

Special article

Multidisciplinary hemovigilance and education program to improve recognition of suspected adverse transfusion reactions

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Introduction

Blood component transfusion remains a common and life-saving intervention for patients in both inpatient and outpatient settings and is integral to health-care delivery worldwide.¹ However, despite its clinical benefits, transfusion carries the risk of both acute and delayed complications varying in severity and underlying mechanisms. Acute reactions occurring during or within 24 hours comprise immune-mediated events, including transfusion-related acute lung injury (TRALI), acute hemolytic transfusion reactions (HTRs), febrile nonhemolytic transfusion reactions, allergic and anaphylactic reactions, as well as nonimmune complications, most notably transfusion-associated circulatory overload (TACO). Delayed complications may include alloimmunization, delayed HTRs, transfusion-associated graft-versus-host disease, transfusion-transmitted infections, iron overload, and transfusion-related immune modulation.²⁻⁴ Early detection and prompt intervention are crucial to mitigate complications and improve clinical outcomes. Consistent reporting and surveillance of suspected transfusion reactions through a comprehensive hemovigilance program enable systematic evaluation of adverse events, protect other patients from similar incidents, and inform preventive strategies to reduce the risk of recurrence; thereby, enhancing overall patient safety.⁵ Our hospital is a participating member of the national hemovigilance system coordinated by the National Blood Centre, Thai Red Cross Society (NBC-TRCS), and has consistently contributed transfusion

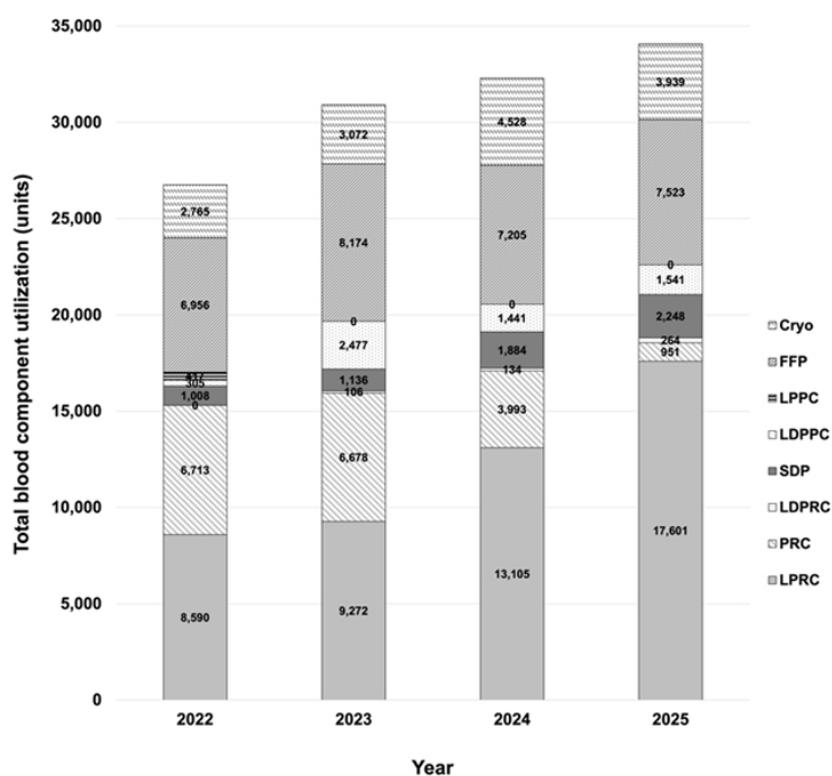
reaction surveillance data to the national hemovigilance database on an ongoing basis up to the present time.⁴ However, internal audits have indicated that suspected reactions were frequently overlooked or reported late. To address these gaps, we implemented a structured, multidisciplinary hemovigilance and education program aimed at strengthening staff knowledge, standardizing reporting processes, and promoting proactive surveillance. This article describes the development, implementation, and impact of this program.

