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ORIGINAL ARTICLE

Adverse events associated with home blood transfusion: A retrospective cohort study

Rebecca Sharp PhD, BHSc (Hons), BN, Lecturer[1] | Lisa Turner MN, GradDipHlthAdmin, BN, National Nursing Director[2] | Jodie Altschwager MN, GradDipNg(ClinNurse), BM, Nursing Director – Program Director[3] | Nadia Corsini PhD, BPsyc (Hons), Senior Research Fellow[4] | Adrian Esterman PhD, MSc, BSc (Hons), Professor[5]

[1]Clinical & Health Sciences and Rosemary Bryant AO Research Centre, University of South Australia, Adelaide, SA, Australia

[2]Silver Chain, Keswick, SA, Australia

[3]Metropolitan Referral Unit, SA Health, Adelaide, SA, Australia

[4]Rosemary Bryant AO Research Centre, University of South Australia, Adelaide, SA, Australia

[5]Biostatistics and Epidemiology, Cancer Research Institute and Clinical and Health Sciences, University of South Australia, Adelaide, SA, Australia

Correspondence
Rebecca Sharp, Clinical & Health Sciences and Rosemary Bryant AO Research Centre, University of South Australia, GPO Box 2471, Adelaide, SA 5001, Australia.
Email: rebecca.sharp@unisa.edu.au

Abstract

Aims and objectives: To determine the rate of individual and system adverse events associated with blood transfusion at home.

Background: Home or residential care facility based blood transfusion is beneficial for individuals requiring transfusion due to reduced disruption to daily life and the comfort of a familiar environment. However, blood transfusion may result in serious adverse events. There is a lack of research in this area, and there is a need to identify rates of adverse events and evaluate the system used for this service.

Design: Retrospective cohort study.

Methods: Existing data routinely collected for clinical care were used to determine client and system adverse events of medically stable adults with a chronic disease who underwent blood transfusion in a home setting provided by a nurse-led service. A STROBE EQUATOR checklist was used for this study (see Appendix S1).

Results: There were 1790 episodes of care involving 533 participants, with 13 cases of transfusion reaction (incident rate [IR] 0.7%; 95% CI 0.43–1.25). Only five of these were severe, resulting in the cessation of the blood transfusion and further medical review or hospital admission (IR 0.28%; 95% CI 0.12–0.68). There were no cases of tampered blood packaging, expired or visually damaged blood products. There were 10 cases of incorrect paperwork (0.6%) and nine cases of incorrect temperature (0.5%). There were 153 cases of vascular access device adverse events (IR 8.5% 95% CI 7.3–9.9), most commonly, difficulty cannulating the individual (n = 82, 54%).

Conclusions: A nurse-led home blood transfusion service was associated with low rates of both individual and system adverse events. Further research is needed to explore the perception of those using this service and supports required to improve the experience.

Relevance to clinical practice: Blood transfusions may be associated with increased risk of morbidity and mortality. This risk may be increased in a home setting due to the distance from an acute care facility. This study has demonstrated that a nurse-led home blood transfusion service is safe (<1% adverse event rate) for those with a medically stable, chronic condition. There were few failures in the system used to provide

this service. Adverse events associated with the vascular access device were the most common complication and the reason for most blood product wastage. Mainly, this was due to difficulty inserting the short-term peripheral intravenous catheter (PIVC). RNs should consider ultrasound to aid PIVC insertion to facilitate treatment provision and enhance the experience of the individual.

KEYWORDS
blood transfusion, home care services, transfusion reaction, vascular access devices

What does this paper contribute to the wider global clinical community?

- This study provides evidence to support blood transfusion at home as a treatment model for medically stable individuals with chronic conditions.
- This treatment model may be considered in other settings to improve the individual experience and facilitate hospital avoidance.

