One-year Retrospective Analysis of Red Cell Concentrate Requisition and Utilisation Practices at Regional and District Hospitals with No Blood Bank On-site, Metro West Cape Town, South Africa: A multicentre descriptive study

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Declaration

I, Chian-Jia Eden Chiu, hereby declare that the work on which this dissertation is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor part of it has been, is being, or is to be submitted for another degree in University of Cape Town or any other university.

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Acknowledgments, format and contributions

This manuscript has been prepared for submission to Transfusion Medicine and Hemotherapy Journal. The journal requires an abstract with a word count of 200-400 words and a maximum word count of 60,000 characters including title page, summary, main text, illustrations, tables and references. Each table or figure counts for 1,500 characters. Arabic numerals in square brackets should be used for references in the dissertation and the references should be listed using the Vancouver style.

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Table of Contents

List of Abbreviations

AHRS	After hours
CTR	Crossmatch-to-transfusion ratio
EC	Emergency Centre
FBH	False Bay Hospital
GSH	Groote Schuur Hospital
H-NBBOS	Hospital with blood bank on-site
H-NBBOS	Hospitals with no blood bank on-site
HIC	High income country
iCTR	Individualised crossmatch-to-transfusion ratio
ICU	Intensive care unit
iTCR	Individualised transfusion-to-crossmatch ratio
KHC	Kimberley Hospital Complex
LMIC	Low-middle income country
M	Medicine
NSH	New Somerset Hospital
NUP	Non-usage probability
OG	Obstetrics/Gynaecology
RCC	Red cell concentrate
RCWM	Red Cross War Memorial Hospital
S	Surgery
T%	Transfusion probability
TBH	Tygerberg Hospital
TI	Transfusion index
U	Undetermined
VHW	Victoria Hospital
WAPI	Wastage as percentage of issue
WFH	Wesfleur Hospital

List of Appendices

List of Tables

List of Figures

Publication-ready Manuscript

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Abstract

Introduction: The usage of red cell concentrate (RCC) is an essential part of patient blood management (PBM). While a substantial amount of literature describes RCC usage at tertiary institutions, very few exists in the setting of regional or district hospitals with no blood bank on-site (H-NBBOS). Addressing this shortfall in countries with a strained health economy, such as South Africa, is imperative. This scarcity of resources also renders the intervention studies needed to improve blood utilisation and PBM particularly difficult.

Material and Methods: A 12-month retrospective and comparative study investigating RCC usage across a hospital with a blood bank on-site (H-BBOS) or H-NBBOS and the various specialities, in Metro West Cape Town, South Africa. We proposed a set of new blood utilisation indices: individualised crossmatch-to-transfusion ratio (iCTR) and individualised transfusion-to-crossmatch ratio (iTCR), over and above conventional indices, to comprehensively ascertain the efficiency of both RCC crossmatching and transfusion practices through individualised cases. Regression analyses were performed to provide recommendations for a cost-effective intervention study to improve future PBM.

Results: Apart from wastage ratio (3.74%) of H-NBBOS, all other overall blood utilisation indices for both H-BBOS and H-NBBOS were in accordance with international benchmarks. The overall crossmatch-to-transfusion ratio (CTR) of 1.19 in H-NBBOS indicated greater crossmatching efficiency than the H-BBOS (1.31). The superior efficiency of H-NBBOS was substantiated via statistical inference of our proposed individualised patient indices of iCTR and iTCR ($p<0.05$). Regression analyses of the various specialities revealed that Surgery and Obstetrics/Gynaecology of both H-NBBOS and the H-BBOS had the least efficient blood utilisation practices and higher chances of wastage.

Conclusions: The conventional overall CTR showed that H-NBBOS were considerably more efficient than the H-BBOS. However, only a marginal difference was detected through the analysis of our proposed iCTR ($p<0.05$). There was a more distinctive difference in transfusion practices, with H-NBBOS transfusing proportionately more than the BBOS hospital. This advocates the importance of also investigating the utilisation efficiency from a transfusion perspective. A cost-effective intervention study focused on Surgery and Obstetrics/Gynaecology departments, particularly in H-NBBOS, is recommended to improve future blood utilisation practices in South Africa. In addition, our proposed indices enabled comprehensible and insightful interrogation of both crossmatching and transfusing practices. The individualisation of efficiency indices also permitted further objective statistical inferences. Therefore, we propose the incorporation of these indices in future blood utilisation analyses.

Introduction

Red cell concentrate (RCC) utilisation is an essential part of patient healthcare [1,2]. Inappropriate RCC usage results in the poor allocation of a scarce resource and incurs unnecessary costs. More importantly, it would negatively impact the patient's morbidity and mortality [3–5]. A substantial number of studies describe the usage of RCC in a tertiary institution, but few in the setting of regional or district hospitals with no blood bank on-site (H-NBBOS) [6–9]. This study aims to bridge this gap, serving as a platform to launch a patient blood management (PBM) programme tailored for such a setting.

Background

Blood is a scarce life-saving resource, especially in Africa where the continent accounts for 13% of the global population but only receives 4% of the global donation [10.] Moreover, the blood donation rates in Africa are approximately ten times lower than in developed countries [11].

A third of the world's population is anaemic, corresponding to 17.8 million people in South Africa, with a greater prevalence in hospitalised patients [12–14]. The treatment of life-threatening anaemia is the main indication for RCC usage [4]. As such there is a growing demand for blood transfusions, which causes transfusion-related morbidity and mortality, independent of anaemia-related risks, to rise secondary to substandard transfusion practices [6,13,15]. Therefore, both anaemia and RCC utilisation contribute significantly towards the health economic burden [3,15].

The World Health Organisation acknowledged the global health challenge in the provision of safe and accessible blood resources, as well as to implement safe transfusion practices [2]. PBM is an evidence-based, systemic approach to transfusion medicine with a firm emphasis on patient-centeredness and empowerment [2]. It consists of three pillars: the optimisation of erythropoiesis; the minimisation of blood loss; and the optimisation of anaemia and physiological reserves with a restrictive transfusion threshold [12]. This triad forms the current principle of patient-focused transfusion medicine [12].