Setting and baseline challenges

This study was conducted at Thammasat University Hospital (TUH), a large tertiary-care teaching and referral center in central Thailand providing comprehensive services across all medical specialties. The hospital manages approximately 4,000 outpatient visits daily and maintains 889 inpatient beds, with plans to expand to 1,000 to 1,200 beds, resulting in high patient acuity and substantial transfusion activity across medical, surgical, and critical care services. At TUH, overall blood component use increased progressively during the study period, as illustrated in Figure 1. Between 2022 and 2025, a total of 124,026 components were transfused, with annual volumes rising from 26,754 to 34,067 units (+27%). Use of leukocyte-poor packed red cells (LPRC) more than doubled, increasing from 8,590 to 17,601 units (+105%), becoming the predominant red cell product. Platelet use also increased substantially, with single-donor platelets (SDP) rising from 1,008 to 2,248 units (+123%), while leukocyte-depleted pooled platelet

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Cryo = cryoprecipitate; FFP = fresh frozen plasma; LPPC = leukocyte-poor platelet concentrates; LDPPC = leukocyte-depleted pooled platelet concentrates; SDP = single-donor platelets; LDPRC = leukodepleted packed red cells; PRC = packed red cells; LPRC = leukocyte-poor packed red cells

Figure 1 Annual trends in blood component utilization at Thammasat University Hospital, 2022-2025

concentrates (LDPPC) remained consistently high (305-2,477 units annually). Fresh frozen plasma (FFP) use remained relatively stable (6,956-8,174 units annually), whereas cryoprecipitate (Cryo) showed a moderate increase from 2,765 to 3,939 units (+42%). In contrast, conventional packed red cell (PRC) use declined sharply from 6,713 to 951 units (-86%), reflecting a transition toward leukocyte-reduced products. Leukocyte-poor platelet concentrates (LPPC) were used only in 2022 (417 units) and were subsequently discontinued.

Before the intervention, hemovigilance at TUVH relied primarily on a voluntary, passive reporting system embedded within routine clinical workflow. Reporting rates were low, documentation was inconsistent, and variability regarding staff recognition of early clinical signs reduced detection sensitivity, resulting in under-recognition and incomplete capture of transfusion-related adverse events. Although active surveillance - systematic post-transfusion patient assessment conducted by the

transfusion service - can enhance case ascertainment, the process remained operationally dependent on bedside or ward-initiated triggers; consequently, events were still missed when no report was generated. These system-level gaps highlighted limitations in surveillance infrastructure and safety culture and indicated the need for process redesign and a standardized implementation strategy. Therefore, we implemented a multidisciplinary hemovigilance care bundle integrating structured education, active case finding, and standardized reporting workflows to strengthen data reliability, improve detection, and enhance transfusion safety.

Hemovigilance and education program development and implementation

At TUVH, baseline hemovigilance activities from 2022 to 2023 relied primarily on passive reporting and routine committee oversight, with limited proactive surveillance or standardized workflows, resulting in variable reporting practices and incomplete data capture. To address

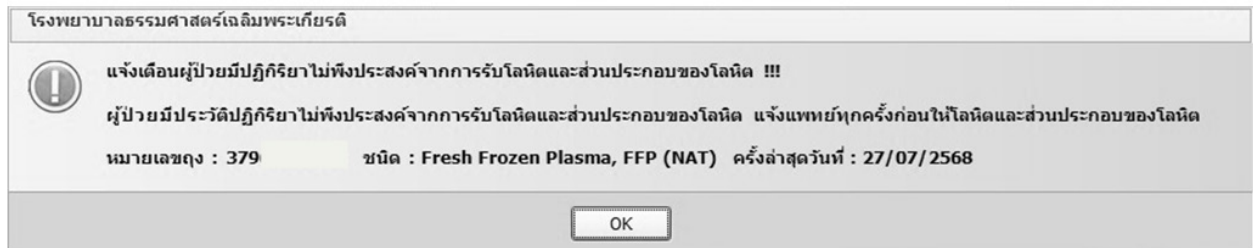


Figure 2 Electronic pop-up alerts for patients with prior transfusion reactions in the Electronic Patient Health Information System (E-Phis). These alerts notify clinicians of documented transfusion reactions and display key details, including implicated unit number, component type, and the most recent episode, to prompt review before subsequent transfusion and enhance patient safety.

these system-level gaps, a multidisciplinary working group comprising transfusion medicine and hematology specialists, nurses, clinicians, blood bank personnel, and quality and safety officers was convened in 2024 to undertake a systems-based process redesign and develop a structured implementation strategy.