1 | BACKGROUND

Long-term blood product transfusion is necessary for some individuals with cancer and other chronic disease (Havet et al., 2012). However, long-term transfusion support for those with anaemia and thrombocytopenia becomes burdensome for individuals who are required to regularly attend an ambulatory care centre to undergo this procedure (Niscola et al., 2012). Additionally, some may find it difficult to attend ambulatory care facilities due to frailty and complex health needs. Home blood transfusion (home or residential aged care facility) may be appropriate for medically stable individuals with chronic conditions (García et al., 2018; Niscola et al., 2012). Home blood transfusion provides convenience due to reduced disruption to daily life and the psychological comfort of a familiar environment (Benson, 2006). It stands to reason that a home-based service would enable individuals with complex health needs to receive treatment, by removing barriers associated with travel, and would be more appropriate for those with certain co-morbidities such as dementia, as treatment in a familiar environment may mean fewer episodes of confusion. Previous research with individuals with cancer who are undergoing palliation has found increased quality of life associated with home blood transfusions (Sciortino et al., 1993). Many find home transfusion more convenient, and some perceive that it is safer than transfusion in a hospital (Ademokun et al., 2005).

However, blood transfusion incurs a small risk of life-threatening adverse events such as anaphylaxis and transfusion-related acute lung injury (TRALI) and the distance from hospital may result in increased morbidity and mortality (Benson, 2006). Whilst blood products are increasingly transfused in the home setting internationally such as in France, Brazil, Spain, Italy, The Netherlands, UK and USA, there is limited research regarding the safety of this practice (Ademokun et al., 2005; Craig et al., 1999; García et al., 2018; Havet et al., 2012; Niscola et al., 2012; Szterling, 2005; Thompson & McKelvey, 1995; Van Gammeren & Haneveer, 2017). Niscola et al. (2012) found low rates of adverse events with red blood cells (RBCs) transfused at home for patients with haematological malignancies in Italy (n = 211), with most adverse events associated with the vascular access device (VAD) inserted for the transfusion and non-haemolytic transfusion reactions. Similarly, Craig et al. (1999) found low adverse events rates with 65 platelet transfusions given at home (two mild non-haemolytic transfusion reactions). In a much larger sample (n = 2126 transfusion episodes), García et al. (2018) found an adverse event rate of 2.7% at the initiation of their home transfusion service which decreased to 1.5% over time.

In addition to transfusion reactions, it is important to evaluate the system used to provide blood products in the home. The supply of incorrect blood products could have catastrophic outcomes if not identified by clinical staff (Fastman & Kaplan, 2011). Discrepancies with paperwork, problems with the quality of blood product supplied and break in the cold chain also may increase blood product wastage, which has ethical and economic consequences (Bots et al., 2016). Delay in the provision of blood products in the home or problems with the VAD may decrease individual satisfaction and requires additional staff resources which has economic consequences. Whilst there is research investigating the systems used in hospital-based blood transfusion (Chou et al., 2019; Frietsch et al., 2017), there is limited research on system adverse events associated with home blood transfusions.

The aim of this study was to determine the rate of individual and system adverse events associated with blood transfusion at home.

2 | METHOD

2.1 | Setting

The South Australian health department (SA Health) supports home transfusions through the HospitalHealthcare@home programme (now SA Community Care) as a hospital avoidance strategy within metropolitan Adelaide, South Australia, Australia. The objective of this health initiative is to deliver support and assistance to people in the home environment to avoid unnecessary

visits to the emergency department, admission to hospital or to assist discharge from hospital. Referrals to the Metropolitan Referral Unit are made by clinicians, either a general practitioner (GP) or treating team from a local metropolitan hospital who provide medical governance for the transfusion. The referring medical practitioner discusses the risks and benefits associated with transfusion and the home blood transfusion service with the individual during the consent process and determines whether the individual is medically stable and is suitable for transfusion at home. This service is open to those with a chronic condition that are medically stable. To be eligible for the service, blood transfusion needs to be a planned episode of care (rather than an emergency procedure). Individuals with a history of blood transfusion reaction are ineligible for the service.

The Metropolitan Referral unit is a SA Health business unit, staffed by SA Health clinicians who admit eligible individuals to the programme and allocate care to panel providers from the non-government sector. Royal District Nursing Service (RDNS) SA (part of Silver Chain group) has provided home transfusions since 2011 for SA Health. Registered Nurses (RNs) lead this model of care in the community, visiting individual homes/residential aged care facilities to provide the transfusion and liaise with the referring GP/hospital-based treating team via telephone to manage adverse events based on their clinical assessment.

