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Review article

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Exploring Laboratory Errors in Blood Transfusion: A Systematic Review

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Abstract

Blood transfusion, a vital medical intervention, is susceptible to errors in the laboratory phase, which can lead to severe consequences. This systematic review explores the literature on laboratory errors in blood transfusion, highlighting the impact of these errors on patient safety and outcomes. It also presents strategies for error prevention and management. The review underscores the potential for improvement in blood transfusion services through ongoing quality improvement efforts, a responsibility for all of us. After a comprehensive search and analysis of relevant literature published from 2014 to 2024 under PARSMA2020 guidelines, nine articles met the inclusion criteria, revealing a range of errors across different stages of the transfusion process. Preanalytical errors were found to be the most common. Procedural deviations, insufficient collaboration, and work fatigue among medical staff were identified as the causes of these errors. The review suggests that implementing educational and contentious training programs for medical staff, along with highly accountable policies, could significantly reduce these errors, thereby reducing total mortality and morbidity rates.

Keywords: ***Blood Transfusion, Laboratory Errors and Samples.***

1. Introduction

Safe and effective blood availability has been crucial in advancing modern medicine worldwide. It has played a life-saving role for accident victims and emergency patients and has an essential, irreplaceable function in supporting medical and surgical practices. It has thus provided enormous therapeutic benefits for patients. The rapid expansion in the clinical application of blood has increased demand. This has pressured blood collection organizations to provide a safe and adequate supply. As a unique biologically sourced product, there is no natural substitute for human blood. Blood transfusion involves human participation, inevitably leading to human errors in this chain of events (Makroo & Bhatia, 2017). Error is defined as any failure in compliance with the SOPs laid down by the department. (Kau, Kaur, & Kaur, 2019). Errors in medicine can be categorized as either knowledge errors or slip errors. Knowledge errors in transfusion lead to inappropriate decisions regarding blood administration, while slip errors result from distractions, fatigue, or inattention. Slip errors that are caught in time or without harm are referred to as 'near-miss events (Jain et al., 2014)

Blood transfusion-associated mortality due to human errors has been reflected in reports published globally, highlighting human errors and their impact on patient safety as a top-priority medical issue. One report from the Serious Hazards of Transfusion (SHOT) estimated a frequency of incorrect blood component transfusion as high as 70% of total transfusion errors, revealing that most transfusion errors were clerical and preventable (Das, Chakrabarty, & Zaman, 2017).

According to the (Cohen, 2013) review, hotspots for errors in the transfusion process are often associated with specific professional groups responsible for them.

Laboratory staff and their assistants in the blood center and the laboratory departments are identified as being responsible for critical points of error, including reception, testing, allocation of components, labeling, issuing, and processing of samples.

Errors occurring during the collection of patient samples for pre-transfusion compatibility testing are particularly critical, as they occur at the outset of the complex transfusion process. Three major 'zones of error' pose significant risks to safe transfusion practices: (i) ensuring accurate patient identification and proper labeling of pre-transfusion specimens; (ii) making appropriate decisions regarding the clinical use of blood components; and (iii) ensuring accurate bedside verification to confirm that the correct blood is administered to the intended recipient (Jain et al., 2014).

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Generally, laboratory errors can be classified into three main phases: Preanalytical errors, Analytical errors, and Post-analytical errors (Abdollahi et al., 2014).

Preanalytical errors are subdivided into errors that occur outside the laboratory and errors that occur within the laboratory:

Outside the laboratory: Inappropriate test requests, order entry errors, misidentification of patients, inappropriate containers, improperly labeled containers, inadequate sample collection and transportation, specimens collected from infusion routes, inadequate sample/anticoagulant volume ratio, and insufficient sample volume.

Within the laboratory: Sorting and routing errors, pour-off errors, and labeling errors.

Analytical Errors are defined as errors that occur during the test and include equipment malfunction, sample mix-ups, interference, undetected failures in quality control, and failure to follow procedures.

Post-analytical errors occur after the test is conducted and include failures in reporting, erroneous validation of analytical data, improper data entry, and excessive turnaround time. Many studies suggest that the steps most prone to error lie in pre- and post-analytical phases (Makroo & Bhatia, 2017).