The program was designed as a multifaceted, hemovigilance care bundle aimed at improving detection sensitivity, reporting compliance, and data completeness. Core components included structured educational sessions and case-based learning focused on early recognition and initial management of transfusion reactions, together with simplified reporting processes using standardized forms, clear escalation pathways, and streamlined workflows. Beginning 2024, hospital-wide annual educational conferences were implemented to promote a safety culture, standardize practices, and strengthen multidisciplinary engagement. In parallel, the transfusion committee convened bimonthly to review transfusion safety metrics, incident reports, and process indicators to support ongoing monitoring and workflow optimization. These meetings incorporated formal reporting and analysis of suspected transfusion reaction incidents presented by blood bank staff and were led by a board-certified hematologist, facilitating structured feedback, root-cause analysis, and continuous quality improvement.

Electronic clinical decision-support tools were integrated in the hospital information system to strengthen point-of-care transfusion safety. These included

real-time pop-up alerts within the Electronic Patient Health Information System (E-Phis) automatically flagging patients with prior transfusion reactions or documented allergies. As illustrated in Figure 2, the alerts display key information including the implicated unit number, component type, and the most recent episode, prompting clinicians to review transfusion history, exercise heightened vigilance, and implement appropriate preventive measures before subsequent transfusion. Implementation followed a phased rollout strategy, beginning with pilot units and subsequently scaled hospital-wide. Visual aids, standardized algorithms, and quick-reference materials were disseminated to support adherence to standardized workflows, while continuous feedback from frontline teams enabled iterative process refinement and reinforced sustainability. Program effectiveness was evaluated over a two-year, post-implementation period (2024-2025) and compared with baseline data from the pre-intervention period (2022-2023).

Clinical outcomes and practice impact

According to the hemovigilance guidelines issued by the NBC-TRCS, standardized definitions are applied to support systematic surveillance of transfusion safety.⁴ Blood components administered for clinical use are monitored for adverse events including both process-related incidents and patient adverse transfusion reactions. Adverse reactions are classified as hemolytic or nonhemolytic. HTRs comprise acute and delayed HTRs, whereas nonhemolytic reactions include febrile nonhemolytic transfusion reactions (FNHTRs) and allergic

reactions, transfusion-associated graft-versus-host disease, posttransfusion purpura, TRALI, transfusion-associated dyspnea (TAD), TACO, hypotensive reactions, and other or unclassified events. The other category encompasses reactions not meeting predefined criteria, including transfusion-associated acute gut injury, transfusion-associated immunomodulation, iron overload, microchimerism, hypokalemia, and thrombotic complications. The guideline further defines standardized criteria for severity grading, imputability assessment, and recommended management and preventive measures to ensure consistent evaluation and improve transfusion safety.⁴

Implementation of the hemovigilance program was associated with increased detection and reporting of suspected transfusion reactions (Table 1). During the baseline period (2022-2023), 77 suspected reactions were identified among 30,522 transfusion episodes, corresponding to a reporting rate of 2.523 per 1,000 episodes. Following program implementation, a total of 106 suspected reactions were reported among 33,283 transfusion episodes during the postimplementation period (2024-2025), yielding a reporting rate of 3.185 per 1,000 episodes, representing a 26.24% increase compared with the baseline period. At the annual level, reporting rates increased from 2.258 and 2.780 per 1,000 episodes in 2022 and 2023, respectively, to 3.529 per 1,000 episodes in 2024, the first year after program implementation. In 2025, the reporting rate remained higher than the baseline years at 2.849 per 1,000 episodes, although lower than the peak observed in 2024. These findings demonstrate an overall upward trend in the detection and reporting of suspected transfusion reactions following program implementation. However, the difference between the baseline and postimplementation periods did not reach statistical significance ($p = 0.119$). The observed increase likely reflects improved awareness, detection sensitivity, and reporting practices associated with the hemovigilance program rather than a true increase in the incidence of transfusion reactions.