South Africa is currently implementing a nationwide PBM with the intention to improve patient outcomes, as well as to rationalise blood utilisation and wastage [14]. District hospitals mainly deliver primary healthcare services, while Regional hospitals provide some specialist support, which may include critical care units for short-term ventilation.[16] These hospitals therefore serve diverse patients and disease spectrums compared to tertiary institutions, with areas of overlap. Most district and regional hospitals usually have no blood bank on-site and thus face distinct challenges in blood utilisation compared to hospitals with a blood bank on-site (H-BBOS). Our study aims to analyse the crossmatching and transfusion practices in this poorly explored setting, an aspect of the third PBM pillar.

One of the universally accepted indices to determine blood ordering and utilisation efficiency is the crossmatch-to-transfusion ratio (CTR) [6,17]. The international benchmark for CTR is 2.5 with an ideal ratio of 1 [17]. Excessive crossmatching and poor utilisation is the main reason for inefficiency [17]. The United Kingdom, a high-income country (HIC), has a CTR of 2.1, while low-middle-income African countries (LMIC) reported highly inconsistent CTRs [5,17]. Egypt, Tanzania and Zambia had CTRs of 3.9, 3.7 and 2.8, respectively, whilst Ethiopia's CTR was 2.3 [6,17]. South Africa has a CTR of 1.4 and 1.03-1.07 at Groote Schuur Hospital (GSH) and Kimberley Hospital Complex (KHC), respectively.[18,19] The studies conducted in Africa were mainly at tertiary institutions [6–9]. Of note, South Africa wastes approximately 7-10% of blood annually due to over-ordering.[6]

We aimed to analyse and describe blood crossmatching and transfusion practices of H-NBBOS in Cape Town, South Africa. The outcomes would preferably be benchmarked with a local institution of a similar category but with a blood bank on-site. However, the H-BBOS in Cape Town are all tertiary or specialised institutions, e.g. GSH, Tygerberg Hospital (TBH) and Red Cross War Memorial Children's Hospital (RCWMH). We used GSH as a control to ascertain if there was poor utilisation across the Metro West hospitals regardless of blood bank facility or whether the behaviours were unique to H-NBBOS.

We compared our data against the 1-year retrospective, single-centre study in Uganda's Mbarara Regional Referral Hospital with no blood bank on-site, whereby the closest blood bank was 2km away [1]. The CTR and transfusion index (TI) were reported as 1.3 and 1.7, respectively [1].

Further proposition

We proposed additional blood utilisation indices to further improve the analysis of crossmatching and transfusion practices, namely individualised CTR (iCTR) and individualised TCR (iTCR). The rationale was that conventional indicators measure requisition and utilisation from an overall hospital-wide perspective and summarises them into a single number (e.g. CTR). However, a single-value representation of data may not provide sufficient information on the various individual cases and may be confounded by outliers. The interrogations of individualised patient ratios, iCTR and iTCR, would enable a more comprehensive interpretation of blood utilisation practices per blood request through objective statistical inference. In addition to the above, the conventional CTR provides information regarding the number of RCC units crossmatched per transfusion. However, with transfusion as a denominator, it does not account for crossmatched units that were not transfused when examining individual patient RCC requests. Transfusion practices not only involve crossmatching, but also the decision to transfuse. Returned or non-transfused RCC could be considered as poor utilisation, as these units were unavailable for other patients while reserved. Once the unit expires it also incurs silent costs [20]. The above-mentioned rationale motivates for our introduction of iTCR, which depicts the proportion of RCC units transfused per crossmatch. We used the international benchmark set for CTR (≤ 2.5) for iCTR. Consequently, given the nature of the iTCR, we used the inverse of CTR (≥ 0.4) as a benchmark.

Materials and Methods

Study Design

In line with prior research (see [1]), we also utilised a one-year sample period (1 July 2018 to 30 June 2019) for consistency, following ethics approval.

Recruitment

Inclusion criteria

Patients 18 years and older, who had RCC requests during the 12-month period at the hospitals listed and described in Table 1.

Table 1. Hospitals of Metro West Cape Town, South Africa

Classification	Category	Hospital	Bed Capacity	Blood bank	Kilometres from blood bank
H-BBOS	Tertiary	Groote Schuur Hospital (GSH)	893	GSH	On-site
H-NBBOS	Regional	New Somerset Hospital (NSH)	334	GSH	8.5
	District	Victoria Hospital (VHW)	180	GSH	10.2
		False Bay Hospital (FBH)	65	GSH	29.5
		Mitchells Plain Hospital (MPH)	230	TBH	21.5
		Wesfleur Hospital (WFH)	28	RCWMH	53

Abbreviations: H-BBOS, hospital with blood bank on site; H-NBBOS, hospitals with no blood bank on site; TBH, Tygerberg Hospital; RCWMH, Red Cross War Memorial Hospital

Exclusion criteria

Patients under 18 years old or with undetermined age were excluded. We also excluded regional or district hospitals, with or without blood bank on-site, that provided specialist services or hospitals located outside the Metro West.

Data collection

The following data were extracted from the Western Cape Blood Service's (WCBS) existing database:

- Demographics
- Date of birth
- Sex
- Ward allocation to determine specialities i.e., Emergency Centre (EC), Intensive Care Unit (ICU), Medicine (M), Surgery (S), Obstetrics/Gynaecology (OG), Undetermined (U)

- Blood product information
- Blood bank reference number unique to individual sample request
- Blood product type or procedure requested (e.g., RCC)
- Reason for discard
- Price per unit product, after-hour requests (AHRS) and cancellation fees

Blood utilisation indices and international benchmark

The blood utilisation indices and their internationally accepted benchmark for efficient blood usage are defined as follows [21]:

Conventional overall blood utilisation indices

- Crossmatched-to-Transfusion ratio (CTR) = $\frac{Total\ nmber\ of\ units\ crossmatched}{Total\ number\ of\ units\ tranfused} \leq 2.5$
- Transfusion probability (T%) = $\frac{Total\ number\ of\ patients\ transfused}{Total\ number\ of\ patients\ crossmatched} \times 100 \geq 30\%$
- Transfusion index (TI) = $\frac{Total\ number\ of\ units\ transfused}{Total\ number\ of\ patients\ crossmatched} \times 100 \geq 0.5$
- Non-usage probability (NUP) = $\frac{Total\ number\ of\ units\ returned}{Total\ number\ of\ units\ crossmatched} \times 100 < 50\%$
- Wastage as percentage of issue (WAPI) = $\frac{Total\ number\ of\ units\ wasted}{Total\ number\ of\ units\ crossmatched} \times 100 < 2.5\%$

Additional blood utilisation indices

- Individualised transfusion-to-crossmatch ratio (iTCR) = $\frac{No.\ of\ units\ transfused\ for\ patient\ x}{No.\ of\ units\ crossmatched\ for\ patient\ x} \geq 0.4$
- Individualised crossmatch-to-transfusion ratio (iCTR) = $\frac{No.\ of\ units\ crossmatched\ for\ patient\ x}{No.\ of\ units\ transfused\ for\ patient\ x} \leq 2.5$

Statistical analysis

Anonymised data were extracted to MS-Excel and categorised into H-BBOS, H-NBBOS, and across the various specialities or departments. Descriptive statistics and appropriate statistical inferences via Matlab were used to summarise and analyse the data. Logistic regressions were utilised to investigate the likelihood of wastage and inefficiencies of blood utilisation.

Logistic Regression Analysis

The detection of individual blood utilisation inefficiency cases (Fig. 4) paves the way for further interrogation on the likelihood of such occurrences. We investigate such inefficiency of RCC utilisation and the wastage, across the various departments within both H-BBOS and H-NBBOS through a set of logistic regressions. Specifically, for any given patient or case, we defined wastage as having discarded crossmatched units. Hence, an indicator variable was deployed to represent wastage, which takes on the value of 1 when a discard has occurred and 0 otherwise. From the perspective of efficiency, we used indicator variables that takes on the value of 1 when a given patient's iCTR > 2.5 (or when iTCR < 0.4) and 0 otherwise. The specified models would help us determine whether a particular department was more likely to be subject to wastage or utilisation inefficiencies.

Results

Study population

Our recruitment and distribution of patients are shown in Tables 2 and 3. A total of 12829 patients fulfilled the inclusion criteria. The proportion of recruited patients were reasonably similar between H-BBOS (52.3%) and H-NBBOS (57.4%), with exclusions at less than 1% for both. The age distribution for both hospitals were approximately symmetrical with a skewness coefficient of 0.35 and 0.55, respectively. FBH presented a unique challenge in further classifying the 188 recruited patients into the various specialities, as the hospital wards accommodated mixed departments. These patients were categorised as undetermined and were excluded from further blood utilisation analyses involving specialities. Apart from a larger Emergency and a smaller Medicine department in H-NBBOS, the rest of both H-BBOS and H-NBBOS specialities shared a similar distribution of patients (see Figure 1). Patients' age for both H-BBOS and H-NBBOS were similarly distributed across the different specialities.