2.2 | Transfusion process

A RN visits the home or residential aged care facility (RACF) where the individual resides. Red blood cells, platelets and albumin are given within the service, with up to three units of RBCs and two units of platelets given in the same day (episode of care) with the RN in attendance for the entire transfusion. Upon arrival, the RN inserts a short-term peripheral intravenous catheter (PIVC) if required. If there are difficulties in insertion, additional resources are used such as extended care paramedics. The blood product is delivered to the individual's home in an insulated container by the pathology service provider who follows Australian national standards (National Blood Authority) for cold chain transportation of blood products (https://www.blood.gov.au/). The RN checks the packaging, condition and temperature of the blood product. The RN also checks paperwork, including consent for the transfusion (obtained by treating Medical/Nurse Practitioner), written order for the blood products(s), pathology forms and any planned medications required. Education is provided to the individual, in this, the RN discusses the potential risk of an adverse event and gains consent to proceed with the transfusion (based on this discussion). The individual acknowledges their understanding of the potential risks through signing an additional "Procedures at risk of anaphylaxis" consent form. Once additional consent is obtained, a clinical pre-assessment is performed including baseline vital signs (temperature, pulse and blood pressure) and check of the patency of the vascular access device. Two RNs perform the pre-administration checking procedure. They are required to demonstrate competency through the completion of clinical transfusion practice eLearning modules (https://bloodsafelearning.org.au/), a self-directed learning workbook and attendance at educational workshops annually. RNs new to blood transfusions must also be assessed as competent to perform transfusions by a RN who is blood transfusion competent and has completed an assessor training course. Vital signs are repeated 15 min after the transfusion has commenced, then hourly and at completion of the blood product. For those individuals that require diuretics, intravenous Frusemide (Furosemide) is administered after the first unit of RBCs. The RN enters clinical data into an electronic medical record system. All RNs are provided with training in adverse event management. If an individual demonstrates a mild reaction (e.g., temperature rise), the RN will consult with the referring treating team via telephone. If the RN determines that the individual is experiencing a serious adverse event, an ambulance is called to transport the individual to hospital and emergency medications/oxygen are given as appropriate (RNs have a standing order for emergency medications for adverse reactions).

2.3 | Study design

A retrospective cohort study design was used to determine rates of adverse events associated with out of hospital blood transfusion. Participants were included if they underwent home blood transfusion provided by RDNS SA (part of Silver Chain group) 2004–2019. Existing data which are routinely collected for clinical care (paper and computer-based records) were used to populate a purpose built spreadsheet. Individual demographics (gender, age) and clinical information were collected from RDNS SA information systems. Clinical information such as primary diagnosis (as per treatment request), haemoglobin (Hb) level (g/L) and platelet count ($\times 10^9$/L), vascular access device, previous history of blood transfusion and adverse events were recorded. Transfusion variables such as number and type of blood products transfused (RBC, platelets or albumin), number of blood products infused, use of planned medications and the length of time of each episode of care were also recorded.

2.4 | Outcome measures

Both individual and system events were the outcome measures of interest. Individual adverse events were defined as a reaction to a blood product documented in the clinical information system by the RN providing care. Medications administered for the management of the adverse event, and in the case of a severe transfusion reaction, the actions required to manage the emergency were also recorded. In addition, vascular access adverse events such as difficulty inserting a peripheral intravenous catheter (PIVC) or occlusion, infiltration and phlebitis were recorded (whether the device was inserted by RNs at the time or an existing longer-term device inserted by an acute care facility).

System adverse events relating to the provision of the blood product and clinical efficiency were also recorded. Any discrepancies in the delivery of the blood product or break in cold chain as documented by the RN were included. These included unacceptable temperature range (measured with a logger in each blood product delivery), tampered packaging, mismatch in blood pack label/compatibility levels and individual paperwork, expired product, visually damaged blood (discolouration, clumping or leaks), and incorrect blood product delivered or blood product wastage. Wastage was included if documented by the RN or if the transfusion was ceased once commenced. Any delay in the provision of blood products was also noted; this was defined as when the blood product was given more than an hour after the start of the visit or the RN documented a delay in the medical record.

