

Electronic Recording of Transfusion-Related Patient Observations: A Comparison of Two Bedside Systems

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Author Contributions

S. S., S. N. and M. M. designed the paper. S. S. collected the data, analysed the data and wrote the paper. S.N, P.W and M.M provided critical review of the paper. All authors approved the final submitted version

Conflict of interest

The authors declare no conflicts of interest.

ABSTRACT

BACKGROUND AND OBJECTIVES

Vital sign observations should be monitored before, during and after transfusion to enable adverse events to be identified, but surveys in the UK show poor compliance with good practice. At the Oxford University Hospitals, there are two electronic bedside processes for recording observations; BloodTrack Tx (Haemonetics Corp.), the routine electronic transfusion process, and a locally developed process, the System for Electronic Nursing Documentation (SEND) with integrated 'track and trigger' calculation for monitoring vital signs. The purpose of this study was to evaluate the conduct of patient observation monitoring for blood transfusion using two electronic bedside processes.

MATERIALS AND METHODS

This study examined the observations recorded during 200 single red cell unit transfusions.

RESULTS

186/200 (93%) transfusions had pre-transfusion observations recorded using BloodTrack Tx. Mid-transfusion checks were performed during 133/200 (67%) of transfusions, out of these checks most (87/200 (44%)) were documented as 'no apparent change' in observations. End transfusion observations were performed using BloodTrack Tx in 178/200 (89%). Both systems were frequently used, and staff had a preference for using SEND first for documenting the pre-transfusion observations (102/116 (88%)) and at the end of a transfusion (75/115 (65%)).

CONCLUSION

Electronic bedside systems result in improved monitoring of transfusion related observations compared to manual processes based on data from UK surveys. There is increasing use of electronic systems in clinical practice; linkage between these two systems would prevent wasteful duplication of observations and could provide improved early warning of adverse events to transfusion compared to manual processes.

Key words: Bedside Electronic Transfusion System, Track & Trigger, Observations, Vital Signs, Transfusion Reaction

INTRODUCTION

Administration of blood products is associated with risks including acute transfusion reactions (ATR). To detect adverse reactions that may need immediate investigation and treatment, the patient's condition and vital sign observations i.e. blood pressure, temperature, pulse and respiratory rate should be closely monitored before, during and after a transfusion [1-3]. Non-infectious reactions such as transfusion associated circulatory overload (TACO) are the most frequent cause of transfusion related morbidity and mortality [4]. To try and reduce this there has been an increased interest in the evolution of predictive algorithms to enable early identification and treatment of transfusion related pulmonary complications such as TACO [4-7]. In addition, it has been highlighted that monitoring bedside observations trends is an important factor in the recognition of TACO [8].

The British Committee for Standards in Haematology (BCSH) recommends that observations of pulse, blood pressure, temperature and respiratory rate should be documented for every blood product transfused. The patient should be monitored for signs and symptoms of an ATR and action should be taken if appropriate [1]. Observations should be taken no more than 60 minutes before the start of transfusion, at the end of transfusion and if the observations have altered significantly 15 minutes after the start of transfusion these should be documented and acted on as necessary. These observations should be clearly distinguished from other routine observations and documented in the patients' notes. However, a UK survey of compliance with these recommendations found suboptimal practice; pre-transfusion observations were measured in 84.9% of patients, 15 minute observations were performed at 15 minutes in 46.8% of transfusions with 86.1% of patients having observations taken within 30 minutes; post transfusion observations were recorded in 84.1% of cases [9].

BloodTrack Tx (Haemonetics Corp., Braintree, MA) is an electronic bedside transfusion process used to check the compatibility of the blood product with the patient at the bedside and document the audit trail of blood product administration, including recording patient observations [10]. This system has been proven to improve the compliance with documentation of transfusion processes and reduces the nursing time associated with giving a transfusion [11]. BloodTrack Tx has been fully implemented at the Oxford University Hospitals (OUH) for over 10 years, staff are familiar with BloodTrack Tx and it is ingrained in their practice for use with transfusion. It is used for all blood component transfusions, and only a very small number (170/20,059 (0.85%) transfusions, March-September 2016) are administered without using this process. The transfusion safety team follow up all instances where it is not used to find out the reasons why not and provide re-training if needed.

