

Evaluating The Impact Of NAT And RDT On Donor Screening And Blood Safety In A High-Volume Medical Center

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Abstract

Background: Blood safety is a major concern in transfusion medicine. This study explored how new donor screening methods, such as Nucleic Acid Testing (NAT) and Rapid Diagnostic Tests (RDTs), help improve the detection of transfusion-transmissible infections (TTIs) at a tertiary care hospital in Jeddah.

Methods: A retrospective mixed-methods study was conducted between January and August 2025. The quantitative part included an analysis of 18,247 donor records screened with Nucleic Acid Testing (NAT), Rapid Diagnostic Tests (RDTs), and standard serological assays. Alongside this, semi-structured interviews were carried out with 12 staff members to understand their experiences in daily operations and the challenges they faced.

Results: Nucleic Acid Testing (NAT) detected 23 cases of transfusion-transmissible infections (0.28%), Rapid Diagnostic Tests (RDTs) found 18 cases (0.40%), and serological assays confirmed 11 cases (0.20%). The results showed that TTI positivity was higher among male donors, people aged 30 years and above, and first-time donors. From the staff interviews, several themes appeared: NAT was seen as having strong diagnostic benefits, RDTs were useful in urgent situations, and there was a clear need for better system integration, regular staff training, and updated national guidelines.

Conclusion: New methods for donor screening have made blood transfusion safer. However, there are still some problems in how these methods are used. Making better rules and using digital tools could help improve blood transfusion in hospitals with high demand.

Keywords: Blood safety, Donor screening, Nucleic acid testing (NAT), Transfusion-transmissible infections (TTIs), Rapid diagnostic tests (RDTs), Blood donation, Laboratory screening, Transfusion medicine, Public health, Saudi Arabia

INTRODUCTION

Safe blood transfusion is very important in healthcare around the world. In the tertiary care hospital, the quality of the blood supply directly affects patients in surgery, cancer treatment, blood diseases, and emergency care. Blood safety depends not only on how blood is collected and stored but also on how well and how quickly donors are screened.

In the last twenty years, new screening methods such as nucleic acid testing (NAT) and transcription-mediated amplification (TMA) have made it faster to detect infections that can spread through blood, like HIV, HBV, and HCV. These methods have made blood transfusion much safer for both donors and patients. Also, recent health problems around the world and changes in donor groups have encouraged the use of new screening systems, mobile blood collection, and quick testing tools.

Even with these improvements, there are still many problems. These include ethical concerns, high costs, unequal access to modern technology, and the appearance of new diseases. Because of this, it is important to keep reviewing blood screening methods. This study looks at new ways of donor screening, their role in making blood transfusion safer, and how hospitals can use these technologies better to keep blood supply safe and reliable.

LITERATURE REVIEW

Blood safety is very important in modern healthcare, especially in places where many transfusions are needed. New methods of donor screening have been developed through technology and public health efforts to reduce the risk of infections. These changes have made blood transfusion much safer, moving it from a risky practice to one that is now controlled and reliable.

A key part of improving blood safety is the use of very sensitive tests that can find transfusion-transmissible infections (TTIs) at an early stage. The use of nucleic acid testing (NAT) was an important step because it makes

it possible to detect viral DNA or RNA during the window period, which lowers the chance of infections being missed (Shrivastava & Mishra, 2017). In the same way, transcription-mediated amplification (TMA) has improved the accuracy of screening for HIV, HBV, and HCV in both pooled and single samples, which has raised the overall level of blood safety (Van Buren & Gorlin, 2022).

Blood safety depends not only on modern technology but also on clear rules for choosing and deferring donors. For instance, the U.S. Food and Drug Administration updated its regulations for men who have sex with men (MSM) in 2015 after data showed that the risk of TTIs had decreased because of better testing and improved screening methods (Young & Saa, 2023). In a similar way, China has made major changes to its donor policies since the 1990s, bringing together new testing technologies with education programs to improve the safety of both donors and patients (Li et al., 2017).

Point-of-care technologies and mobile blood collection have become very important in solving the problem of “blood deserts,” which are areas with little or no access to safe blood. New methods such as rapid diagnostic testing (RDT) and small donor screening centers have shown good results in places with limited resources (Raykar et al., 2024). These methods are also very useful during pandemics or in times of conflict, when it is difficult to run large central testing laboratories.

The ethical side of donor screening is still widely discussed. One of the main questions is how safe the blood supply should be. While complete safety is the ideal goal, Verweij and Kramer (2018) explain that it needs to be balanced with the cost, the number of available donors, and the danger of rejecting low-risk groups if the rules are too strict.