2.5 | Analysis

Each transfusion episode (each day the individual received a transfusion, irrespective of number of blood products given) was the unit of analysis. Hence, participants were included in the study more than once as many require ongoing transfusions. To account for this, adjustment for clustering was undertaken in the analysis. Descriptive statistics were used to present information about the study population. The association between participant variables such as diagnosis and risk of adverse events were analysed using a log binomial generalised linear model (GLM). Statistical analyses were undertaken using the Stata 16 statistical package, Stata Corp. All results with $p \leq .05$ were considered statistically significant.

2.6 | Sample size justification

Based on an expected incidence rate of 3%, a sample size of 1106 provides an accuracy of ±1% with 95% confidence. This was based on an expected incidence of 1% for individual adverse events (Delaney, 2016; National Blood Authority, 2015) and 2% incidence for system adverse events.

2.7 | Ethical considerations

Ethics approval was obtained from both the clinical site and the university. This study was conducted in accordance with the 1964 Helsinki Declaration. A strengthening the reporting of observational studies in epidemiology (STROBE) checklist was used for this study (see Appendix S1).

3 | RESULTS

There were 1790 episodes of care with 533 individuals (2004–2019). Nearly equal numbers of participants receiving blood transfusion were male and female (Table 1), with a mean age of 82 years old (SD 11.38). Nearly all had a history of previous blood transfusion, and none had a history of transfusion reaction. Most had the transfusion in the residential care facility in which they resided and had a haematological cancer/disorder diagnosis. Of those with a haematological cancer/disorder diagnosis, 51% of episodes of care were for individuals with haematological cancer.

Red blood cells were the most common blood product transfused, most participants had two units of RBCs transfused through a PIVC with a mean Hb of 77 g/L (SD 16 g/L) (Table 2). Of those participants who had platelets, the mean platelet count was 16×10^9/L (SD 19) and nearly all had one unit transfused. Most participants had a planned medication provided during transfusion (diuretic).

3.1 | Overall blood transfusion reactions

There were 13 cases of transfusion reaction, an overall incidence rate (IR) of 0.7% (95% CI 0.43–1.25). However, most were minor reactions. In five cases, the blood transfusion was unaffected (38%), and in three cases (23%), the blood transfusion was initially held but then restarted after medication was given (paracetamol or diuretic).

Neither gender, age, history of previous blood transfusion nor transfusion in an RACF were associated with a blood transfusion reaction (Table 1). Those with a diagnosis of "other anaemia" which included sideroblastic, macrocytic, autoimmune, normocytic and pernicious anaemia were nearly six times more likely to have a transfusion reaction compared to those with a haematological cancer ($p = .025$). The type of vascular access device used, platelet count, components transfused and planned medications did not appear to be associated with a blood transfusion reaction (Table 2). However, Hb level was associated with the risk of an adverse reaction, with a 4% reduction in risk for each extra unit of Hb g/L ($p < .001$). The administration of two units of RBCs appeared to be protective (RR 0.25; 95% CI 0.07–0.88; $p = .033$) whilst the administration of three units was associated with nearly twice the risk of transfusion reaction, although the latter finding was not statistically significant (RR 2.05; 95% CI 0.42–9.97; $p = .395$).

3.2 | Severe blood transfusion reactions

There were five episodes of severe blood transfusion reaction (IR 0.28%; 95% CI 0.12–0.68) resulting in the cessation of the blood transfusion and further medical review or hospital admission. Of the five cases of serious reactions, four cases (IR 0.23%; 95% CI 0.08–0.60) required an ambulance to transport the individual to hospital. Small numbers of severe blood transfusion reactions meant that univariate analysis was not possible.