Despite the introduction of advanced technologies in the transfusion chain, such as automation, computerization, barcode-based coupling of patient I.D. bands with blood product labels, and radiofrequency identification (RFID), which have significantly reduced clerical and human error rates, various factors such as costs, security, and privacy may hinder the adoption of these advanced technologies in many institutions and countries. Moreover, no system has been developed to eliminate instances of human error to date (Ri et al., 2020) (Shahshahani & Hayati, 2020)

This paper aims to elucidate the human errors made by laboratory staff that compromise patient safety.

2. Methods

2.1. Design

A systematic review of the international literature followed the PRISMA methodology (PRISMA Group, 2020), considering articles in the English language. The research question was formulated using PICO:

P: Population: Laboratory staff participating in blood transfusion processes
I: indicator: Identification and analysis of common laboratory errors in blood transfusion
C: Comparison: Different types of laboratory human-made errors and error frequencies in the blood transfusion chain
O: Outcome: Include factors and causes of these errors

Based on this framework, the PICO question was as follows:

What are the most common types of human-made laboratory errors, and what are their frequencies and contributing factors to blood transfusion?

2.2. Eligibility criteria

This review included published articles that reported studies regarding laboratory errors in the blood transfusion chain. For assessing types of errors and their related causes, eligible study designs were observational, cohort studies, cross-sectional, prospective, and retrospective analyses. Articles were limited to English and included publications from January 1, 2014, until 2024. Review articles, opinion articles, letters not presenting original data, and studies reporting case series, case reports, and interventions were excluded.

3.3. Information Sources and Search Strategy

Systematic review was conducted using Medline/PubMed, Google Scholar, and the Global Journal of Transfusion Medicine. The following search terms were used: “laboratory errors,” “human laboratory errors,” “blood transfusion,” and “transfusion chain.” The searches were concluded by March 2024.

Study Selection

The results of the initial search strategy were first screened by title and abstract. The full texts of relevant articles were examined for inclusion and exclusion criteria (see Fig. 1). Duplicated reports and any articles with no full text and non-relevant studies have been removed.

3.4. Data Collection Process and Data Items

Data extraction forms included information on the type of study, country, year and date of publication, error rates, types of errors listed, their causes, as well as the error with the highest frequency in each study

4. Result

4.1. Study selection and characteristics

A total of 91 articles were retrieved using the search strategy: Google Scholar (n=19), PubMed (n=45), and the Global Journal for Transfusion Medicine (n=27). Reasons for exclusion included irrelevance to the review aim, non-human-made errors (i.e., intrinsic factors such as inherited, cell, and serum defects), papers not written in English, and full texts not being available. After screening and deleting duplicates, nine articles were considered appropriate. Characteristics of the included studies have been summarised in Table 1.

