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Effectiveness of intervention due to feedback on errors arising from inappropriate transportation and storage of blood bags in hospitals: a quasi-experimental study

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Abstract

Background: The limited supply of red blood cells (RBCs) for transfusion has clinical implications, and can lead to the introduction of different approaches in decreasing blood wastage and the safe and effective delivery of blood products.

Objective: To identify the influences of feedback-based intervention on inappropriate temperatures during transportation and storage of blood bags.

Methods: This was a quasi-experimental pretest-posttest design with a non-equivalent control group that was carried out on 200 RBC. The study was conducted in a teaching hospital in Mashhad, Iran, and in two periods during the same season: winter of 2015 (pre-intervention period) and winter of 2016 (post-intervention period). Staff of the blood bank department, as the intervention group, received the intervention including feedback regarding the inappropriate temperature in the blood bank during the pre-intervention period. The control group included personnel and nurses from the OR, CSICU, and transportation department, who did not receive any feedback. The effect of the intervention on the RBCs' temperature was evaluated by comparing the percentage of inappropriate temperature of RBC bags before and after the implementation of the intervention.

Results: Inappropriate temperature in the blood bank decreased from 30% to 12% after the intervention was implemented (relative reduction of 60%). Meanwhile, there was even an increase in inappropriate temperature in the control group including OR (from 6.5% to 20.5%), CSICU (from 1% to 2.5%) and transportation (from 0.6% to 16.6%).

Conclusion: The implementation of a feedback-based intervention to increase the awareness of the staff of critical conditions can improve conditions of blood storage and transport. The use of various interventions along with this type of intervention seems necessary to increase effectiveness.

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Keywords: Blood transfusion, Erythrocyte, Blood quality, Feedback

1. Introduction

Red blood cell (RBC) transfusion is an important part of the treatment process. It has an essential role in saving patients' lives and improving their physical health in critical conditions. The need for transfusion of blood products continues to rise due to an increase in diseases that endanger human life. Therefore, it has become a global concern to have adequate blood products that fulfill the increasing need and to prevent any wastage of blood products (1).

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Wastage of blood products should be eliminated or reduced to less than 1% if possible (2). The rate of RBC wastage is different in various countries. The United Kingdom has a wastage rate ranging from 0.26% to 6.7%, while the United States has a 4.4% rate (3-5). A study assessing blood transfusion and waste in Qazvin hospitals in Iran reported that 3,048 (9.8%) out of 30,913 issued blood products were discarded. From the discarded 3,048 units, 59.4% were packed red blood cells (6). Temperature is one of the main factors that can greatly affect blood quality (7). Inappropriate temperature during blood storage and transportation leads to high level wastage of RBC bags. RBC bags must be stored and transported between 1-6 °C and 1-10 °C, respectively (8, 9). Storage and transportation of RBCs outside the standard range leads to hemolysis with blood biochemical changes (10). Infusing inappropriately stored RBCs can have fatal consequences since they might cause severe complications and should be discarded (11-15). It is essential to use various strategies to decrease blood wastage and deliver blood products safely and effectively. One of the common interventions in this regard is educating the staff based on the feedback received about the conditions of blood storage and transport. Feedback is a theory-based concept that can reinforce or modify behaviors in order to confirm positive behaviors and correct negative behaviors (16, 17). Several studies in the field of medicine investigated the effectiveness of feedback intervention on clinical practice (18). The majority have shown the beneficial effects of feedback to improve the quality of clinical care. Despite the implementation of multiple interventions, there is still room for improvement in blood transfusion conditions. The purpose of this study was to determine the effect of feedback intervention on errors caused by improper storage and transportation of blood bags. The research hypothesis was that there would be an improvement in the inappropriate temperature of blood bags in the intervention group after implementing feedback.