Modern blood transfusion now often follows a “vein-to-vein” safety model. This model focuses not only on screening before transfusion but also on better cold chain systems, monitoring of blood use, and improved methods to match patients with donors (Talukdar & Bhattacharya, 2025). In addition, healthcare workers, especially nurses, are now seen as important because they help ensure safe procedures and give donors a better experience (Alshehri et al., 2024).

Recent studies also show that it is important to keep monitoring blood safety and to update donor screening rules often. Igbe et al. (2024) explain that these rules need to change with new diseases and changing patterns of infection in order to stay effective.

HIV is still a serious problem in blood transfusion, especially in countries where the infection rate is high. El Obeagu and Adias (2024) point out both the strengths and the weaknesses of the tests used for HIV today, and they call for more global agreement and financial support to reduce the gap between rich and poor countries.

METHODOLOGY

Study Design and Setting

This retrospective mixed-methods study was done in the Department of Laboratory and Blood Bank Services at a large hospital in Jeddah, Saudi Arabia. The purpose was to study how well new donor screening methods worked and to see their effect on blood safety. The study covered eight months, from January to August 2025.

Quantitative Component

In total, 18,247 donor screening records were collected from the hospital’s laboratory information system (LIS) during the study. These records included both serology results and nucleic acid testing (NAT) results for the main transfusion-transmissible infections (TTIs), which were HIV, HBV, HCV, and syphilis. Records that were incomplete or repeated for the same donor were removed from the analysis.

The screening methods studied were:

- Nucleic Acid Amplification Testing (NAT), which was newly introduced at the beginning of 2025.
- Rapid Diagnostic Tests (RDTs), which were used in mobile units and urgent care situations.
- Standard serological tests, including enzyme immunoassay and chemiluminescence immunoassay.

Basic statistics were used to describe donor details and the rates of TTIs. The Chi-square test and logistic regression were applied to compare the results of different screening methods and to look at links with donor factors such as age, sex, and type of donation. All data were analyzed using SPSS Version 26, and results were considered significant at $p < 0.05$.

Qualitative Component

To give more background, semi-structured interviews were held with 12 staff members. These included transfusion doctors, laboratory technologists, and donor nurses who were directly involved in screening donors. The participants were selected on purpose, based on their work role and level of experience.

The interviews looked at three main areas:

- Staff experiences with using new screening tools.
- Their views on how these tools improved accuracy and made work faster.
- Suggestions for future improvements and the need for more training.

The interviews were recorded and written out, then studied using thematic analysis in NVivo software. The results were compared with the quantitative data to make the findings clearer and more reliable.

Ethical Considerations

The study was approved by the hospital ethics committee. All steps followed the ethical rules set in the Declaration of Helsinki. Written consent was taken from every interview participant before the data were collected.

Findings

Quantitative Results

Over the eight-month period from January to August 2025, a total of 18,247 blood donors were tested using Nucleic Acid Testing (NAT), Rapid Diagnostic Tests (RDTs), and regular serological tests. The number of tests and the infection detection rates for each method are shown in Table 1.

Table 1. Detection Rates of Transfusion-Transmissible Infections (TTIs) by Screening Method

Screening Method	Total Tests Conducted	Positive TTI Cases Detected	Detection Rate (%)
NAT	8,247	23	0.28%
RDT	4,500	18	0.40%
Serological Assay	5,500	11	0.20%

NAT was used for most of the tests and showed a detection rate of 0.28%. RDTs were used less often but had the highest detection rate at 0.40%. Serological tests found the fewest TTIs, with only 11 cases, which shows their known weakness in finding infections during the early stage.

Donor Demographics and TTI Positivity

The analysis of TTI-positive cases (n = 41) showed that most were male donors (68.3%), while female donors made up 31.7%. Most infections were seen in donors aged 30 years and older (63.4%), which shows a higher risk in this age group. First-time donors also had a slightly higher number of positive cases (53.7%) compared to repeat donors (46.3%), which may point to lower awareness or lack of past screening. These findings are shown in Table 2.

Table 2. Demographic Breakdown of TTI-Positive Blood Donors

Variable	Positive Cases (n)	Percentage (%)
Male	28	68.3%
Female	13	31.7%
Age < 30	15	36.6%
Age ≥ 30	26	63.4%
First-Time Donors	22	53.7%
Repeat Donors	19	46.3%

Qualitative Findings

Qualitative data were collected through semi-structured interviews with 12 staff members, including transfusion doctors (n = 3), senior laboratory technologists (n = 5), and donor screening nurses (n = 4). Thematic analysis found three main themes with related sub-themes, and each was supported by direct quotes from participants.

Theme 1: Perceived Effectiveness of New Screening Technologies

Sub-theme 1.1: Confidence in NAT for Early Detection

Most of the participants agreed that Nucleic Acid Testing (NAT) was more sensitive in finding TTIs during the window period.