In addition to observations taken during a transfusion, hospitalised patients must also have observations taken to help identify deterioration in their clinical condition [12]. The System for Electronic Nursing Documentation (SEND) is an electronic bedside observations monitoring system developed by the Institute of Biomedical Engineering, University of Oxford to replace traditional paper observations charts. SEND uses bespoke rolling stands which carry a Windows tablet computer, power supply and observation monitoring equipment e.g. pulse oximeter, digital blood pressure monitor and digital thermometer (Fig. 1). This system allows staff to input patient observations in real time on the tablet at the patient's bedside with automated 'track & trigger' (T&T) score calculation. The T&T score is calculated from the observation values; vital signs values that are above or below the normal range are assigned weighted points, the sum of the points results in the T&T score. Deterioration in patient observations produces an increased score, a score of 1 or above initiates an escalation pathway, by recommending increased frequency of

observations and medical review by senior clinical staff [13]. SEND has been gradually introduced in phases throughout the OUH over the last 3 years and is now used in most adult in-patient areas and some out-patient departments (92 wards/locations across the OUH); there has been positive feedback from clinical staff on the initial implementation phase in the OUH [14].

Electronic systems for both the clinical transfusion process and routine monitoring of patient observations are being increasingly used [15]. The National Institute for Health and Care Excellence (NICE) recommend that electronic systems could be used to improve identification of in-patient deterioration [12]. A national business intelligence report of digital services in the NHS showed electronic blood tracking was used in 96 hospitals in 2014 and electronic track and trigger systems were being used in at least 59 institutions in 2014. Where both electronic systems for transfusion and T&T are being used the potential exists for their linkage to provide early warning of adverse transfusion reactions.

The purpose of this study was to evaluate the current conduct of patient observation monitoring using the two electronic bedside processes at the OUH prior to any consideration of linking the two processes.

MATERIALS AND METHODS

Study Site

The Churchill Hospital site at the OUH was selected for this study because SEND has been established in all clinical areas since 2014 for taking patient observations and enabled a comparison to be made with observations taken on BloodTrack Tx which has been used in the OUH for all transfusions for over 10 years. This site has general and specialist surgery including organ transplantation, a cancer and haematology centre, renal dialysis unit and several other specialist centres.

BloodTrack Tx Process

The electronic transfusion system BloodTrack Tx, uses 2-dimensional barcodes on patient wristbands, on blood samples and on blood units, within which is encoded the patient core identity data. Staff members are required to identify themselves on the system by scanning barcodes on their security identity (ID) badges using the handheld computer. The patient is then identified by the staff member scanning the barcode on the patient wristband. The user is then prompted to follow the key steps of the pre-transfusion process, including documentation of patient observations; this ensures the correct protocol is followed and that patients receive the correct blood unit. There are no prompts to enter observations during a transfusion, however, staff are trained to observe the patient and enter observations data into BloodTrack Tx 15-30 minutes after the start of each unit. Staff are also trained to enter observations in the event of an adverse reaction to transfusion. As part of the end of transfusion process there is a prompt for the staff member to enter the patient observations data. Clinical staff were instructed not to change processes for recording transfusion related observations after the introduction of SEND.

Despite good compliance with pre and post-transfusion observation recording, it was found that compliance with recording mid-transfusion observations is variable across the OUH. To encourage monitoring and recording of the patient's status during a transfusion, an amendment to the BloodTrack Tx process was made in June 2009. If the patient's condition was unchanged during the first 30 minutes of the transfusion, the option of 'no apparent change' could be recorded using BloodTrack Tx without recording observations. The clinical areas are periodically made aware of their compliance with recording mid-transfusion observations. In the documentation of the mid-transfusion check in this study we accepted either the documentation of 'no apparent change' or documentation of a full set of observations using BloodTrack Tx.

BloodTrack Tx also enables the user to document a transfusion reaction on the handheld computer when taking observations during a transfusion and at the end of a transfusion using a pre-set reactions menu; this record is then visible to the blood bank [10, 11].

SEND observations process

The digital bedside T&T system, SEND, also requires barcode scanning of staff member's ID badge to log in and identify the staff member and the patient wristband to identify the patient. The user then follows the prompts on screen to enter the observations, these include; temperature, blood pressure, heart rate, respiratory rate, O₂ saturation, type of O₂ therapy, level of consciousness (Glasgow coma scale (GCS) and Alert, Voice, Pain, Unresponsive (AVPU) scale) and a select list of nurse concerns (e.g. shock, diarrhoea/vomiting, infection). The software will only permit entry of data within specified limits as this excludes erroneous data entry. A T&T score is displayed for each value as soon as the user enters an observation; it is not required to enter a value for each observation before a total T&T score is calculated. SEND then displays advice to the user based on the final T&T score which ensures the patient receives further care.