Transfusion reactions were classified according to the definitions outlined in the Thai hemovigilance guidelines.⁴ A total of 183 transfusion-related adverse reactions were identified during the study period. Among affected patients, 114 were male (62.3%) and 69 were female (37.7%), with a mean age of 50.6 ± 23.1 years. Regarding ABO blood group distribution, group O accounted for the largest proportion of reported reactions ($n = 79$, 43.2%), followed by group B ($n = 53$, 29.0%), group A ($n = 35$, 19.1%), and group AB ($n = 16$, 8.7%). The distribution of reported transfusion-related adverse reactions by reaction type is shown in Table 2. Allergic reaction was the most frequently reported reaction ($n = 70$, 38.3%), followed by FNHTR ($n = 65$, 35.5%). Mixed reactions accounted for a notable proportion of cases including FNHTR/allergic ($n = 23$, 12.6%) and FNHTR/TAD ($n = 19$, 10.4%). TAD alone was reported in 4 cases (2.2%). Other reactions were uncommon ($n = 2$, 1.1%) and included nausea or vomiting and hematuria. Overall reporting rates ranged from 2.26 to 3.53 cases per 1,000 transfusion episodes during the study period, with annual data summarized in Table 2.

Reactions were further stratified according to blood component type (Figure 3). Among red cell transfusions, including LDPRC, LPRC, and PRC, FNHTR accounted for the largest proportion of events (50/115, 43.5%), followed by allergic reactions (35/115, 30.4%). Mixed FNHTR/TAD and mixed FNHTR/allergic reactions represented smaller proportions (14/115, 12.2% and 12/115, 10.4%, respectively). Platelet transfusions including SDP and LDPPC showed a similar pattern, with FNHTR (31/52, 59.6%) and allergic reactions (12/52, 23.1%) comprising the most reported reactions. In contrast, plasma or cryoprecipitate transfusions were predominantly associated with allergic reactions, accounting for 96/141 (68.1%) of reactions in this component category, followed by mixed FNHTR/allergic reactions (29/141, 20.6%). Reactions following transfusion of multiple components within the same episode were uncommon and were largely allergic in nature (5/7, 71.4%). Detailed distributions of reaction patterns by component type are illustrated in Figure 3.

Table 1 Comparison of suspected transfusion reaction reporting rates before (2022-2023) and after (2024-2025) implementation of the hemovigilance program

Period	Suspected reactions (n)	Total transfusion episodes (n)	Reporting rate (per 1,000 episodes)	%Change	p-value
Pre-implementation (2022-2023)	77	30,522	2.523		
2022	34	15,056	2.258	Reference	-
2023	43	15,466	2.780		
Post-implementation (2024-2025)	106	33,283	3.185		
2024	58	16,435	3.529	+26.239%	0.119
2025	48	16,848	2.849		

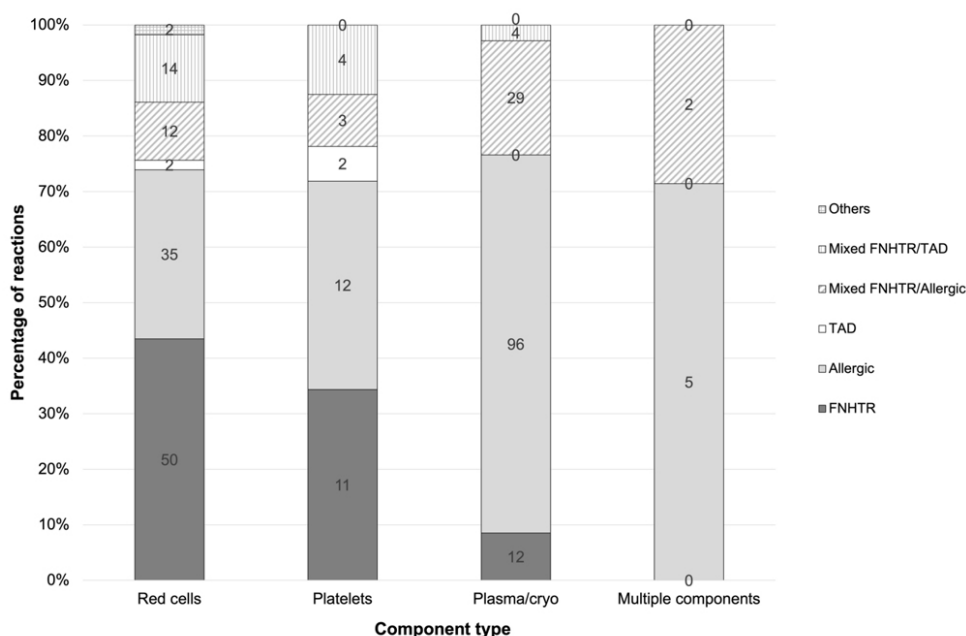
Reporting rate was calculated as the number of suspected transfusion reactions per 1,000 transfusion episodes. Percentage change was calculated relative to the pre-implementation period. *P*-values were calculated using the Chi-square test.