2. Material and Methods

2.1. Study design

This quasi-experimental pretest-posttest study was conducted in a teaching hospital with 1,118 beds in Mashhad, Iran, and in two periods during the same season: winter of 2015 (pre-intervention period) and winter of 2016 (post-intervention period). During the study period, 200 RBC bags were transported from the blood bank to the CSICU and OR for transfusion. Responsible personnel in the blood storage and transportation phases were divided into two groups. The intervention group comprised of the personnel in the blood bank department and the control group included personnel and nurses in the OR, CSICU or during transportation. During the pre-intervention period, both groups were not aware of the details and objectives of the study. They were asked to conduct the same work routine. The research was approved by an appropriate ethics committee of the institute.

2.2. Sample size

Based on the results that had been published in similar articles, the percentage of inappropriate temperature during the pre-intervention period was considered to be 40%. To detect an effect size of 20%, a reduction from 40% (pre-intervention period) to 20% (post intervention period), with a power of 0.8 and an alpha error of 0.05, calculated sample size was approximately 100 RBC bags for each period.

2.3. Outcome measurement

The primary study outcome was the percentage of inappropriate temperature of the RBC bags in each phase analyzed. In this study, there were six phases of storage and transportation for the blood bags, which included: blood bank storage, transportation from the blood bank to the OR, OR storage, transportation to the CSICU if not used in the OR, CSICU storage and finally transportation back to the blood bank if the blood bags were not used in the CSICU. In this study, the term ‘error’ has come to be used to refer to a temperature of a bag of RBCs that was not in the range of 1-6 °C and 1-10 °C in the storage and transportation phases, respectively.

2.4. Instruments

A temperature monitoring system was developed by the research group for this study and was used to monitor the temperature of RBCs (19). The temperature monitoring system was equipped with an accurate sensor and a memory to save temperature in the specified time interval (one per 2 minutes). The devices were attached to individual bags of RBCs that were transported from the blood bank to CSICU and OR. In this research, a form was designed to collect the required information. Each part of the form was completed by trained personnel in the six different phases of blood bag delivery and storage. The fields in the form included some demographic data of target patients, bag unit number, device number, date and time when the device was attached and the date and time of bag issuance. The time of entrance to and exit from each phase of each blood bag was also recorded. After the data entry was completed, the form would be attached to the bag.

2.5. Intervention

The intervention consisted of feedback on errors related to inappropriate temperature that occurred in the storage phase in the blood bank during the pre-intervention period. The intervention was performed in the following order:

- The head of the blood bank department was given a structured presentation that explained the details of improper conditions in blood storage and transportation.
- Paper-based feedback was also provided to blood bank personnel who were members of the intervention group. This report included: 1) the frequency of errors; 2) the approximate time when the errors occurred; 3) the most frequent causes of errors; and 4) suggestions for improvement.

The control group did not receive any feedback and did not change their work routine during the post-intervention period.

2.6. Data analysis

The research team extracted the time spent for the blood bags in the different storage phases from the tracking form. This determined the total measurements in each phase. The effect of the intervention on the RBCs' temperature was evaluated by comparing the percentage of inappropriate temperature of RBC bags in the pre- and post-intervention period.

3. Results

A total of 119,511 and 160,562 measurements were recorded by the temperature monitoring devices (one per 2 minutes) in the pre- and post-intervention periods, respectively. Inappropriate temperatures for pre- and post-intervention periods were 9% and 7.5% of total measurements, respectively. In order to determine the percentage of errors in different phases, the proportion of out-of-range data during each phase to the total out-of-range data was assessed in pre- and post-intervention period. The most frequent error during the pre-intervention period occurred in the blood bank. In this specific phase, the percentage of errors decreased from 74% in pre-intervention to 36% in post-intervention. Surprisingly, there was a noticeable increase in the percentage of errors when compared to the pre-intervention period observed in the OR (from 19.5% to 40%), CSICU (from 6% to 20%) and transportation (from 0.5% to 4%). The most frequent errors during the post-intervention period occurred in the OR. Because the bags were stored for a different duration in each phase, the critical condition of each phase should be considered based on the time spent in that phase. Therefore we calculated the proportion of out-of-range data to the total data in the same phase. Figure 1a and Figure 1b below show the details of error percentages in different phases.