Table 2. Patient recruitment and transactions of H-BBOS and H-NBBOS

	H-BBOS	H-NBBOS					
Summary of study patient recruitment	GSH†	TOTAL†	NSH‖	VHW‖	MPH‖	WFH‖	FBH‖
Total patients ordered blood products (%)	16620 (100.0)	7212 (100.0)	3457 (47.9)	1214 (16.8)	2185 (30.3)	86 (1.2)	270 (3.7)
Total patients ordered crossmatched RCC (%)	8844 (53.2)	4200 (58.2)	1756 (24.3)	861 (11.9)	1325 (18.4)	69 (1.0)	189 (2.6)
Total patients ordered crossmatched RCC and ≥ 18 years old (%)	8688 (52.3)	4141 (57.4)	1725 (23.9)	851 (11.8)	1310 (18.2)	67 (0.93)	188 (2.6)
Female (%)	4673(53.8)	2820 (68.1)	1276 (30.8)	500 (12.1)	894 (21.6)	48 (1.2)	102 (2.5)
Female average age in years (SD)	46.6 (17.9)	44.2 (19.0)	41.3 (18.1)	56.1 (19.6)	41.6 (17.5)	42.9 (18.7)	45.2 (17.6)
Male (%)	4011 (46.2)	1278 (30.9)	447 (10.8)	336 (8.1)	392 (9.5)	18 (0.43)	85 (2.1)
Male average age in years (SD)	47.1 (17.4)	52.2 (18.5)	50.0 (17.0)	56.7 (18.2)	48.5 (17.5)	52.7 (15.2)	63.4 (24.2)
Unknown sex (%)	4 (0.05)	41 (0.99)	2 (0.05)	15 (0.36)	22 (0.53)	1 (0.02)	1 (0.02)
Total patients ordered crossmatched RCC but excluded (%)	156 (0.94)	59 (0.8)	31 (0.43)	10 (0.13)	15 (0.21)	2 (0.03)	1 (0.01)
≤ 17 years old	155	58	30	10	15	2	1
Undetermined age	1	1	1	0	0	0	0
Total patients per speciality	8688 (100.0)	4141 (100.0)	1725 (41.7)	851 (20.6)	1310 (31.6)	67 (1.6)	188 (4.5)
Emergency Center (%)	868 (10.0)	1365 (33.0)	498 (12.0)	356 (8.6)	474 (11.4)	37 (0.89)	*
Intensive Care Unit (%)	678 (7.8)	87 (2.1)	55 (1.3)	28 (0.68)	4 (0.10)	0 (0.0)	*
Medicine (%)	2477 (28.5)	477 (11.5)	191 (4.6)	107 (2.6)	162 (3.9)	17 (0.41)	*
Obstetrics and Gynaecology (%)	1360 (15.7)	905 (21.9)	536 (12.9)	5 (0.12)	354 (8.5)	10 (0.24)	*
Surgery (%)	2993 (34.5)	1023 (24.7)	406 (9.8)	321 (7.8)	296 (7.1)	0 (0.0)	*
Undetermined (%)	312 (3.6)	284 (6.8)	39 (0.94)	34 (0.82)	20 (0.48)	3 (0.07)	188 (4.5)
Summary of red cell concentrate inventory							
Total RCC units (%)	19215 (100.0)	10956 (100.0)	4495 (41.0)	2169 (19.8)	3604 (32.9)	227 (2.1)	461 (4.2)
Total emergency RCC units (%)	108 (0.6)	1741 (15.9)	551 (5.0)	339 (3.1)	692 (6.3)	85 (0.78)	74 (4.3)
Total crossmatched RCC units with age ≥ 18 years old (%)	18846 (98.1)	9107 (83.1)	3887 (35.5)	1809 (16.5)	2888 (26.4)	138 (1.3)	385 (3.5)
Total RCC units transfused (%)	14353 (76.2)	7678 (84.3)	3239 (35.6)	1588 (17.4)	2360 (25.9)	133 (1.5)	358 (3.9)
Total RCC units returned (%)	4493 (23.8)	1429 (15.7)	648 (7.1)	221 (2.4)	528 (5.8)	5 (0.05)	27 (0.30)
Total RCC units returned with no units transfused (%)	3014 (16.0)	853 (9.4)	344 (3.8)	139 (1.5)	346 (3.8)	3 (0.03)	21 (0.23)
Total RCC units discarded from returned units (%)	229 (1.2)	341 (3.7)	204 (2.2)	35 (0.38)	100 (1.1)	2 (0.02)	0 (0.0)
Total after-hour RCC units requested (%)	9770 (51.8)	6043 (66.4)	2838 (31.2)	1349 (14.8)	1664 (18.3)	39 (0.43)	153 (1.7)
Total crossmatched RCC units excluded (%)	261 (1.4)	108 (0.99)	57 (0.52)	21 (0.19)	24 (0.22)	4 (0.04)	2 (0.02)
≤ 17 years old	260	106	55	21	24	4	2
Undetermined age	1	2	2	0	0	0	0
Summary of patients involved in RCC transactions							
Total patients crossmatched RCC	8688 (100.0)	4141(100.0)	1725 (41.7)	851 (20.6)	1310 (31.6)	67 (1.6)	188 (4.5)
Total patients transfused RCC (%)	7090 (81.6)	3713 (89.7)	1551 (37.5)	779 (18.8)	1140 (27.5)	65 (1.6)	178 (4.3)
Total patients returned RCC (%)	2556 (29.4)	786 (19.0)	369 (8.9)	125 (3.0)	274 (6.6)	3 (0.07)	15 (0.36)
Total patients returned RCC with no transfusion (%)	1598 (18.4)	428 (10.3)	174 (4.2)	72 (1.7)	170 (4.1)	2 (0.05)	10 (0.24)
Total patients discarded RCC (%)	172 (2.0)	218 (5.3)	131 (3.2)	26 (0.63)	60 (1.4)	1 (0.02)	0 (0.0)
Total patients after-hour requested RCC (%)	3829 (44.0)	2689 (64.9)	1244 (30.0)	632 (15.3)	720 (17.4)	18 (0.43)	75 (1.8)

‖ Percentages expressed as a proportion of H-NBBOS total

† Percentages expressed as a proportion of total crossmatched RCC or patients in H-BBOS or H-NBBOS

* The 188 patients of FBH were not involved in speciality analyses and therefore classified as undetermined.

Abbreviations: H-BBOS, hospital with blood bank on-site; H-NBBOS, hospitals with no blood bank on-site; GSH, Groote Schuur Hospital; NSH, New Somerset Hospital; VHW Victoria Hospital; MPH, Mitchells Plain Hospital; WFH, Wesfleur Hospital; FBH, False Bay Hospital; CTR, crossmatch-to-transfusion ratio; TCR, transfusion-to-crossmatch ratio; T%, transfusion probability; TI, transfusion index; NUP, non-usage probability; WAPI, wastage as a percentage of issue; iCTR, individualised crossmatch-to-transfusion ratio; iTCR, individualised transfusion-to-crossmatch ratio; 95%CI, 95% confidence interval; RCC, red cell concentrates.

Table 3. Patient recruitment and RCC transactions in specialities of H-BBOS and H-NBBOS