Of those who suffered severe transfusion reactions, most were male (80%; 95% CI 28–99), resided in an RACF (60%; 95% CI 15–95), had a haematological cancer/disorder diagnosis (60%; 95% CI 15–95) and had previously received a blood transfusion (100%) with no

TABLE 1 Episode characteristics and risk of blood transfusion reaction

	All blood transfusion reactions					
	No (*n* = 1777)	Yes (*n* = 13)	Total (*n* = 1790)	Univariate analysis		
Characteristic	*n* (%)	*n* (%)	*n* (%)	RR	95% CI	Sig[a]
Gender						
Female	900 (99.34)	6 (0.66)	906 (100)	1.00	—	—
Male	877 (99.21)	7 (0.79)	884 (100)	1.21	0.403–3.533	0.747
Total	1777 (99.27)	13 (0.73)	1790 (100)			
Age (years)						
19–45	46 (100)	0 (0)	46 (100)	0.99[b]	0.952–1.046	0.945
46–65	81 (98.78)	1 (1.22)	82 (100)			
66–79	432 (99.08)	4 (0.92)	436 (100)			
80+	1218 (99.35)	8 (0.65)	1226 (100)			
Total	1777 (99.27)	13 (0.73)	1790 (100)			
History of blood transfusion						
Y	1678 (99.29)	12 (0.71)	1690 (100)	0.71	0.092– 5.424	0.741
N	99 (99)	1 (1)	100 (100)	1.00		
Total	1777 (99.27)	13 (0.73)	1790 (100)			
History of transfusion reaction						
Y	0 (0)	0 (0)	0 (0)	—	—	—
N	1777 (99.27)	13 (0.73)	1790 (100)			
Total	1777 (99.27)	13 (0.73)	1790 (100)			
Transfusion location						
Home	675 (99.26)	5 (0.74)	680 (100)	1.00		
RACF	1102 (99.28)	8 (0.72)	1110 (100)	0.98	0.320– 2.999	0.972
Total	1777 (99.27)	13 (0.73)	1790 (100)			
Diagnosis[c]						
Haematological Cancer/disorder	1067 (99.35)	7 (0.65)	1074 (100)	1.00		
Solid tumour	117 (99.15)	1 (0.85)	118 (100)	1.30	0.179–9.417	0.795
Unspecified anaemia[c]	473 (99.16)	4 (0.84)	477 (100)	1.29	0.369–4.478	0.692
Other anaemia[d]	25 (96.15)	1 (3.85)	26 (100)	5.90	1.252–27.805	0.025
Digestive bleed	43 (100)	0 (0)	43 (100)	—	—	—
Chronic renal failure	20 (100)	0 (0)	20 (100)	—	—	—
Iron deficiency	15 (100)	0 (0)	15 (100)	—	—	—
Total	1760 (99.27)	13 (0.73)	1773 (100)			

Abbreviations: CI, confidence interval; RACF, residential aged care facility; RR, relative risk.

[a]Based on log binomial generalised linear model.

[b]Analysed as a continuous variable.

[c]Some treatment requests indicated anaemia as reason for blood transfusion but did not specify underlying diagnosis, and these were coded as unspecified anaemia.

[d]Sideroblastic anaemia, macrocytic anaemia, autoimmune anaemia, normocytic anaemia or pernicious anaemia.

prior transfusion reaction. Most had a PICC (80%; 95% CI 28–99), a planned medication (diuretic) (60%; 95% CI 15–95) and all had RBCs transfused (100%). Sixty per cent had a reaction in the first unit of blood (60%; 95% CI 15–95), whilst 40% had a reaction in the second unit of blood (95% CI 5–85). Of those who had three units of blood (*n* = 72), none had a severe reaction. None of the participants having platelets had a severe blood transfusion reaction.

3.3 | System adverse events

There were no cases of tampered blood packaging, expired or visually damaged blood products. There were 10 cases of incorrect paperwork (0.6%). In three cases, the individual's name or date of birth were incorrect, in five cases, no paperwork was included (four cases the compatibility report was missing and in