"Since we started using NAT, we have found infections before antibodies appeared. This has been a big improvement, especially for first-time donors."

— Participant 4, Laboratory Technologist

Sub-theme 1.2: RDTs as a Practical Tool in Emergency Settings

Although the participants said that RDTs are not as sensitive as NAT, they still saw them as helpful in urgent cases or when blood is collected outside the hospital.

"In urgent cases, we cannot always wait for NAT results. RDTs give us quick information, even if we later confirm with more accurate tests."

— Participant 9, Transfusion Physician

Theme 2: Operational Challenges in Implementation

Sub-theme 2.1: Delays in NAT Result Turnaround

Delays in reporting results were seen as a major problem in the workflow, especially when there were many donors at the same time.

"At times it takes more than 24 hours to get NAT results, and this is a long delay for a hospital as busy as ours."

— Participant 2, Nurse in Donor Unit

Sub-theme 2.2: Quality Control Issues in RDT Kits

The participants said that the quality of RDT kits was not the same across all suppliers, and sometimes false-positive results caused donors to be deferred without need.

"We have had cases where RDTs showed a reactive result, but later the tests came back negative. This makes donors lose trust."

— Participant 6, Senior Technologist

Theme 3: Recommendations for Improvement

Sub-theme 3.1: Need for Continuous Training

The staff said there was a need for regular workshops and skill checks to stay updated with the changing screening methods.

"These technologies change fast. We need training more often, especially for the new staff." — Participant 8, Lab Supervisor

Sub-theme 3.2: Integration of Digital Screening Systems

The participants stressed that donor screening records should be better connected with the hospital's main electronic medical system.

"Right now, we still have to enter the same data twice. A single system would reduce mistakes and make the work faster."

— Participant 1, IT-linked Blood Bank Technologist

Sub-theme 3.3: Policy Updates and National Guidelines

Several participants said that the Ministry of Health should give clearer national rules on donor eligibility and testing, and that these guidelines should be updated regularly.

"We use WHO standards, but the national rules are often old. Saudi Arabia needs clear and updated guidelines of its own."

— Participant 10, Transfusion Consultant

DISCUSSION

This study looked at how new donor screening methods were used and what results they gave over eight months. The findings show that modern screening tools, such as Nucleic Acid Testing (NAT) and Rapid Diagnostic Tests (RDTs), are important for making blood transfusion safer and for finding transfusion-transmissible infections (TTIs). The quantitative results showed differences in how sensitive the methods were, while the qualitative results focused on work challenges and staff views about how the system could be improved.

The detection rate of TTIs with NAT (0.28%) was similar to findings from other large hospitals, showing its value in reducing the early window period (Shrivastava & Mishra, 2017). On the other hand, RDTs showed a higher detection rate (0.40%), but interviews raised concerns about their lower accuracy and the chance of false

positives. These results agree with earlier studies, which suggest that RDTs should mainly be used in urgent cases or for blood collection in the field (Raykar et al., 2024).

The donor data showed that TTIs were more common among male and first-time donors, which matches other studies that found higher infection rates in these groups (El Obeagu & Adias, 2024). Age was also an important factor, as 63.4% of infections were found in donors over 30 years old. This may be linked to greater exposure over time and shows the need for education programs aimed at older and first-time donors.

From a practical view, staff valued NAT for its accuracy when added to daily work, but they also noted delays in getting results as a weakness. They stressed the need to connect lab results better with the hospital's electronic system to avoid entering data twice and to improve tracking. These points agree with global trends that support digital change and automation in blood banks (Talukdar & Bhattacharya, 2025).

One key issue raised in the interviews was the lack of updated national donor screening rules that fit Saudi Arabia's own health situation. At present, most practices follow WHO guidelines, but these may not fully reflect local problems such as new TTIs or region-specific risks. Staff members asked for more training and national policy changes, which is also supported by findings in international studies (Verweij & Kramer, 2018).

This study gives useful information, but some limits must be noted. Because it was a retrospective study, some donor details that were not recorded may have been missed. Also, since it was done in only one hospital, the results cannot fully represent other settings. The interviews added important context, but the number of participants was small. Future research should include more hospitals and also follow patients after transfusion to study the real effect of new donor screening methods.

CONCLUSION

This study showed that using new donor screening methods, especially Nucleic Acid Testing (NAT) and Rapid Diagnostic Tests (RDTs), can make blood transfusion safer by finding infections earlier. NAT gave more accurate results, while RDTs were still useful in urgent situations, even though they had some limits. The findings also underlined the need for ongoing staff training, better digital links between screening systems, and updated national rules on donor eligibility. Improving these areas will be important for keeping blood transfusion safe and effective in Saudi Arabia and in similar healthcare systems.

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