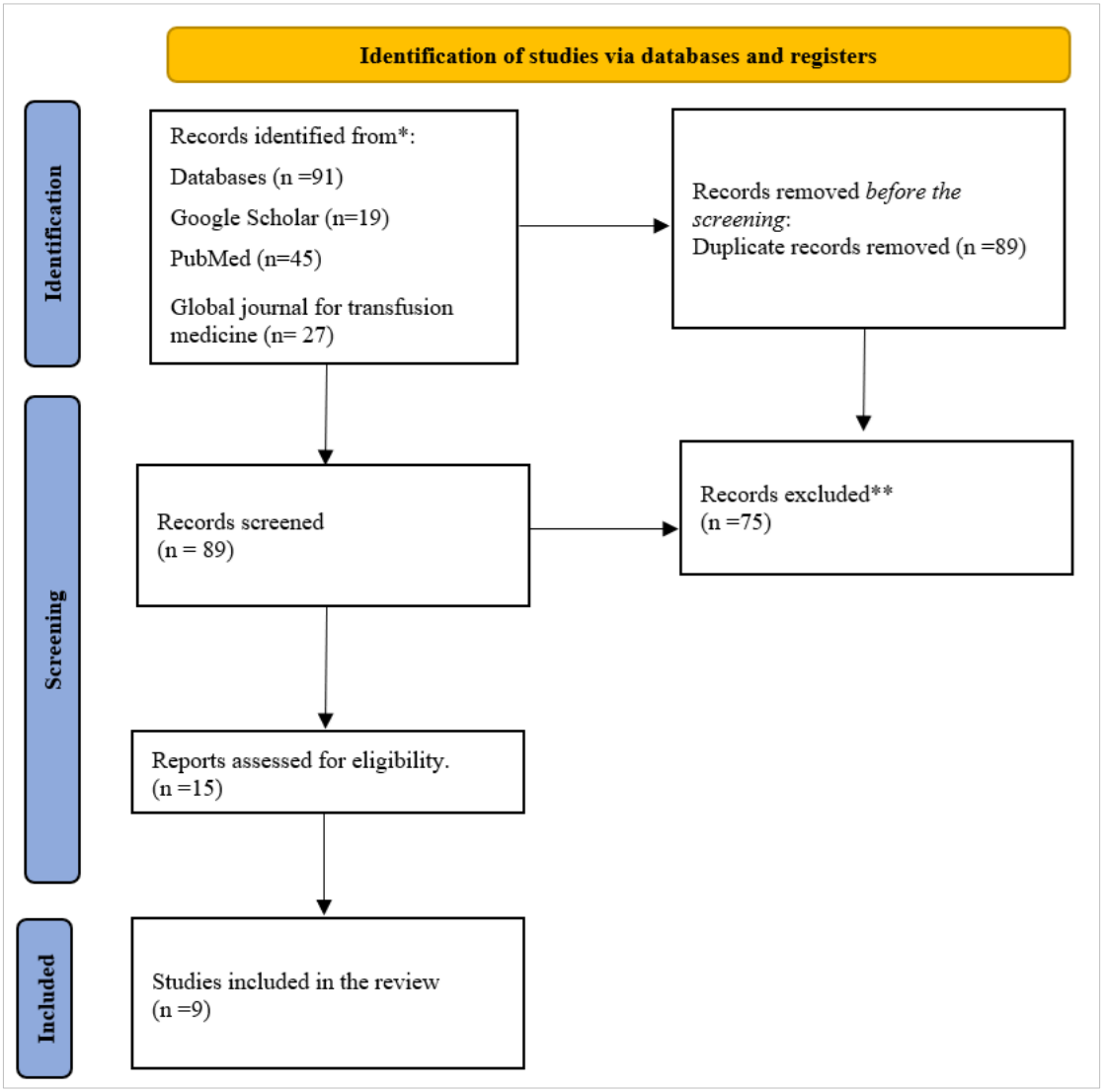

Figure 1: PRISMA 2020 flow diagram for new systematic reviews, which included searches of databases and registers only

Table 1: Characteristics of the included studies

Author	Year of publication	Type of Study	Journal name	Aim	The most common error is the frequency	Country
(Miah, Doha, Islam, & Sharmin, 2021)	2021	Retrospective cohort	Global Journal of Transfusion Medicine	To perceive the frequency of adverse reactions to blood transfusion and the errors associated with its barrier.	Incomplete requisition with wrong component order (47%)	Bangladesh
(Vijenthira, et al., 2021)	2021	Retrospective analysis	International Society of Blood Transfusion	To describe registration errors aiming to characterize these errors	name errors (31.7%),	Canada
(Ri, et al., 2020)	2020	Retrospective review	Transfusion and Apheresis Science	Expanded survey of transfusion-related incidents that occurred across the entire prefecture of Aichi,	Bed site (implementation)with total 0.58 %	Japan
(Shahshahani & Hayati, 2020)	2020	Cross-sectional study	International Journal of Haematology-Oncology and Stem Cell Research	To determine the frequency and causes of ABO blood grouping discrepancies among blood donors	(9.3%) of ABO discrepancies were technical/clerical error	Iran
(Kau, Kaur, & Kaur, 2019)	2019	Prospective analytical study	International Society of Blood Transfusion	To detect the type and etiology of errors in the blood transfusion process	Blood component labeling errors (17.9%)	India

(Strauss, et al., 2018)	2018	Retrospective	TRANSFUSION SERVICE	Analysis of sample collection (S.C.) and sample handling (S.H.)	(37% of all S.C. errors) were samples collected unnecessarily. (61%) of the sample, the handling error was no phlebotomist/witness identification on the requisition/computer form	Canada
(Makroo & Bhatia, 2017)	2017	Retrospective	Asian Journal of Transfusion Science	To assess its role in improving transfusion practice by adding a layer of safety to compatibility testing.	81% were pre-analytic errors	India
(Das, Chakrabarty , & Zaman, 2017)	2017	Prospective	Global Journal of Transfusion Medicine	To estimate the incidence and nature of transfusion errors, identify the source site of occurrence, and assess the underlying problems in the system.	Total human error: 22.6%	India
(Jain, Kumari, Marwaha, & Sharma, 2014)	2014	Prospective study	Indian Society of Haematology & Transfusion Medicine	To identify requisition errors before compatibility testing.	C. R. No. discrepancy was the most common requisition form error (1.11 %)	India