Table 2 Annual distribution of reported transfusion-related adverse reactions by reaction type during the study period (2022-2025)

Reaction pattern	2022, n (rate [*])	2023, n (rate [*])	2024, n (rate [*])	2025, n (rate [*])	Total, n (%)
Transfusion episodes	15,056	15,466	16,435	16,848	63,805
Allergic	13 (0.86)	15 (0.97)	22 (1.34)	20 (1.19)	70 (38.25)
FNHTR	14 (0.93)	10 (0.65)	20 (1.22)	21 (1.25)	65 (35.52)
TAD	0 (0.00)	2 (0.13)	1 (0.06)	1 (0.06)	4 (2.19)
Mixed FNHTR/Allergic	3 (0.20)	10 (0.65)	8 (0.49)	2 (0.12)	23 (12.57)
Mixed FNHTR/TAD	3 (0.20)	6 (0.39)	6 (0.37)	4 (0.24)	19 (10.38)
Others	1 (0.07)	0 (0.00)	1 (0.06)	0 (0.00)	2 (1.09)
Total reactions	34 (2.26)	43 (2.78)	58 (3.53)	48 (2.85)	183 (100.00)

*Rates are expressed as cases per 1,000 transfusion episodes. Mixed reactions indicate episodes with concurrent transfusion-related adverse reactions.

FNHTR = febrile non-hemolytic transfusion reaction; TAD = transfusion-associated dyspnea



Cryo = cryoprecipitate; FNHTR = febrile non-hemolytic transfusion reaction; TAD = transfusion-associated dyspnea

Figure 3 Distribution of transfusion-related adverse reactions according to blood component type

Discussion

In this study, implementation of an active hemovigilance program was associated with a higher rate of reported transfusion reactions compared with the baseline period, although the difference was not statistically significant. This increase likely reflects improved detection and reporting rather than a true rise in the underlying incidence of transfusion reactions. Similar patterns have been observed in other institutional and international hemovigilance systems, where structured surveillance and proactive monitoring improve recognition and documentation of transfusion-related adverse events.⁶⁻⁸ Underreporting remains a persistent challenge in hemovigilance and may result from several clinical and operational factors. Mild or nonspecific symptoms may not always be recognized as transfusion reactions, and healthcare providers may assume that only severe reactions warrant reporting. In addition, reporting procedures perceived as time-consuming may discourage documentation in routine practice, while diagnostic uncertainty among patients with complex medical conditions may lead clinicians to attribute symptoms to the underlying disease rather than transfusion. Related studies have reported similar barriers including failure to recognize transfusion reactions, misconceptions regarding reporting requirements, and concerns about the effort involved in reporting.⁹

Because causality cannot always be determined at the time of the event, hemovigilance systems should encourage reporting of all suspected transfusion-related adverse events, with subsequent expert review to assess imputability when needed. In our program, healthcare personnel were encouraged to report any adverse event occurring during or shortly after transfusion. Cases with suspected or unusual features were discussed with a transfusion medicine physician to support clinical assessment and management. Regular educational activities and bimonthly transfusion committee meetings further promoted multidisciplinary engagement, case review, and continuous quality improvement. Together,

these measures enhance surveillance sensitivity while maintaining rigorous clinical oversight of transfusion reactions. Prior studies have similarly demonstrated that reporting rates improve when reporting responsibility is shared across the healthcare team members including transfusion laboratory personnel, and when the process for initiating transfusion reaction reports is simplified and more accessible.^{10,11} Such system-level approaches reduce barriers to reporting and facilitate more timely recognition and documentation of transfusion-related adverse events within routine clinical practice.