SEND observations in this study were categorised as pre-, mid- and end transfusion observations based on the time the BloodTrack Tx observations were taken. Any set of observations entered into SEND up to 60 minutes prior to the pre-transfusion transaction time on BloodTrack Tx or 10 minutes after the pre-transfusion time point, were considered to be the 'pre-transfusion' set of observations for SEND. If observations were recorded using SEND between the pre-transfusion and end transfusion transaction time point these were considered a set of mid-transfusion observations, multiple mid-transfusion checks on either system were allocated into 2nd and 3rd mid-transfusion check categories as appropriate. The end transfusion observations included from SEND were those which occurred up to 10 minutes before or after the end transfusion process on BloodTrack Tx. If there was no end transaction recorded on BloodTrack Tx, the SEND observations could not be collected because the timing of the end of the transfusion was not known.

Study Data Collection

200 red cell transfusion episodes were studied during a three month period (October – December 2015). Transfusion of 100 single adult red cell units were studied on the haematology ward and 100 transfusions of single adult red cell units were studied at other clinical locations. Users were not instructed to change the observations recording process, this study was a retrospective observational study of the use of two electronic bedside systems. Recorded observation data (temperature, pulse, blood pressure and respiration rate) were collected from the two system databases and examined retrospectively.

Data were collected from both BloodTrack Tx and SEND databases using Microsoft Access 2010 (Microsoft Corp., Redmond, WA), collated in Microsoft Access and examined using Microsoft Excel 2013 (Microsoft Corp., Redmond, WA). The patient observation data were compiled and assessed for compliance with required reporting at the start of a transfusion, during and at the end

of transfusion. All observations were examined for duplicate recording, using a find duplicates query (Microsoft Access) to identify identical sets of observations data out of those entered on both systems at the same transfusion time point.

Direct Observation of Staff Performing Observations

The purpose of performing direct observations on clinical staff was to understand how staff utilise the electronic bedside systems, interact with equipment at the patient bedside, how much time was taken to perform the task and any barriers or workarounds when performing the task or errors made in the process.

A multi-disciplinary team performed direct user observations on clinical staff at in-patient and out-patient locations when a transfusion was administered; 7 transfusions (3 out-patients and 4 in-patients) were observed. The process was analysed using Human Factors analysis techniques including; Swim Lane Analysis, Hierarchical Task Analysis (HTA) and Failure Mode and Effect Analysis (FMEA). FMEA assigns numerical scores for the severity of each failure in the process, likelihood of risk occurrence and likelihood the error is detected – these scores are multiplied to produce a Risk Priority Number (RPN). The RPN can be used to improve the process by comparing different ways of performing the process prior to implementation, this method of proactive monitoring enables the task to be improved to address the tasks which create the biggest risks.

RESULTS

Data were collected from 200 transfusion episodes from the haematology ward (100/200) and non-haematology clinical specialities comprised of renal medicine, renal transplantation and urology (56/200 transfusions), oncology (31/200 transfusions), surgery (9/200 transfusions) and ambulatory medicine (4/200 transfusions). There were 7 transfusions analysed by direct observation, 3 transfusions in an out-patient area and 4 transfusions on an in-patient ward.

Compliance with Recording of Observations Related to Transfusion (Fig. 2)

The two electronic systems were both frequently used to record observations during a transfusion. 186/200 (93%) pre-transfusion observations were recorded using BloodTrack Tx. It was found that 14/200 (7%) transfusions which did not have observations recorded were on the renal dialysis unit, due to an error in the set-up of the BloodTrack Tx device. This permitted the start and end check of transfusions to be conducted safely but did not give the user the option to enter the patient observations during this process. Pre-transfusion observations were collected using SEND in 116/200 (58%) transfusions.

Mid-transfusion checks were performed in 133/200 (67%) of patients on BloodTrack Tx, out of these checks (87/200 (44%)) were documented as an observation of 'no apparent change' in the patient observations. Full sets of observations were recorded using BloodTrack Tx in 46/200 (23%) of mid-transfusion checks. Full mid-transfusion observations were recorded using SEND in 119/200 (60%).

In a small number of patients there were second or third mid-transfusion checks following the initial mid-transfusion check. Additional mid-transfusion checks were recorded using BloodTrack Tx on 6/200 (3%) occasions and SEND was preferred for additional checks in 19/200 (10%) transfusions.