4.2. Blood Transfusion Laboratory Errors Classification and Most Common Occurrence Frequencies

Nine articles address the issue of laboratory errors in blood transfusion from various perspectives, each presenting the errors in a manner that serves its aim. Two retrospective studies analyzed errors reported in the Transfusion Error Surveillance System (TESS) database in Canada; the first study by (Strauss et al., 2018) analyzed sample collection and sample handling errors; the most common sample collection error was sample collected unnecessarily (37% of all S.C. errors); and the most common sample handling error was no phlebotomist/witness identification on the requisition/computer form (61%). The second study by (Vijenthira et al., 2021) focused specifically on registration errors; the most frequent errors reported were name errors (37%).

A cross-sectional study by (Miah et al., 2021) listed errors without specific classifications or focusing on particular error areas and stated that the most commonly encountered error was incomplete blood requisition and order for the wrong component (47%).

A study of blood group discrepancies related to errors (Shahshahani & Hayati, 2020) concluded that Nine percent of ABO blood group discrepancies occurred due to technical/clerical errors.

A survey conducted by (Ri et al., 2020) relied on the Ministry of Health, Labour, and Welfare (MHLW) of Japan study group's categorization of transfusion-related errors, incidents/and accidents were categorized according to the stages in which they occurred. The highest incidences of these events occurred during implementation/recording at the bedside.

(Kau, Kaur, & Kaur, 2019) Classified and coded events according to the Medical Event Reporting System-Transfusion Medicine (MERS-TM). They categorized errors into actual events (including no-harm and adverse events) and near-miss events (divided into laboratory near-misses and bedside near-misses). The most common type of error in our study was labeling errors 17.9%; nevertheless, 85.3% of errors were discovered in the laboratory, and the remainder were discovered on the wards (14.1%) error categorized into two broad categories and intrinsic (Das, Chakrabarty, & Zaman, 2017); extrinsic incidents were accurate human errors, while intrinsic errors were caused by inherent factors in cells or serum then, extrinsic errors were further subcategorized according to the severity of incidents as major and minor errors. A significant error was defined need as a human error that was not identified before the issuing of a blood component from the laboratory area, and a minor error was defined as a human error that was identified before the issuing of a blood component from the laboratory area with a total of 22.6% human errors.

Errors identified by (Makroo and Bhatia, 2017) were categorized into pre-analytic, analytic, and post-analytic errors, depending on the step at which they occurred in the process; about 81% of errors occurred in the pre-analytic step.

A prospective study by (Jain et al., 2014) focused primarily on requisition form errors and stated that total requisition form errors were 2.6%; however, the unique central registration number (C. R. No.) discrepancy was the most common (1.11 %) error observed.

4.3. Errors That Reviled from All Studies Have Been Included in This Review:

In this review, errors will be presented as pre-analytic, analytic, and post-analytic transfusion errors to make them easier to understand:

4.3.1. Pre Blood-Transfusion Errors

Failure to identify the correct blood group of the recipient or donor causes discrepancies (Miah et al., 2021). Spoilage of autologous blood samples due to incorrect handling of the storage bag (Ri et al., 2020), Sample haemolysed Sample collected unnecessarily (Strauss et al., 2018).

(Jain , Kumari , Marwaha, & Sharma, 2014., Miah, Doha, Islam, & Sharmin, 2021., Vijenthira, et al., 2021) were highlighted patient name errors in their studies, which included the requisition form and the sample being different, spelling errors, discrepancies between the name in the hospital system and on the provincial health insurance card, no notification of name change when provisional names (e.g., Unidentified, Andrew) were updated, incorrect

assignment of provisional names (i.e., assigning a name of the wrong sex) and simply 'incorrect name' without further description.

Sample vial-related errors like Inappropriate sample containers/vials were reported by (Strauss et al., 2018., Das, Chakrabarty, & Zaman 2017., and Jain Kumari, Marwaha, & Sharma, 2014).