TABLE 2 Clinical characteristics and risk of blood transfusion reaction

	All blood transfusion reactions					
	No (*n* = 1777)	Yes (*n* = 13)	Total (*n* = 1790)	Univariate analysis		
Characteristic	*n* (%)	*n* (%)	*n* (%)	RR	95% CI	Sig[a]
Vascular access device						
PICC	192 (99.48)	1 (0.52)	193 (100)	1.00	—	—
PIVC	1565 (99.24)	12 (0.76)	1577 (100)	1.47	0.181–11.903	0.719
TIVAD	20 (100)	0 (0)	20 (100)	—		
Total	1777 (99.27)	13 (0.73)	1790 (100)			
Platelet count						
≤20 × 10^9/L	135 (99.26)	1 (0.74)	136 (100)	1.00[b]	0.996–1.004	0.889
≥21 × 10^9/L	215 (99.08)	2 (0.92)	217 (100)			
Total	350 (99.15)	3 (0.85)	353 (100)			
Hb						
≤70 g/L	367 (98.39)	6 (1.61)	373 (100)	0.96[b]	0.936–0.978	0.000
71–100 g/L	1097 (99.55)	5 (0.45)	1102 (100)			
≥101 g/L	18 (100)	0 (0)	18 (100)			
Total	1482 (99.26)	11 (0.74)	1493 (100)			
Components transfused						
RBC	1622 (99.27)	12 (0.73)	1634 (100)	1.00		
RBC + PLTs	86 (100)	0 (0)	86 (100)	—		
PLTs	66 (98.51)	1 (1.49)	67 (100)	2.01	0.225–18.289	0.527
Albumin	1 (100)	0 (0)	1 (100)	—		
Total	1775 (99.27)	13 (0.73)	1788 (100)			
Number of RBC units						
1	439 (98.65)	6 (1.35)	445 (100)	1.00	—	—
2	1199 (99.67)	4 (0.33)	1203 (100)	0.25	0.0682–0.891	0.033
3	70 (97.22)	2 (2.78)	72 (100)	2.05	0.389–10.892	0.395
Total	1708 (99.30)	12 (0.70)	1720 (100)			
Number of PLTs						
1	146 (99.32)	1 (0.68)	147 (100)			
2	5 (100)	0 (0)	5 (100)	—		
Total	151 (99.34)	1 (0.66)	152 (100)			
Planned medication[c]						
Y	1193 (99.33)	8 (0.67)	1201 (100)	1.27	0.416–3.895	0.671
N	584 (99.15)	5 (0.85)	589 (100)	1.00		
Total	1777 (99.27)	13 (0.73)	1790 (100)			

Abbreviations: CI, confidence interval; Hb, haemoglobin; PICC, peripherally inserted central catheter; PIVC, peripheral intravenous catheter; PLTs, Platelets; RBC, red blood cells; RR, relative risk; TIVAD, Totally implantable vascular access device.

[a]Based on log binomial generalised linear model.

[b]Analysed as a continuous variable.

[c]All planned medications were diuretics.

one case, the RBC unit has no client details on it) and in two cases, details regarding the missing paperwork were unavailable. In most cases, the RN resolved the paperwork errors and gave the blood transfusion. In two cases, the blood product was returned to the blood bank. There was one case of the delivery of incorrect blood products (delivery of an additional unit of RBC which was not ordered) and one case of blood product recall. In nine cases, there were problems with the temperature of blood products at delivery. In most cases, this was due to a missing temperature gauge (78%) in the blood transport packaging.

3.4 | Blood product wastage

There were 33 cases where blood products were wasted due to clinical reasons (IR 1.8%; 95% CI 1.3–2.6). Wastage was mostly due to the vascular access device (19 cases, 58%). In most cases, this was because the PIVC "tissued" (infiltrated into surrounding tissue), a new PIVC could not be inserted and after GP review, the blood transfusion was ceased. In eight cases, (24%) wastage was due to problems with the temperature of the blood prior to infusion. In four cases, wastage was due to the deterioration in health or agitation of the individual. In the latter case, the individual repeatedly dislodged the vascular access device (underlying diagnosis of dementia). There was one case each of blood product wastage due to errors in paperwork and RN errors during administration.