	H-BBOS						H-NBBOS					
Summary of red cell concentrate inventory†	EC	ICU	M	OG	S	U	EC	ICU	M	OG	S	U*
Total units crossmatched (%)**	2053 (10.9)	1335 (7.1)	4192 (22.2)	3201 (17.0)	7377 (39.1)	688 (3.7)	3166 (34.8)	208 (2.3)	975 (10.7)	1879 (20.6)	2275 (25.0)	604 (6.6)
Total RCC units transfused (%)	1651 (80.4)	1105 (82.8)	3621 (86.4)	2366 (73.9)	5070 (68.7)	540 (78.5)	2710 (85.6)	176 (84.6)	867 (88.9)	1513 (80.5)	1887 (83.0)	525 (86.9)
Total RCC units returned (%)	402 (19.6)	230 (17.2)	571 (13.6)	835 (26.1)	2307 (31.3)	148 (21.5)	456 (14.4)	32 (15.4)	108 (11.1)	366 (19.5)	388 (17.1)	79 (13.1)
Total RCC units returned with no units transfused (%)	275 (13.4)	116 (8.7)	360 (8.6)	638 (19.9)	1529 (20.7)	96 (14.0)	266 (8.4)	16 (7.7)	69 (7.1)	233 (12.4)	219 (9.6)	50 (8.3)
Total RCC units discarded from returned units (%)	18 (0.88)	8 (0.60)	41 (0.98)	46 (1.44)	107 (1.45)	9 (1.3)	97 (3.1)	9 (4.3)	20 (2.1)	103 (5.5)	97 (4.3)	15 (2.5)
Total after-hour RCC units requested (%)	1435 (69.9)	754 (56.5)	1030 (24.6)	2072 (64.7)	4168 (56.5)	311 (45.2)	2258 (71.3)	149 (71.6)	588 (60.3)	1228 (65.4)	1533 (67.4)	287 (47.5)
Summary of patients involved in RCC transactions†												
Total patients crossmatched RCC (%)**	868 (10.0)	678 (7.8)	2477 (28.5)	1360 (15.7)	2993 (34.4)	312 (3.6)	1365 (33.0)	87 (2.1)	477 (11.5)	905 (21.9)	1023 (24.7)	284 (6.9)
Total patients transfused RCC (%)	723 (83.3)	614 (90.6)	2252 (90.9)	1029 (75.7)	2207 (73.7)	265 (84.9)	1238 (90.7)	77 (88.5)	443 (92.9)	782 (86.4)	912 (89.2)	261 (91.9)
Total patients returned RCC (%)	232 (26.7)	141 (20.8)	370 (14.9)	461 (33.9)	1276 (42.63)	76 (24.4)	243 (17.8)	18 (20.7)	61 (12.8)	210 (23.2)	211 (20.6)	43 (15.1)
Total patients returned RCC with no transfusion (%)	145 (16.7)	64 (9.4)	225 (9.1)	331 (24.3)	786 (26.3)	47 (15.1)	127 (9.3)	10 (11.5)	34 (7.1)	123 (13.6)	111 (10.9)	23 (8.1)
Total patients discarded RCC (%)	14 (1.6)	6 (0.88)	30 (1.21)	32 (2.4)	84 (2.8)	6 (1.9)	58 (4.3)	6 (6.9)	16 (3.4)	64 (7.1)	62 (6.1)	12 (4.2)
Total patients after-hour requested RCC (%)	584 (67.3)	328 (48.4)	487 (19.7)	834 (61.3)	1476 (49.3)	120 (34.5)	960 (70.3)	61 (70.1)	283 (59.3)	586 (64.8)	666 (65.1)	133 (46.8)

* Includes FBH 188 patients and 385 RCC units.
** Percentage as a proportion contributed by the speciality of H-BBOS and H-NBBOS as per total units or patients.
† Other percentages expressed as a proportion of total crossmatched RCC units or patients in speciality.
Abbreviations: H-BBOS, hospital with blood bank on-site; H-NBBOS, hospitals with no blood bank on-site; RCC, red cell concentrate; EC, emergency centre; ICU, intensive care unit; M, medicine; OG, obstetrics and gynaecology; S, surgery; U, Undetermined; AHRS, after-hours; FBH, False Bay Hospital; RCC, red cell concentrates.

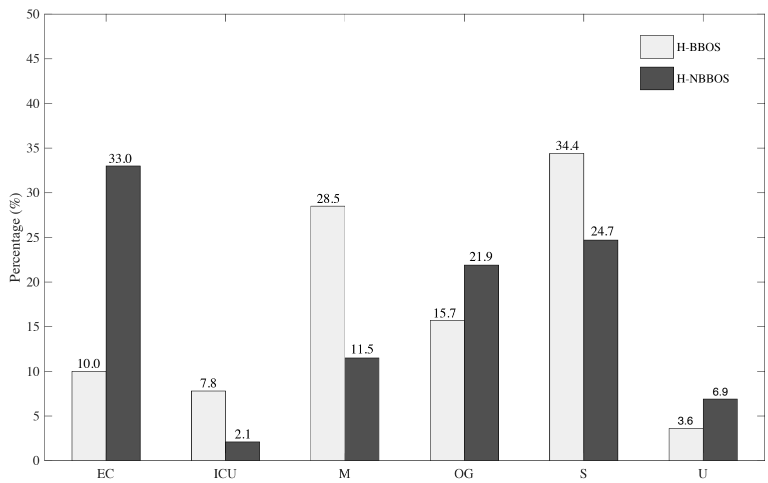

Fig. 1. Patient proportion by specialities. Abbreviations: H-BBOS, hospital with blood bank on-site; H-NBBOS, hospitals with no blood bank on-site; EC, emergency centre; ICU, intensive care unit; M, medicine; OG, obstetrics and gynaecology; S, surgery; U, undetermined.

RCC usage

Tables 2 and 3 present the inventory breakdown of RCC transactions during the 12-month period. In comparison to H-BBOS, the H-NBBOS transfused 8.1%, discarded 2.5% and after-hour requested 14.6% more RCC (see Figure 2). Notably, the H-NBBOS also used approximately 17 times more emergency RCC than the H-BBOS. However, the H-BBOS returned 23.8% of their crossmatched units, which was 8.1% more than the H-NBBOS. Of the 23.8% RCC returned from the H-BBOS, 16% were full returns of the units ordered, which translated to zero transfusions performed per crossmatch request.

A total of 570 units were discarded, which consisted of 1.2% of H-BBOS total RCC and 3.7% of H-NBBOS total RCC. The H-BBOS departments with the highest percentage of discards were Surgery, followed closely by the Obstetrics/Gynaecology department. At the H-NBBOS, the Obstetrics/Gynaecology department had the highest discard percentage. The greatest proportion of RCC discards were due to ‘returns after 24-hours’, followed by ‘no ties’ and ‘warm returns’, referring to blood that could have been returned to the blood bank (Figure 3). Regarding after-hour RCC requests, the largest discrepancies were observed between Medicine departments of H-BBOS and H-NBBOS, with the latter showing 2.5 times higher RCC than its counterpart.