Studies found requisition form problems (Miah et al., 2021., Kau, Kaur, & Kaur, 2019., Das, Chakrabarty, & Zaman, 2017., Makroo & Bhatia, 2017., and Jain Kumari, Marwaha, & Sharma, 2014), such as central registration number (C.R. No.) on the vial not identical to the C. R. No. on the requisition form, cutting/overwriting of C.R. No. A C.R. No. It needs to be on the sample vial and the requisition form. Either on the sample vial the requisition form, or both. Mixed errors- like different patient's name and C.R. No. In addition, Incomplete/incorrect requisition forms (patient details/component requested/blood group/signature, etc., missing/incorrect/wrong blood order) were also identified on the requisition and sample.

Moreover, (Kau et al., 2019 Strauss et al., 2018 Makroo and Bhatia, 2017) revealed insufficient, inappropriate, or incorrectly labeled samples.

In terms of Donor/patient mis- identification illustrated via (Vijenthira et al., 2021., Shahshahani & Hayati, 2020), wrong armbands, patients using another individual's identification, incorrect sex as patient mis identification errors in contrast, donor misidentification occurred when the blood donor presented another donor I.D. card. It also occurred when donor data was erroneously recorded in another donor's datasheet, which could happen when another record in the registration system had a similar name or date of birth.

4.3.2. Analytic Blood Transfusion Errors

False grouping in blood bags, mislabelling of the patient's sample, and recording during blood grouping analytic errors were reported by (Miah et al., 2021).

Moreover, both (Miah et al., 2021., and Das, Chakrabarty, and Zaman, 2017) reported wrong patient blood in the sample vial and Wrong blood in the tube. Technical errors include Mislabelling of sample tubes, wrong tests, and sample mix-ups (Shahshahani & Hayati, 2020., Makroo & Bhatia, 2017). additionally, it presented about 9% of ABO blood group discrepancy.

Other analytic errors identified were Equipment errors, Special tests/procedures not done (antibody screening, irradiation, viral testing, etc.), incorrect cross-match, blood component issue errors in compatibility, failure of washing red cells while performing blood grouping failure to perform reverse grouping, failure to perform Weak D test (Kau et al., 2019)., and Das, Chakrabarty, & Zaman, 2017

4.3.3. Post-Analytic Blood Transfusion Errors

Handling and storage errors of bags (Kau et al., 2019) (Strauss et al., 2018), Wrong component issued and Delay in issues, Incorrect labeling on unit/ compatibility (Makroo & Bhatia, 2017), and misinterpretation of the result and transcription errors on blood issue register, errors in the form of wrong patient names and identify cations either on sample vials and blood requisitions at bedside or compatibility report and label in blood bank (Das, Chakrabarty, & Zaman, 2017) were reported as post-analytic errors.

4.4. Location and Root Causes of Blood Transfusion Laboratory Errors

(Vijenthira, et al., 2021) Clarified that the person involved in the error was most frequently a hospital clerk (51.3%) or a nurse (27.1%), while errors were typically discovered by a medical laboratory technologist or assistant (78.5%) and found Errors most commonly occurred in outpatient clinics or procedure units and the emergency department but in the hospital, the most minor errors occurred in operating rooms.

Similarly, the two locations with the highest rates of sample collection and sample handling errors were the operation room and the emergency department (Strauss et al., 2018).

On the other hand, (Jain et al., 2014) stated that the highest number of requisition errors were observed in those received from the Emergency and Trauma services, possibly reflecting these areas' heavy workload.

Furthermore, a better understanding of (or insufficient compliance with) operational procedures, collaboration among the medical staff, and human errors attributable to work fatigue contributed to errors (Ri et al., 2020). (Das, Chakrabarty, & Zaman, 2017) the study reflected that all technical errors (analytic errors) related to donor samples were due to deviations from the departmental standard and operating procedures (SOP). Most of the errors happened during the night shift. In contrast (Kau et al., 2019) reported that the maximum errors located in laboratories (48%) occurred in the evening shift (49.4%), followed by the night shift.