End transfusion observation checks were performed using BloodTrack Tx in 178/200 (89%). In 115/200 (58%) end transfusions, observations were collected using SEND.

Electronic System Preference for Observations Recording (Table 1)

When both systems were used to record observations staff members had a preference for using SEND before using BloodTrack Tx for documenting the pre-transfusion observations (102/116 (88%)) and the end transfusion observations (75/115 (65%)). Mid-transfusion observations were recorded on SEND first in 41/119 (34%) transfusions.

In addition, clinical staff showed a preference for recording observations on SEND instead of BloodTrack Tx during the transfusion. Staff tended to use the 'no apparent change' check on BloodTrack Tx without entering values and then record the values in SEND. When additional 2nd and 3rd mid-transfusion checks were performed these were more often documented using SEND only (Fig. 2).

Identical Observations Recorded Using BloodTrack Tx and SEND (Table 1)

Duplication of recorded data occurred at all transfusion time points; when both systems were used to record observations at the same time point there were 73/116 (63%) duplicate pre-transfusion observations recorded, 18/119 (15%) duplicate mid-transfusion observations and 76/115 (66%) duplicate end transfusion observations demonstrating the use of both systems to record the same information.

Documenting a Transfusion Reaction

There were 5 patients reported on BloodTrack Tx because of a suspected ATR; one patient had two types of reaction recorded (headache and fever) and the other reactions reported were dyspnoea, hypertension and fever. One patient had dyspnoea recorded as a reaction, but there was no change documented in respiration rate, but the patient did experience a rise in pulse rate from

69 to 113 bpm – increasing the T&T score obtained from SEND from 0 to 3. It was not possible to document tachycardia as a transfusion reaction on BloodTrack Tx using the pre-set reactions menu; it could be the staff member was unable to document the correct reaction so selected an alternative or this may have been selected in error. All increases in patient temperatures were <1.0°C, one reported reaction of fever during the transfusion was actually a reduction in temperature compared to the pre-transfusion observations.

Direct Observation of Staff Performing Transfusion Observations

Direct user observations confirmed staff preferred using SEND to document observations, and then copied results into BloodTrack Tx. Staff were also observed balancing the BloodTrack Tx equipment around the minimal patient bed space in order to perform the task. This demonstrated wasted clinical time spent transcribing observations from one system to another and collecting and moving equipment to perform the task.

Swim lane analysis and HTA showed the multiple steps required to perform the task and the number of times the user is switching between equipment which is wasteful of clinical time. This also showed that paper charts and sheets of paper are being used to record observations in outpatient locations prior to entering these into BloodTrack Tx or SEND; adding an additional transcription step to the workflow.

FMEA was performed on the current process of administering a blood unit and recording observations to identify the possible errors and the potential consequences of the error occurring in the clinical environment. The FMEA was repeated on a proposed new method using a more integrated electronic system for administering a blood product and monitoring patient observations. The RPN showed both processes had similar methods of failure and risk, such as not

confirming patient identification correctly leading to proceeding with the wrong patient record. Other potential errors included transcription error and the user failing to complete the task leading to incomplete documentation in the patient record which are likely to be undetected by the staff member therefore increasing the RPN. However, the RPN was higher in the current process (RPN = 541) due to the repetitive tasks and duplication of data, the proposed change in process which eliminates data transcription and repetition of tasks by integrating the two systems lowers the RPN (RPN=449).

DISCUSSION

Patients receiving transfusions should be monitored carefully to detect adverse reactions that may need immediate investigation and treatment. It is recommended that the patient's condition and observations i.e. blood pressure, temperature, pulse and respiratory rate should be closely monitored before, during and after a transfusion [1]. A previous national UK survey of compliance with these recommendations found suboptimal documentation [9]. This study has shown that an electronic transfusion process provides better compliance with good practice for documenting patient observations during transfusions.

At the OUH, there are two electronic bedside processes for recording observations. This study found that staff frequently recorded duplicate observations in the two electronic bedside systems; there was a preference for using the electronic T&T system (SEND) before the transfusion and using SEND alone to document observations during a transfusion. Staff are aware of the requirement to document observations data in BloodTrack Tx to adhere to OUH transfusion policy; yet SEND makes it easier for clinical staff to conduct patient monitoring at the bedside. The need for use of two bedside electronic systems when starting or ending a transfusion or documenting patient observations during transfusion generates increased work for clinical staff and requires extra equipment at the bedside.