3.5 | Vascular access device adverse events

There were 153 cases of vascular access device adverse events (IR 8.5% 95% CI7.3–9.9). The most common adverse event was difficulty cannulating the individual (n = 82, 54%). Whilst there were 41 cases (27%) of the PIVC tissuing (infiltration), 23 cases where the PIVC dislodged (15%), three cases of leaking (2%), three cases of bruising from multiple attempts (2%) and one case of uncontrolled bleeding from the PICC insertion site (1%). Of those who experienced difficulty during cannulation, additional resources were often used. Mostly, this was from extended care paramedics (ECPs) who assisted in 62 cases (84%), GPs assisted in five cases (7%), participants were sent to hospital to be cannulated in four cases (5%) and both an ECP and hospital were used in two cases (3%). In one case, a visiting Hospital@home nurse assisted cannulating the individual (1%). Of those who were difficult to cannulate, 14 (10%) were not able to have another PIVC inserted and were unable to have their blood transfusion.

3.6 | Delay during episodes of care

There were 130 cases of delay (blood transfusion given more than an hour after the start of the visit or the RN documented a delay in medical record). This was 7% of the total episodes of care (IR 7.3% 95% CI 6.1–8.6). The most common reason for delay was due to the vascular access device (commonly difficulty inserting the PIVC) (n = 82, 63%). The second most common reason for delay was due to late delivery of blood products (n = 19, 15%). Whilst incomplete or missing paperwork created delay in 12 cases (9%) and incorrect blood product temperature created delay in nine cases (7%), auxiliary factors such as lack of supplementary oxygen or planned medication created delay in four cases (3%). Poor individual condition created delay in one case (1%), and in one case, the blood product delivered was recalled and a new product was sent (1%).

4 | DISCUSSION

This research has demonstrated that a nurse-led home blood transfusion service is a safe model of care for medically stable individuals with a chronic health condition. There were only 13 cases of transfusion reaction in the present study (0.7%), most were minor and did not affect the transfusion. Of these, there were only five episodes of severe blood transfusion reaction (0.28%), resulting in the cessation of the blood transfusion and further medical review or hospital admission. Of the five cases of serious reactions, four cases required emergency transport to hospital.

The overall rate of transfusion adverse events in the present study of 0.7% is lower than the rate found in previous research in similar populations. García et al. (2018) in a home-based setting in Spain found an adverse event rate of 1.52% of transfusion episodes. Similarly, Szterling (2005) found a 2% transfusion reaction rate in Brazil.

Whilst Niscola et al. (2012) in 4980 episodes of care found a lower adverse event rate in a study that examined adverse event rates with home-based transfusion with individuals with myelodysplastic syndromes (0.12% of transfusions), perhaps this lower rate is due to the underlying diagnosis of participants in their study. The present study found that participants with a diagnosis of "other anaemia" (sideroblastic, macrocytic, autoimmune, normocytic or pernicious anaemia) were nearly six times more likely to have an adverse reaction than those with a haematological cancer/disorder which indicates that diagnosis may affect transfusion reaction risk. Also, we found that another clinical factor (lower Hb levels) was associated with increased risk of transfusion reaction. However, these results are based on small numbers of adverse events and should be confirmed with further studies before they are used to inform clinical decision making. An unexpected finding was that two units of RBCs appeared to be protective of transfusion reaction compared to one unit. It is unknown whether this is due to an underlying biological mechanism; however, small numbers mean that these results should be interpreted with caution.

In the present study, only 0.28% of episodes of care were associated with severe reactions (required medical review or hospital admission). Whilst the diagnosis they received at hospital is unavailable for these individuals, most cases appear to be mild cases of non-haemolytic transfusion reactions or the clinicians suspected this condition as per the RDNS SA clinical information system notes. Similarly, García et al. (2018) found the most common adverse event in their study (48%) was fever and chills; however, none of the participants in their study required hospital admission. This may be because they had medical staff available to visit individual's homes to assess and manage adverse events, whereas a nurse-led model was used in the current study which did not have medical staff available to visit the individual in a timely manner.

This research has demonstrated that there were few system adverse events. Blood products were delivered at the required temperature in a timely manner for the majority of episodes of care. There were no cases of reduced quality or expired blood products

and few problems with the cold chain in the present study. Whilst there were 33 cases where blood products were wasted due to clinical reasons, most blood product wastage was in fact due to the failure of the VAD.