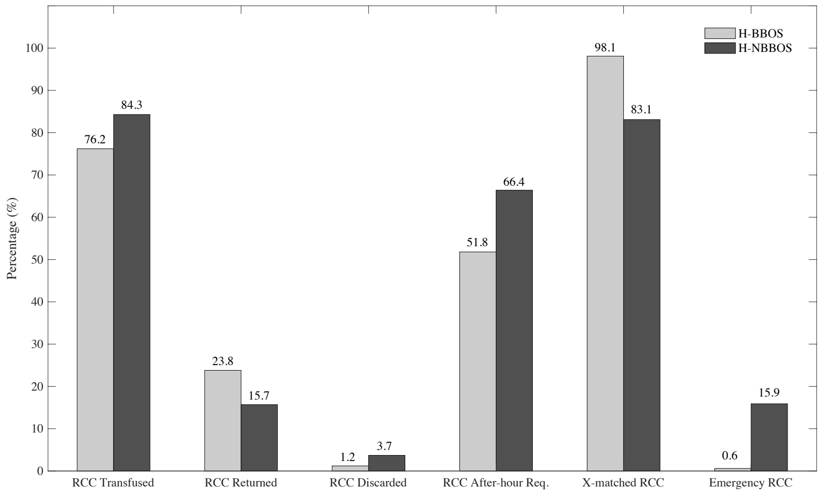

Fig. 2. RCC transactions of H-BBOS and H-NBBOS. Abbreviations: H-BBOS, hospital with blood bank on-site; H-NBBOS, hospitals with no blood bank on-site; RCC, red cell concentrate; X-matched, crossmatched.

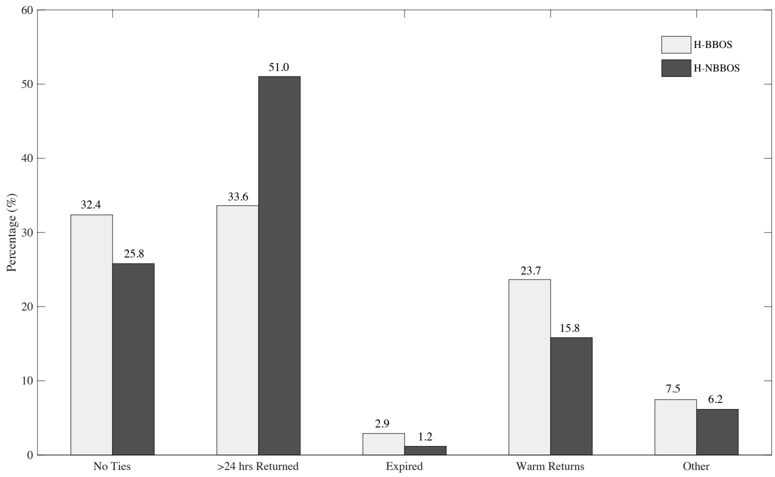

Fig. 3 Reasons for RCC discard at H-BBOS and H-NBBOS. Abbreviations: H-BBOS, hospital with blood bank on-site; H-NBBOS, hospitals with no blood bank on-site; RCC, red cell concentrate; X-matched, crossmatched.

Conventional overall blood utilisation indices

H-NBBOS vs H-BBOS (Table 4)

Both H-NBBOS and H-BBOS had overall CTRs below the international benchmark. However, the H-NBBOS outperformed the H-BBOS in all indices except for the wastage percentage (WAPI). H-NBBOS transfused 8% more of their crossmatched units than the H-BBOS, while the H-BBOS crossmatched 12% more units in comparison. This translated into both facilities crossmatching approximately two units per patient on average. However, H-NBBOS patients would receive approximately 84% of the crossmatched units (TI of 1.85), while the H-BBOS only transfused approximately 76% (TI of 1.65). Hence, the H-BBOS patients had an 8% lower probability of receiving a transfusion in comparison. The H-NBBOS had a substantial wastage percentage (WAPI) of 1.5 times the international benchmark and three times more compared to the H-BBOS. However, the H-BBOS had a greater proportion of unutilised RCC, at 1.5 times the H-NBBOS rate.

Table 4. H-BBOS and H-NBBOS blood utilisation indices

	H-BBOS	H-NBBOS					
Overall blood utilisation indices	GSH	Total	NSH	VHW	MPH	WFH	FBH
CTR	1,31	1,19	1,20	1,14	1,22	1,04	1,08
TCR	0,76	0,84	0,83	0,88	0,82	0,96	0,93
T%	81,61	89,66	89,91	91,54	87,02	97,01	94,68
TI	1,65	1,85	1,88	1,87	1,80	1,99	1,90
NUP (%)	23,84	15,69	16,67	12,22	18,28	3,62	7,01
WAPI (%)	1,22	3,74	5,25	1,93	3,46	1,45	0,00
Other							
Average RCC untis crossmatched	2,17	2,20	2,25	2,13	2,20	2,06	2,05
Total RCC units discarded from returned units	229	341	204	35	100	2	0
Individual blood utilisation indices							
iCTR (95%CI)	1.12 (1.11;1.13)	1.09 (1.08;1.10)	1.11	1.08	1.08	1.02	1.03
iTCR (95%CI)	0.77 (0.76;0.78)	0.86 (0.85;0.87)	0.85	0.89	0.84	0.96	0.93
Female iCTR (95%CI)	1.12 (1.11;1.13)	1.08 (1.07;1.09)					
Female iTCR (95%CI)	0.78 (0.77;0.79)	0.86 (0.85;0.87)					
Male iCTR (95%CI)	1.12 (1.11;1.14)	1.11 (1.09;1.14)					
Male iTCR(95%CI)	0.76 (0.74;0.77)	0.86 (0.85;0.88)					

Abbreviations: H-BBOS: hospital with blood bank on-site; H-NBBOS, hospitals with no blood bank on-site; GSH, Groote Schuur Hospital; NSH, New Somerset Hospital; VHW, Victoria Hospital; MPH, Mitchells Plain Hospital; WFH, Wesfleur Hopsital; FBH, False Bay Hospital; CTR, crossmatch-to-transfusion ratio; TCR, transfusion-to-crossmatch ratio; T%, transfusion probabilitly; TI, transfusion index; NUP, non-usage probability; WAPI, wastage as a percentage of issue; iCTR, individualised crossmatch-to-transfusion ratio; iTCR, individualised transfusion-to-crossmatch ratio; 95%CI, 95% confidence interval; RCC, red cell concentrate

H-NBBOS vs H-BBOS Specialities (Table 5)

It should be noted that FBH's 385 RCC units (3.5% of H-NBBOS' total RCC) with undetermined specialities were excluded from further speciality analyses as presented in Table 2. Both facilities' overall CTRs for the various specialities indicated efficient blood utilisation (1.04-1.22), in accordance with the international benchmark. Evidently, the H-NBBOS had more similar values throughout the specialities, approximating its overall CTR of 1.19, while the H-BBOS specialities were more inhomogeneous. However, every speciality in the H-NBBOS performed better than their respective counterparts in the H-BBOS. Notably, the Obstetrics/Gynaecology and Surgery departments of the H-BBOS had an overall surplus of 11% and 25% more crossmatched units per transfusion, respectively, when compared to their counterparts in the H-NBBOS. These two H-BBOS departments also had the lowest transfusion probability (%T) compared to the other in-house H-BBOS specialities. The ICU, Obstetrics/Gynaecology and Surgery departments of H-NBBOS contributed the highest overall wastage percentage (WAPI).