(Makroo & Bhatia, 2017., and Jain , Kumari , Marwaha, & Sharma, 2014) Clarified that significant factors contributing to mislabelling resulting in wrong blood in the tube (WBIT) were labeling the tubes away from the bedside or labeling by someone other than the phlebotomist and sampling multiple patients around the same time, resulting in sample mix-ups and incorrect labeling; additionally, the requesting clinician might have miswritten requisition form error such as blood group mentioned on the form, or the sample might have been taken from a wrong patient.

Problems with correct patient identification usually result from the phlebotomist omitting or not completing the necessary patient identification steps at the time of sample collection (Makroo & Bhatia, 2017).

5. Discussion

The findings of this review highlight the types and nature of laboratory errors within the blood transfusion process in many countries worldwide. Although there was a small scale of countries that had studies regarding the topic, there were many countries that had the error-monitoring system, which could be a great source of information that can be used in developing plans for system improvement and need assessment (Vijenthira et al., 2021) (Kau et al., 2019) (Strauss et al., 2018). Pre-analytic phase errors represented the most mutual errors among all studies, which is a critical area for improvement.

Studies suggested that staff education and training programs should prioritize error prevention strategies and promote a culture of accountability. Collaborative efforts between medical personnel and laboratory staff are essential to minimize human errors.

6. Strategies for Error Prevention

The electronic decision support systems are further advanced to validate blood component requests against national transfusion guidelines automatically. Laboratory staff can be further supported by implementing pre- and post-analytical training programs to ensure they have the necessary skills to perform their duties to the highest standard. Effective training programs can prevent errors related to the testing process. Collaboration between institutions through peer review and the sharing of benchmark data are highlighted as effective methods to supervise laboratory processes

and prevent errors in blood testing. Additionally, findings from testing should be independently reviewed before release, which is also viewed as an effective supervision strategy to prevent errors. (Badrick, 2021) (Iwen et al.2020) (Nichols et al.2020).

The removal of silos in laboratory blood transfusion services is a collective theme within several error-reduction strategies. A multidisciplinary team that includes clinical specialists, senior laboratory staff, and clinical support staff can help to ensure laboratory errors are addressed at every level. Laboratory staff must have appropriate training and feel supported to make decisions and query requests to prevent errors from occurring. The implementation of electronic decision support systems and electronic information management systems are highlighted throughout the literature as effective measures to prevent errors at multiple stages from occurring. The systems can be specifically designed to prevent patient misidentification, sample collection, and testing errors. In addition, well-designed electronic systems can prevent errors associated with communication, inadequate supervision, and reporting of critical results. (Fernandes et al.2020) (Antoniadi et al.2021).

6.1. Quality Control Measures

The current systematic review focused on identifying errors in the blood transfusion process that can be attributed to poor laboratory practice. As such, it allows the recommendation of a list of Q.C. measures that laboratory professionals should adhere to prevent preanalytical, analytical, and post-analytical errors. This systematic review investigated the laboratory errors in blood transfusion. The review was limited to publications that described any error encountered in the performance of laboratory tests for blood transfusion or quality control measures undertaken to ensure testing accuracy in the blood transfusion process. Although a few errors might occur due to mislabeling, inappropriate testing, or incorrect release of blood components from the blood bank, most errors described in literature occurred at the pre-and post-analytical phases, which are outside the control of laboratory staff. (Bolton-Maggs & Watt, 2020) (Rambiritch et al.2021) (Sepetiene et al.2021).

The identified Q.C. measures were further categorized either under "Preanalytical (47.9 percent)" or "Analytical and Post-analytical (52.1 percent)" issues. The most commonly tested preanalytical were serum sample identification (7.2 percent), patient identification during blood collection (6.6 percent), the appropriate volume of blood in requested samples (5.3 percent), and hemolysis of blood samples (3.3 percent). Factors associated with blood collection represented 17.5 percent of all the tested preanalytical Q.C. On the other hand, nearly half of the reviewed Q.C. measures (46.6 percent) in the analytical and post-analytical phases belonged to checking inappropriate order requests and issues surrounding the identity of the blood samples. The most frequently tested Q.C. was related to the identity of blood samples received for cross-matching and the blood bags issued from the blood bank. Other frequently tested Q.C. measures were identifying blood samples for group and save testing, blood bags issued for uncross-matched blood transfusion, and Q.C. related to wristbands or identification cards for patients during blood collection. (AL-ESHAQ, 2020) (Mascotti, 2021) (Andriessen et al.2022) (Howard, 2020) (Health Organization, 2021).