Vascular access device adverse events were the most common clinical complication in the present study. Previous research with home blood transfusions in a similar age group also found most adverse events were associated with the VAD (Ademokun et al., 2005; Niscola et al., 2012). The most common adverse event in our study was difficulty cannulating the individual, with multiple attempts required and/or additional resources needed. Difficult vascular access (DVA) is a known complication in many cohorts, with up to a third of adults experiencing difficulty with cannulation within the hospital emergency setting (Fields et al., 2014; Whalen et al., 2017). This is compounded in this cohort where older age and co-morbidities may result in anatomical changes including changes in vein structure which is associated with increased risk for DVA (Carr et al., 2019; Gabriel, 2012).

Armenteros-Yeguas et al. (2017) in research with a similar older population with multiple co-morbidities found a DVA prevalence rate of 59%. Yet little research has focussed on DVA in older individuals which is problematic due to an ageing population with multiple co-morbidities. Ultrasound guided PIVC insertion could be introduced for those with DVA in the home setting. Ultrasound guided cannulation has been demonstrated to result in more successful PIVC insertions than visualisation/palpation alone in hospitalised cohorts (Stolz et al., 2015). DVA pathways are increasingly used in hospitals to identify individuals who have DVA that would benefit from ultrasound guided cannulation and could be reconfigured for the home setting (Sou et al., 2017). Ultrasound, due to its portability, would make a convenient resource to assist with cannulation and would be presumedly less costly than the use of a paramedic service.

Many participants in this study had multiple blood transfusions over time, and those who experienced DVA did so repeatedly. In some cases, individuals did not receive the transfusion as ordered by their treating team due to the inability to insert a PIVC. As PIVCs are inserted and removed after each episode of care, these may not be the most appropriate VAD for individuals in the community who have DVA and require ongoing transfusion support. However, the irregular frequency of blood transfusions in this cohort makes vascular access device selection difficult. The Michigan Appropriateness Guide for Intravenous Catheters (MAGIC) guide (Chopra et al., 2015) assists clinicians in VAD selection for those in hospital. Totally implantable vascular access devices (TIVADs or Ports) are recommended where a device is needed frequently for more than 31 days (Chopra et al., 2015). TIVADs can be accessed (needled) as required and when not in use they lie under the skin, with minimal impact on activities of daily living. However, these devices involve a surgical procedure to insert and remove, require adequately skilled nursing staff to access and adverse events such as infection are also more complicated to manage (Liaw et al., 2008).

4.1 | Limitations

A limitation with all retrospective studies is the reliance on existing data. This was the case in this study, with incomplete and missing data. In many cases an underlying diagnosis was not provided in the treatment request for participants. Further, data were entered manually into a purpose built spreadsheet by a RN employed by RDNS Silver Chain; hence there is a risk of transcription error which would affect the accuracy of the data.

Whilst we measured blood product wastage as documented by the RN, we were not able to access blood bank data to ascertain the outcome of returned blood products. The adverse event outcomes of interest were defined based on clinically and system criteria, which do not consider experiences and events that may be considered adverse or undesirable from the perspective of the individual. Finally, this study was undertaken at one health care service whose practices may not be representative of all health care services and hence the generalisability of the results is reduced. Further research is required to determine the safety of home blood transfusions in other populations.

4.2 | Further research

Further research is needed to investigate vascular access device choice for individuals in the community, especially those who are transfusion dependent and may require ongoing blood transfusions at irregular intervals. The individual experience of home-based blood transfusion needs further investigation to understand their experience of the service and identify unmet needs. This will allow supports to be introduced that improve the experience of home blood transfusion and facilitate person centred care.

5 | CONCLUSION

A nurse-led home blood transfusion service was associated with low rates of individual and system adverse events. Further resources are needed to ensure that vascular access devices are inserted at first attempt to facilitate treatment provision and enhance the experience of the individual.

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CONFLICT OF INTEREST

None.

AUTHOR CONTRIBUTIONS

Study plan and design: RS, AE, LT and JA; data collection supervision: RS, NC and LT; data analysis: RS and AE; assisting with interpretation of the results: RS, NC, LT, AE and JA. All authors had an active role in

drafting and revising the manuscript. All authors approved the final version to be submitted.

ORCID

Rebecca Sharp https://orcid.org/0000-0003-3334-2990

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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