BloodTrack Tx is essential for ensuring safe blood transfusion administration i.e. that the correct unit of blood is transfused, but the system only offers basic functionality for documenting observations linked to a transfusion and it has no input limits to restrict erroneous data entry. An analysis of all observations recorded using BloodTrack Tx over a 5 month period showed 2.6% of observations were documented incorrectly. In contrast to BloodTrack Tx, SEND does have functionality to restrict erroneous data. In addition, SEND, unlike BloodTrack Tx, provides

review of sequential observations automatically calculating the T&T score and offering advice to the staff member in terms of more frequent monitoring or a requirement for medical attention.

SEND also enables the user to perform and record observations at the bedside using one piece of equipment. Another advantage of using SEND during transfusion is the ability to record and monitor oxygen saturation (O_2 saturation %), as advised by the Serious Hazards of Transfusion (SHOT) scheme to assist with the identification of TACO following a transfusion [16]. There is the potential for electronic bedside observations systems to assist in the detection of acute adverse effects of transfusion but larger studies will be needed to confirm this.

The study could not determine how staff prefer to monitor patients when there is suspicion of an adverse reaction to transfusion. It was also found that if a transfusion reaction is reported on BloodTrack Tx the staff had recorded more observations on both SEND and BloodTrack Tx preceding the report. This may be because the T&T score provides additional value to the interpretation of observations during a transfusion and may help staff identify a reaction. This study found an incorrect report on BloodTrack Tx of tachycardia as a reaction, therefore the option to document tachycardia was added to the BloodTrack Tx menu and since the addition this has been used to report a reaction 28 times in 5 months. There were a low number of possible adverse reactions recorded during this period. A better understanding is needed of how best to take advantage of electronic bedside systems for the reporting and management of suspected adverse reactions to transfusion.

Human Factors analyses showed that the design for integration of these two systems should eliminate the duplicative actions whilst preserving the safety functions of both systems. This method analysed proactive risk prevention for designing a new process for observations recording during a transfusion and assisted in developing a user centric process. Further information could

be gained by obtaining feedback regarding the use of the two systems to determine how adverse reactions are monitored and why staff duplicate data or omit data from either system. The analyses also highlighted weaknesses in the current systems, such as the potential for incorrect patient identification if the user does not follow the agreed process. This method could be used for further assessing the transfusion process in more detail from start to finish; to identify other potential high risk practices.

In summary, this study has shown that electronic bedside systems result in improved collection of data on observations of patients undergoing transfusions compared to previous national surveys in the UK. However, a comparison of the use of two electronic bedside systems showed considerable duplication of reporting which is inefficient of staff time. The use of SEND had advantages of ready availability of the equipment for conducting bedside observations and the use of T&T algorithms to detect clinically significant changes in observations. This latter attribute could enable rapid identification, investigation and treatment of an adverse reaction to transfusion.

Integrated digital systems in hospitals have the potential to achieve paper-free patient health records. We now plan to link the two electronic systems used for patient observation monitoring to provide a simplified and efficient process for clinical staff to record and review patient observations during transfusion. Other hospitals may have duplicative methods for collecting observations related to transfusion and may find it useful to conduct similar analyses to ours in order to improve their processes.

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LEGENDS

Figure 1.

The SEND bedside observations recording tablet and observations monitoring equipment: pulse oximeter, digital blood pressure monitor and digital thermometer and the barcode reader for scanning the patient's wristband on the bespoke rolling stand.

Figure 2.

Number of observations recorded on BloodTrack Tx and SEND at each transfusion time point.

(Full set observations; pulse, blood pressure, respiration rate and temperature were recorded using BloodTrack Tx. Mid-transfusion checks on BloodTrack Tx can be documented as 'no apparent change' with no observations recorded. SEND observations are full sets of observations (pulse, blood pressure, respiration rate and temperature)).

Table 1.

The number of sets of observations clinical staff recorded on SEND before BloodTrack Tx at each transfusion time point and the number of times that identical observation values were recorded at the same transfusion time point on both SEND and BloodTrack Tx.

Figure 1

The SEND bedside observations recording tablet and observations monitoring equipment: pulse oximeter, digital blood pressure monitor and digital thermometer and the barcode reader for scanning the patient's wristband on the bespoke rolling stand.



Figure 2

Number of observations recorded on BloodTrack Tx and SEND at each transfusion time point.