6.2. Staff Training and Education

Most of the studies included in this review reported that training and education interventions significantly reduced error rates at different stages of the transfusion process. For example, an in-service education program substantially reduced the number of non-serious clerical errors in one study. One other study documented a significant decrease in errors in blood component issues following an electronic transfusion management system. These findings suggest that I.T. provides necessary safeguards to enhance the positive effect of associated educational interventions. The results of another study also suggested that the implementation of computerized barcode-based electronic system errors at patient identification decreases incidents of near-miss transfusion errors. It was observed that changes in the near-miss error rate occurred after implementing a computerized physician order system in combination with a decision support system. The significant drop in the number of near-miss transfusion errors after implementation suggests that I.T. has the potential to enhance the effects of educational interventions by providing necessary safeguards. (Sahmoud et al.2021) (Bolton-Maggs & Watt, 2020) (Moiz et al.2020) (Soliman & Elhapashy2021) (Brown & Brown, 2023) (Rambiritch et al.2021).

Blood transfusion is a complex process that requires a collaborative working effort of staff from different disciplines. Errors at any level of the blood transfusion process can jeopardize patient safety. Several studies have shown that most transfusion error s result from poor staff knowledge or inadequate training. Hence, regular training and education of staff at all levels involved in blood transfusion is essential to increase knowledge and awareness of possible errors that may occur and how best to prevent them. (Sahmoud et al.2021)(Bolton-Maggs & Watt, 2020)(Yami et al.2021)(Lancaster et al.2021).

6.3. Future Directions

In conclusion, the pre-transfusion testing process is a safety-critical and complex system that requires a combination of error-detection methods to ensure patient safety. New technologies that allow for near-zero errors' should be explored and implemented. Researchers and laboratories should invest in developing standardized procedures, training, and monitoring programs that effectively reduce the error rate. Implementing the recommendations outlined in this review requires a multidisciplinary collaboration of all staff involved in the pre-transfusion testing process. Systems for reporting and investigating errors should be developed and encouraged, and the knowledge gained should be used to design targeted interventions to reduce error rates. Furthermore, we encourage researchers to conduct cross-country explanatory studies using comparable methodologies to address the current knowledge gaps and to accurately determine the error rate and patterns in the pre-transfusion testing process. (Cagliano et al.2021) (Rambo & Magnago, 2023).

Laboratory testing is an essential aspect in the preparation of safe blood products for transfusion. This systematic review identified and explored errors in the pre-transfusion testing of patient and donor samples in the blood transfusion laboratory. We found that most errors resulted in patient harm, with some leading to significant morbidity/mortality. The overall error rate was high, with a significant variation in the error rates reported in different studies. One of the critical reasons for this variation was the different methodologies used to detect errors, leading to the underestimation of errors related to the less sensitive techniques. The incidence of laboratory errors in blood transfusion testing remains largely unknown and unexplored. This review also revealed that only a few intervention studies have been conducted to prevent or mitigate these errors. Common contributory factors were identified. Most errors were considered preventable, suggesting that systems-based solutions are needed to reduce error rates. (Padalko et al.2023), (Dandekar et al.2021), (Moiz et al.2020).

7. Strength and Limitation

The strength of this review lies in its adherence to the PRISMA 2020 guidelines for systematic reviews, ensuring a structured and transparent approach to data synthesis. However, several limitations need to be acknowledged. Firstly, despite conducting a comprehensive search using relevant keywords, not all related articles may have been identified due to restrictions on specific database sites. The search was limited to only three databases, potentially excluding relevant studies from other sources. Secondly, the review was conducted by a single author, which increases the risk of bias as there was no independent reviewer to verify the findings. Finally, a methodological quality assessment of the included studies was not conducted, which could impact the overall reliability and validity of the review findings. Addressing these limitations in future research could strengthen the rigor and comprehensiveness of similar systematic reviews.

8. Conclusion

In conclusion, this review provided insights into human errors compromising patient safety in the blood transfusion chain. Identifying common error types, frequencies, and root causes underscores the urgency of proactive measures to mitigate risks and enhance blood transfusion quality. Strengthening procedural adherence, promoting staff education, and fostering interdisciplinary collaboration are imperative steps toward error reduction and improved patient outcomes.

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Conflict of Interest

The authors declared that there are no conflicts of interest

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