientific, medical, and technical committee member), International Society of Blood Transfusion (scientific advisory board member), and Biomedical Excellence for Safer Transfusions (working party member); was vice president, research, Blood Centers of the Pacific (BCP), San Francisco, Calif, vice president, research, Blood Systems Inc, Scottsdale, Ariz (parent of BCP), and acting president, Blood Systems Foundation; and received honoraria for continuing medical education programs from Agouron, Cambridge Healthtech Institute, DiaMed, Florida Blood Services/University of South Florida, and Ortho Diagnostics Systems. Dr Murphy received a speaker's honorarium from Chiron Corp. Dr Kleinman received contract support from NHLBI (through REDS) for work related to transfusion-transmitted diseases and blood safety, was a paid consultant to Roche Molecular Systems and Chiron for development and assessment of blood screening assays, and received honoraria for participation on the scientific advisory board of VI Technologies, a com-

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**Funding/Support:** This work was supported by NHLBI contracts N01-HB-97077 (superseded by N01-HB-47114), -97078, -97079, -97080, -97081, and -97082.

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