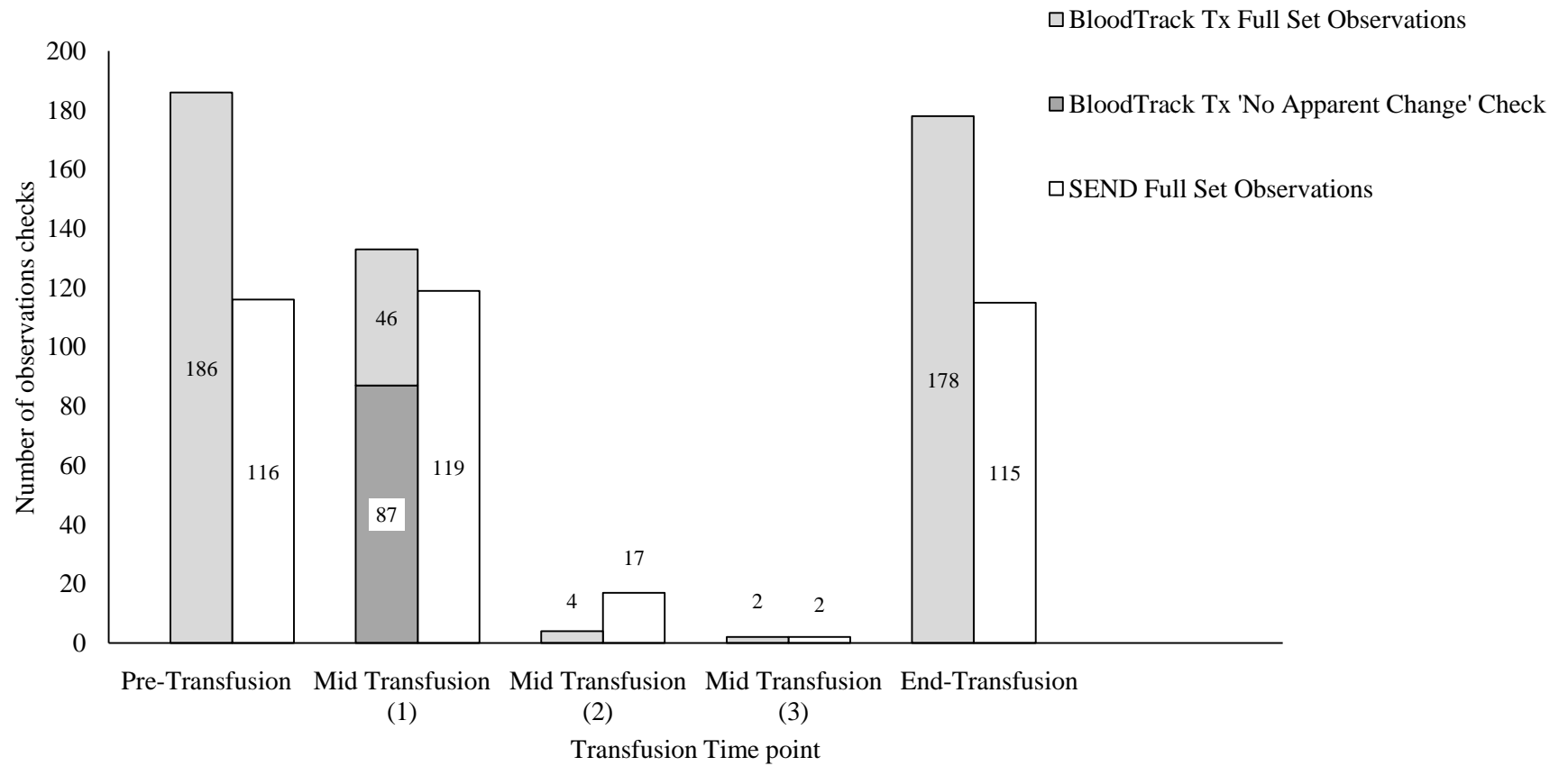


Table 1.

The number of sets of observations clinical staff recorded on SEND before BloodTrack Tx at each transfusion time point and the number of times that identical observation values were recorded at the same transfusion time point on both SEND and BloodTrack Tx.

Transfusion time point	Observations recorded on SEND before BloodTrack Tx	Identical observation values recorded on SEND and BloodTrack Tx
Pre-Transfusion	102/116 (88%)	73/116 (63%)
Mid Transfusion Check (1)	41/119 (34%)	18/119 (15%)
Mid Transfusion Check (2)	0/17 (0%)	1/17 (6%)
Mid Transfusion Check (3)	0/2 (0%)	0/2 (0%)
End Transfusion	75/115 (65%)	76/115 (66%)