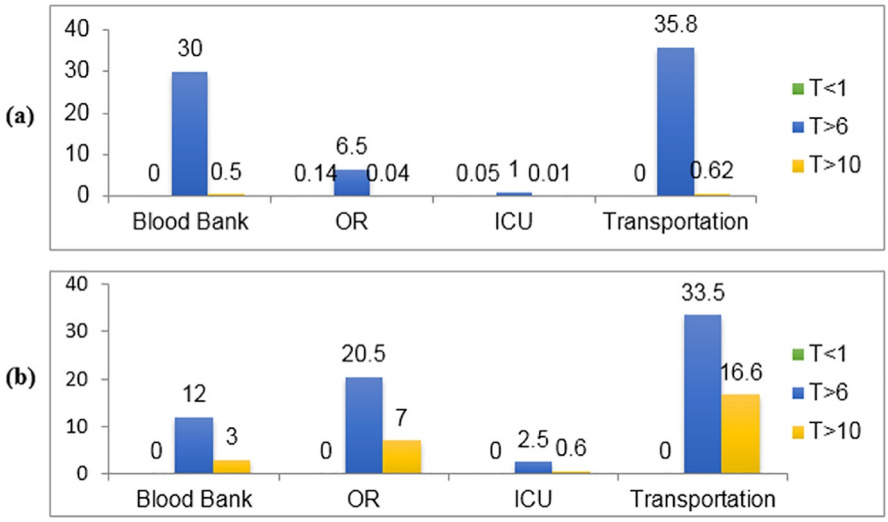

Figure 1. (a) The proportion of out-of-range data during each phase to the total data in the same phase during the pre-intervention period (b) The proportion of out-of-range data during each phase to the total data in the same phase during the post-intervention period. *T is the abbreviation for temperature. *Transportation= Transportation from blood bank to OR + Transportation from OR to CSICU + Transportation from CSICU to blood bank.

In the blood bank, there was a decrease in the percentage of errors from 30% at the pre-intervention period to 12% at the post-intervention period, which represented a relative reduction of 60%. Notably, there was an increase in the

percentage of errors compared to the pre-intervention period observed in the phases related to the control group, which included the OR (from 6.5% to 20.5%), CSICU (from 1% to 2.5%) and transportation (from 0.6% to 16.6%).