Table 5. H-BBOS and H-NBBOS specialities' blood utilisation indices

	H-BBOS					H-NBBOS				
Overall blood utilisation indices	EC	ICU	M	OG	S	EC	ICU	M	OG	S
CTR	1,24	1,21	1,16	1,35	1,46	1,17	1,18	1,12	1,24	1,21
TCR	0,80	0,83	0,86	0,74	0,69	0,86	0,85	0,89	0,81	0,83
T%	81,61	83,29	90,92	75,66	73,74	90,70	88,51	92,87	86,41	89,15
TI	1,90	1,63	1,46	1,74	1,69	1,99	2,02	1,82	1,67	1,84
NUP (%)	19,58	17,23	13,62	26,09	31,27	14,40	15,38	11,08	19,48	17,05
WAPI (%)	0,88	0,60	0,98	1,44	1,45	3,06	4,33	2,05	5,48	4,26
Other										
Average RCC units crossmatched	2,37	1,97	1,69	2,35	2,46	2,32	2,39	2,04	2,08	2,22
Total RCC units discarded	18	8	41	46	107	97	9	20	103	97
Individual blood utilisation indices										
iCTR (95%CI)	1.10 (1.07;1.12)	1.12 (1.09;1.15)	1.06 (1.05;1.07)	1.11 (1.09;1.13)	1.19 (1.17;1.21)	1.09 (1.07;1.10)	1.09 (1.02;1.16)	1.05 (1.03;1.08)	1.09 (1.07;1.11)	1.11 (1.09;1.14)
iTCR (95%CI)	0.79 (0.77;0.82)	0.85 (0.83;0.88)	0.88 (0.87;0.89)	0.72 (0.69;0.74)	0.67 (0.65;0.68)	0.87 (0.85;0.89)	0.85 (0.78;0.92)	0.90 (0.88;0.93)	0.82 (0.80;0.85)	0.85 (0.83;0.87)

Abbreviations: H-BBOS, hospital with blood bank on-site; H-NBBOS, hospitals with no blood bank on-site; EC, emergency centre; ICU, intensive care unit; M, medicine; OG, obstetrics and gynaecology; S, surgery; CTR, crossmatch-to-transfusion ratio; TCR, transfusion-to-crossmatch ratio; T%, transfusion probabilitly; TI, transfusion index; NUP, non-usage probability; WAPI, wastage as a percentage of issue; iCTR, individual crossmatch-to-transfusion ratio; iTCR, individual transfusion-to-crossmatch ratio; 95%CI, 95% confidence interval; RCC, red cell comcentrate.

Individualised CTR and individualised TCR (Table 4 and Table 5)

H-NBBOS vs H-BBOS

The average iCTRs for both H-BBOS and H-NBBOS were noticeably more ideal than their overall CTR. We found a statistically significant difference in mean of 3% ($p < 0.05$), indicating that the H-BBOS had a greater excess of crossmatched units per transfusion compared to the H-NBBOS. A difference in mean test of iTCR showed that the H-BBOS transfused significantly less per crossmatch unit than the H-NBBOS by 9% ($p < 0.05$). Figure 4 depicts the distributions of iCTR and iTCR across both the H-BBOS and H-NBBOS. While the majority of individualised ratios are within the international benchmarks (iCTR < 2.5 and iTCR > 0.4).

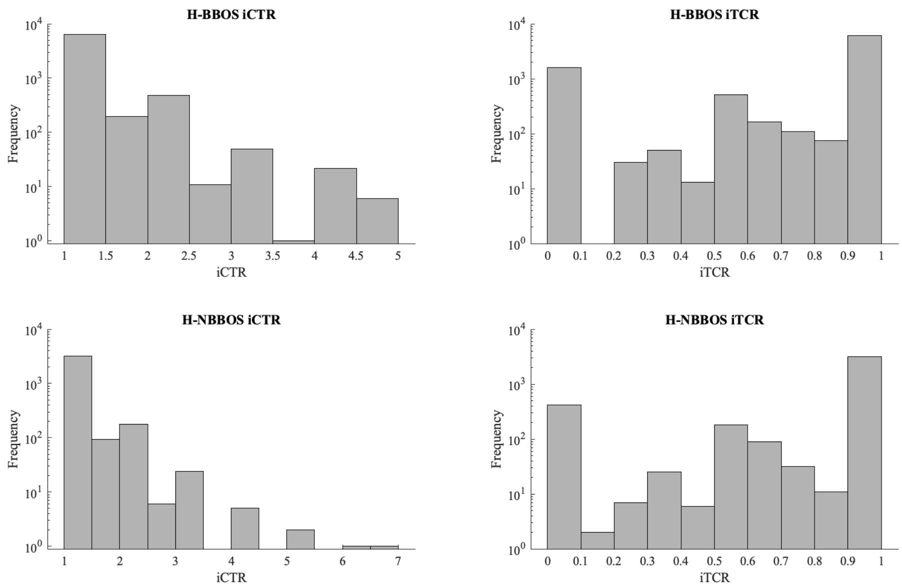

Fig. 4. Histogram of iCTR and iTCR across the H-BBOS and H-NBBOS in logarithmic scale. Abbreviations: H-BBOS, hospital with blood bank on-site; H-NBBOS, hospitals with no blood bank on-site; iCTR, individualised crossmatch-to-transfusion ratio; iTCR, individualised transfusion-to-crossmatch ratio.