In addition, electronic clinical decision-support tools integrated in the hospital information system improved point-of-care transfusion safety by generating real-time alerts for patients with prior transfusion reactions or documented allergies. In practice, the alert system proved particularly valuable for patients requiring frequent transfusion support. At our institution, a pediatric patient with recurrent allergic reactions was repeatedly identified by the alert system, reinforcing team awareness and vigilant monitoring during each subsequent transfusion episode, although the alerts themselves did not reduce reaction occurrence. This observation aligns with related reports indicating that prior transfusion exposure is common among patients developing transfusion reactions. De Sousa Neto and Barbosa reported that 36.5% of patients experiencing adverse transfusion reactions had a history of previous transfusions,¹² while Bhattacharya et al. observed prior transfusion exposure in 52.38% of affected patients,¹³ suggesting that repeated transfusion exposure may contribute to an increased likelihood of transfusion-related adverse events.

Contemporary transfusion practice increasingly prioritizes component modification to reduce the risk of transfusion-related adverse reactions. In our institution, use of conventional PRC declined markedly from 6,713 to 951 units (-86%), reflecting a transition toward leukocyte-reduced red cell components. Likewise, LPPC were used only in 2022 (417 units) and were subsequently discontinued following the national policy

from the NBC-TRCS recommending replacement with leukocyte-reduced platelet products as part of broader transfusion safety strategies. The spectrum of transfusion reactions observed in this study is consistent with patterns reported in established hemovigilance systems. Among 63,805 transfusion episodes, 183 transfusion-related adverse reactions were identified, corresponding to an incidence comparable to previously reported institutional estimates (approximately 0.18%-0.24%).¹²⁻¹⁴ Allergic reactions and FNHTR accounted for most events, reflecting the predominance of these generally non-life-threatening complications in routine transfusion practice. A similar pattern has been reported elsewhere; Harvey, et al. documented allergic reactions in 46.8% of reported transfusion-related adverse events.¹⁵ Mixed reaction patterns were also observed, underscoring the clinical overlap of transfusion-related symptoms and the inherent challenges of reaction classification in routine care. The distribution of reactions across ABO blood groups broadly paralleled the expected prevalence among transfused patients, suggesting that the observed pattern largely reflects transfusion exposure rather than blood group-specific susceptibility. Overall reporting rates fell within the range described in institutional hemovigilance programs; however, such estimates remain strongly influenced by surveillance intensity, reporting practices, and case ascertainment. These observations further highlight the well-recognized variability in transfusion reaction reporting across institutions, particularly in systems relying on passive surveillance.^{8,16}

The component-specific distribution of reactions observed in this study is consistent with the established pathophysiology of common transfusion reactions. FNHTR predominated following red cell transfusions, whereas allergic reactions were more frequently associated with

plasma-containing components, particularly plasma or cryoprecipitate. This pattern likely reflects the higher burden of donor plasma proteins capable of triggering hypersensitivity responses.¹⁷ Platelet transfusions demonstrated a comparable distribution with FNHTR and allergic reactions accounting for most events. Similar component-related trends have been reported by Cho, et al., indicating allergic reactions occurred significantly more often with plasma and platelet components than with red cell components.¹⁸

Conclusion

Implementing a multidisciplinary hemovigilance and education program improved recognition and reporting of suspected adverse transfusion reactions in routine clinical practice. Educational initiatives, streamlined reporting pathways, multidisciplinary review, and integration of electronic clinical decision-support tools collectively strengthened awareness and detection of transfusion-related adverse events. The overall reaction profile, predominated by allergic reactions and FNHTR, was consistent with patterns reported in established hemovigilance systems and reflected the biological characteristics of transfused blood components. These findings support the continued implementation and refinement of multidisciplinary hemovigilance strategies to improve reporting quality and transfusion safety. All reported transfusion reactions in this study have been incorporated into the national hemovigilance database maintained by the NBC-TRCS. Expanded participation in the national hemovigilance system is essential to establish robust baseline statistics and develop nationally representative standards and quality indicators for transfusion safety in Thailand, providing country-specific evidence to guide interventions for the Thai population.

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