4. Discussion

The results of this study showed that the intervention led to a marked reduction in the percentage of inappropriate temperature in the blood bank related to the intervention group, while an increase was observed in the percentage of inappropriate temperature in the phases related to the control group. These results support our hypothesis that feedback-based intervention in the blood transfusion field can be as effective as in other fields (18, 20-22). To the best of our knowledge, no studies in the field of blood transfusion have exclusively evaluated the effects of a feedback-based intervention for improving inappropriate temperature during storage and transportation of blood bags. In the majority of the studies, multiple interventions were performed simultaneously. Therefore, it is not possible to conclude the impact of each intervention individually and identify the most effective one. The results of this study showed that the feedback given to the staff of the blood bank could raise awareness about critical storage conditions. Considering that the staff of the blood bank play a critical role in preserving the quality of blood products (23), it appeared that the target population understood the feedback, and this could be seen as one of the causal factors of the decrease in inappropriate temperature of blood bag storage. While the percentage of inappropriate temperature notably reduced by about 30% to 12% in the blood bank after the implementation of the intervention, considering the high percentage of inappropriate temperature even after the implementation of the intervention, there is still room for improvement in the conditions of blood bag storage. The International Organization for Standard requirement for medical laboratories (ISO15189) noted that the blood bank is responsible for maintaining the quality of blood products which contains the monitoring of the blood bag temperature chain control (23). A possible explanation for the high percentage of inappropriate temperature in the blood bank may be the lack of adequate staff in the blood bank to carry out the blood compatibility tests. As a consequence, blood bags are placed out of the refrigerator in ambient temperature for a long time. On the other hand, the observed increase in percentage of inappropriate temperature in some phases of storage and transportation in the post-intervention period could be attributed to lack of periodic monitoring and inspections of the blood storage equipment such as refrigerators. So, blood bags are placed in non-standard temperature until they are used or transferred to other wards. The observed increase in percentage of inappropriate temperature in the post intervention period that was implemented one year after the basal period could be related to progressive deterioration in equipment. Also, the usage of non-standard cool boxes or the transport of RBCs together with patients between OR, CSICU or other wards might cause transportation of RBCs outside the specific defined temperatures. The high level of inappropriate temperature in different phases is more likely to be related to the implementation of a health system reform plan in Iran. Based on the results of previous studies, implementation of the plan resulted in insufficient equipment, insufficient staff, increase in the workload and, consequently, a decrease in work quality (24, 25). In the same way, the consequences increase the workload of personnel, especially in the blood bank, which already was faced with a shortage of personnel. The results of most previous studies that investigated different contributing factors associated with blood wastage indicated a positive effect of intervention. One study, which aimed to reduce blood wastage, applied the sigma methodology and showed that 87% of wasted RBCs were caused by inappropriate temperature during storage and transportation. The interventions conducted by the investigators resulted in a decrease of RBC product wastage from 4.4% to 2%. The important factors which affected the RBC wastage were the inadequate knowledge and education of the staff, the lack of accountability, and inappropriate transportation equipment and temperature monitoring devices (5). Results of similar studies indicated that multiple interventions, such as educational programs, different types of targeted messages, and an enhanced transportation process were effective in reducing wastage of RBCs (26-29). Results of a study by Bots et al. showed the insufficiency of first intervention including awareness of medical staff and modifying transportation procedure in RBCs wastage reduction. In the second intervention, intensifying training of and communication with the medical staff and improving the transport conditions led to the decrease in RBCs wastage (30).

The findings of our study may be somewhat limited by the study design. First, in quasi-experimental design, there is a potential for confounders. In order to evaluate the effect of external confounders, we used a non-equivalent control group. Using a non-equivalent control group is problematic; however, in a single hospital, it is not possible to select an equivalent control group. Secondly, in pretest-posttest design, multiple simultaneous interventions might affect the study outcome measures. We are not sure, but some of the changes that have occurred due to the implementation of the health system reform plan may have affected the results of our study. The study was implemented during the same season in two consecutive years, which meant that there was a long gap between the pre-intervention period and post-intervention period. This may have affected the outcome, but considering that the ambient temperature was

influential on the study results, it was important to implement pre- and post-intervention period during the same season. Thus, we accepted the long interval to provide similar conditions in pre-intervention period and post-intervention period, although, this long gap could have reduced the durable impact of the intervention. Blood products from production until utilization may be stored in different temperature conditions. Therefore, it is necessary to monitor the temperature of blood products from production time in determining whether the products can be used or must be discarded. In the present study, only blood bags that were sent from the blood bank to the OR and CSICU were studied because of the limitation in the number of temperature monitoring devices. Despite these limitations, the key strengths of this study are the large sample size in the intervention and control group, and the use of a device that made continuous monitoring and recording of blood bag temperature possible. The findings of this study have a number of implications on the process of blood product storage and transportation. Based on the results of the effect of feedback-based intervention in the present study, we suggest periodic reports of the situation should be provided for the responsible staff and related education programs to raise awareness and accountability of personnel should be conducted. Based on the experiences of other studies, developing targeted interventions such as use of passive interventions such as posters, booklets, and paper guidelines as low-cost tools, creating minor changes in the storage and transportation process, using standard equipment, employing monitoring devices and utilizing decision support systems in future research can lead to an improvement in blood bag storage and transportation conditions.

5. Conclusions

The clinical implications of the limited supply of red blood cells (RBCs) for transfusion can lead to the application of various strategies to decrease blood wastage and safely and effectively deliver the blood products. Despite the implementation of multiple interventions, there is still room for improvement in blood transfusion conditions. The results of this study showed that the feedback-based intervention led to a marked reduction in the percentage of inappropriate temperature in the blood bank related to the intervention group.

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Conflict of Interest:

There is no conflict of interest to be declared.

Authors' contributions:

SE, SA, MK, AA and SA (first author) conceived the study idea and design. SE, HS, ZT and SA (first author) participated in the device development. SK, FK and SA (first author) collected the data. SE, HT and SA interpreted the data. SA (first author) drafted the manuscript. All authors have been involved in critically revising the manuscript. All authors read and approved the final manuscript.

Note:

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References:

1) Chapman J, Cook R. The Blood Stocks Management Scheme, a partnership venture between the National Blood Service of England and North Wales and participating hospitals for maximizing blood supply chain management. Vox Sang. 2002; 83(3): 239-46.doi: 10.1046/j.1423-0410.2002.00218.x.
2) Zoric L, Daurat G, Demattei C, Macheboeuf M, Boisson C, Bouix O, et al. Blood wastage reduction: a 10-year observational evaluation in a large teaching institution in France. European Journal of Anaesthesiology. 2013; 30(5): 250-5.doi: 10.1097/EJA.0b013e32835fadcf.
3) Stanger SH, Yates N, Wilding R, Cotton S. Blood inventory management: hospital best practice. Transfusion medicine reviews. 2012; 26(2): 153-63. doi: 10.1016/j.tmrv.2011.09.001.

4) Perera G, Hyam C, Taylor C, Chapman J. Hospital blood inventory practice: the factors affecting stock level and wastage. Transfusion Medicine. 2009; 19(2): 99-104. doi: 10.1111/j.1365-3148.2009.00914.x.
5) Heitmiller ES, Hill RB, Marshall CE, Parsons BJ, Berkow LC, Barrasso CA, et al. Blood wastage reduction using Lean Sigma methodology. Transfusion. 2010; 50(9): 1887-96. doi: 10.1111/j.1537-2995.2010.02679.x.
6) Far RM, Rad FS, Abdolazimi Z, Kohan MMD. Determination of rate and causes of wastage of blood and blood products in Iranian hospitals. Turkish Journal of Hematology. 2014; 31(2): 161. doi: 10.4274/tjh.2012.0105.
7) Sowemimo-Coker SO. Red blood cell hemolysis during processing. Transfus Med Rev. 2002; 16(1): 46-60. doi: 10.1053/tmrv.2002.29404.
8) AABB Standards Program Committee. Standards for blood banks and transfusion services. 28th ed. Bethesda: AABB; 2012.
9) Council of Europe. Guide to the preparation, use and quality assurance of blood components. 16th ed. Strasbourg: European Directorate for the Quality of Medicines & Healthcare of the Council of Europe; 2010.
10) Sawant RB, Jathar SK, Rajadhyaksha SB, Kadam PT. Red cell hemolysis during processing and storage. Asian J Transfus Sci. 2007; 1(2): 47-51. doi: 10.4103/0973-6247.33446
11) Regan F, Taylor C. Blood transfusion medicine. BMJ. 2002; 325(7356): 143-7. doi: 10.1136/bmj.325.7356.143.
12) Retter A, Wyncoll D, Pearse R, Carson D, McKechnie S, Stanworth S, et al. British Committee for Standards in Haematology. Guidelines on the management of anaemia and red cell transfusion in adult critically ill patients. Br J Haematol. 2013; 160(4): 445-64. doi: 10.1111/bjh.12143.
13) Marik PE, Corwin HL. Efficacy of red blood cell transfusion in the critically ill: a systematic review of the literature. Crit Care Med. 2008; 36(9): 2667-74. doi: 10.1097/CCM.0b013e3181844677.
14) Melanie JM, Matthew JAW. Complications of blood transfusion. Continuing Education in Anaesthesia Critical Care & Pain. 2006; 6(6): 225-9. doi: 10.1093/bjaceaccp/mkl053.
15) Mvere D, Bond K. The blood cold chain: guide to the selection and procurement of equipment and accessories: World Health Organization; 2002. PMID: 12971156.
16) Ormrod JE, Davis KM. Human learning: Merrill; 2004.
17) Hesketh E, Laidlaw J. Developing the teaching instinct, 1: feedback. Medical teacher. 2002; 24(3): 245-8. doi: 10.1080/014215902201409911.
18) Mugford M, Banfield P, O'Hanlon M. Effects of feedback of information on clinical practice: a review. BMJ. 1991; 303(6799): 398-402. doi: 10.1136/bmj.303.6799.398.
19) Aalaei S, Amini S, Keramati MR, Shahraki H, Abu-Hanna A, Eslami S. Blood Bag Temperature Monitoring System. Machine learning. 2014; 13: 14. doi: 10.3233/978-1-61499-432-9-730.
20) Anton P, Peiró S, Aranaz JM, Calpena R, Compan A, Leutscher E, et al. Effectiveness of a physician-oriented feedback intervention on inappropriate hospital stays. Journal of epidemiology and community health. 2007; 61(2): 128-34. doi: 10.1136/jech.2005.040428.
21) Nejad AS, Noori MRF, Haghdoost AA, Bahaadinbeigy K, Abu-Hanna A, Eslami S. The effect of registry-based performance feedback via short text messages and traditional postal letters on prescribing parenteral steroids by general practitioners—A randomized controlled trial. International journal of medical informatics. 2016; 87: 36-43. doi: 10.1016/j.ijmedinf.2015.12.008.
22) Woodward M, Streeton C, Guttmann A, Killer G, Peck R. Polypharmacy management among Australian veterans: improving prescribing through the Australian Department of Veterans' Affairs' prescriber feedback programme. Internal medicine journal. 2008; 38(2): 95-100. doi: 10.1111/j.1445-5994.2007.01453.x.
23) Guzel O, Guner EI. ISO 15189 Accreditation: Requirements for quality and competence of medical laboratories, experience of a laboratory I. Clinical biochemistry. 2009; 42(4): 274-8. doi: 10.1016/j.clinbiochem.2008.09.011.
24) Gholami S, Oveisi S, Ghamari F, Etedal MG, Rajaee R. Study of Educational Hospital Employees' Satisfaction with the Administration of the Health Reform Plan in Ghazvin, 2015. Electron physician. 2015; 7(7): 1500-4. doi: 10.19082/1500. PMID: 26767104, PMCID: PMC4700896.
25) Heydari A, Mazlum SR, Moonaghi HK, Mojalli M, Hosseini Shahidi L, Namdar H . Educational challenges ahead of nursing from the perspective of faculty members of Mashhad University of Medical Sciences. Journal of Advances in Medical Education & Professionalism. 2013; 1(4): 125-8.

26) Sharley PH, Williams I, Hague S. Blood transportation for medical retrieval services. Air medical journal. 2003; 22(6): 24-7. doi: 10.1016/j.amj.2003.08.006.
27) Nurasyikin Y, Leong CF, Fadhlullah TM, Hafiz WM, Nadiah Z, Atieqah AN, et al. Role of blood bag temperature indicators in maintaining patent temperature of the returned unused blood bags in blood bank. Clin Ter. 2011; 162(1): 19-22. PMID: 21448541.
28) Whitney GM, Woods MC, France DJ, Austin TM, Deegan RJ, Paroskie A, et al. Reducing intraoperative red blood cell unit wastage in a large academic medical center. Transfusion. 2015; 55(11): 2752-8. doi: 10.1111/trf.13214.
29) Collins RA, Wisniewski MK, Waters JH, Triulzi DJ, Yazer MH. Effectiveness of multiple initiatives to reduce blood component wastage. American journal of clinical pathology. 2015; 143(3): 329-35. doi: 10.1309/AJCP42WMHSSTPHXI.
30) Bots M, Grouw E, Rooyen‐Schreurs I, Akker G, Sturk A, Klinkspoor J, et al. Strategies to reduce wastage of red blood cell units. Vox Sang. 2016; 110(2): 143-9. doi: 10.1111/vox.12351.