H-NBBOS vs H-BBOS Specialities

In terms of crossmatching practices, the analysis of variance across the H-BBOS specialities' iCTRs indicated a significant difference between means, while no difference was found between H-NBBOS specialities. The average iCTR across each speciality of both facilities outperformed their overall CTR, approaching even closer to the ideal benchmark ratio. Generally, the H-NBBOS specialities were more efficient than their respective H-BBOS counterparts, as demonstrated by their average iCTRs, although the disparity compared to their corresponding overall CTR is less pronounced. However, no difference in mean was detected when drawing a direct comparison in specialities between H-NBBOS and H-BBOS, except for the Surgery department. The H-BBOS Surgery department had a significant surplus of crossmatched units per transfusion compared to the H-NBBOS Surgery by 9% ($p<0.05$).

From the perspective of transfusion, when drawing direct comparisons between the iTCR of the respective specialities across H-NBBOS and H-BBOS, significant differences in mean were found between the Emergency, Obstetrics/Gynaecology and Surgery departments. The Obstetrics/Gynaecology and Surgery departments of H-NBBOS transfused significantly more per crossmatched unit than their H-BBOS counterparts by 10% and 18% ($p<0.05$), respectively.

Age and Sex

There was no correlation between age and iCTR or iTCR. Female patients of H-BBOS had a statistically significant greater excess of crossmatched units per transfusion than the H-NBBOS female patients by 4% ($p <0.05$). No significant difference was found between the male patients' iCTRs. A significant difference in mean was detected between both sexes' iTCRs, with H-NBBOS females and males transfusing significantly more per crossmatched unit compared to the H-BBOS by 8% and 10% ($p<0.05$), respectively.

Departmental Discard Practice Analysis

For H-BBOS, our logistic regression provided evidence to suggest that Emergency, ICU and Medicine departments were less likely to discard crossmatched units in comparison to Surgery, at a 5% level of significance. However, there was a lack of statistical evidence to suggest the same from Obstetrics/Gynaecology. Note that Surgery was selected as the reference group given its highest wastage percentage (WAPI) as per prior discussions.

Table 6. Regression Analysis of Discards across specialities of H-BBOS and H-NBBOS

	Intercept	EC	ICU	M	OG	S
H-BBOS Discards [S as reference group]	0.0281 (9.293)**	-0.0119 (-2.279)*	-0.0192 (-4.088)**	-0.0160 (-4.271)**	-0.0045 (-0.889)	
H-NBBOS [OG as reference group]	0.0707 (8.290)**	-0.0282 (-2.786)**	-0.0018 (-0.061)	-0.0372 (-3.130)**		-0.0101 (-0.892)

*,** represents statistical significance at the 5% and 1%, respectively.
Numbers in parentheses () represents the corresponding t statistics.
Empty cells are departments used as references in each regression.
Abbreviations: H-BBOS, hospital with blood bank on site; H-NBBOS, hospitals with no blood bank on site; EC, emergency centre; ICU, intensive care unit; M, medicine; OG, obstetrics and gynaecology; S, surgery

With regards to H-NBBOS, we found statistical evidence to suggest that Emergency and Medicine departments were significantly less likely to waste crossmatched units in comparison to the referenced Obstetrics/Gynaecology department ($p<0.01$). However, there was insufficient statistical evidence to suggest the same for both ICU and Surgery. In line with the aforementioned, the Obstetrics/Gynaecology department was chosen as the reference group for H-NBBOS due to its highest wastage percentage. A separate regression analysis between ICU and Surgery, of which we omitted the results, also presented no statistical evidence to suggest the two departments had different discard practices ($p=0.769$).

Departmental Utilisation Inefficiency Analysis

From the standpoint of inefficient utilisation, we investigated the various departmental practices from both crossmatching and transfusion perspectives (with inefficiencies defined as iCTR > 2.5 and iTCR < 0.4, respectively). Within H-BBOS, Emergency, ICU and Medicine departments demonstrated significantly less likely occurrences of inefficiencies in comparison to Surgery ($p<0.05$). This corroborated with our findings in the regression analyses of wastage. Noticeably, within the H-NBBOS, no statistical significance was detected for differences in the likeliness of inefficiency across all departments in comparison to Obstetrics/Gynaecology from the perspective of crossmatching (using iCTR). This may be due to the restrictions of the iCTR, which omitted patients who were crossmatched but not transfused. On the contrary, from the perspective of transfusion practice (using iTCR), we found strong statistical evidence to suggest that both Emergency and Medicine departments were significantly less likely to be inefficient relative to Obstetrics/Gynaecology. However, there was a lack of statistical evidence to suggest the same for both ICU and Surgery. Such findings were also consistent with that of the wastage regression analyses.

Table 7. Regression Analysis of RCC utilisation inefficiencies across specialities of H-BBOS and H-NBBOS

	Intercept	EC	ICU	M	OG	S
H-BBOS iCTR [S as reference group]	0.0177 (6.298)**	-0.0094 (-2.134)*	-0.0095 (-2.076)*	-0.0115 (-3.515)**	-0.0080 (-1.915)	
H-BBOS iTCR [S as reference group]	0.2756 (33.737)**	-0.1017 (-6.666)**	-0.1739 (-12.234)**	-0.1792 (-17.741)**	-0.0249 (-1.739)	
H-NBBOS iCTR [OG as reference group]	0.0077 (2.456)*	0.0020 (0.483)	0.0053 (0.395)	-0.0032 (-0.707)		0.0044 (0.918)
H-NBBOS iTCR [OG as reference group]	0.1425 (12.252)**	-0.0407 (-2.861)**	-0.0161 (-0.425)	-0.0671 (-3.992)**		-0.0233 (-1.509)

*,** represents statistical significance at the 5% and 1%, respectively.
Numbers in parentheses () represents the corresponding t statistics.
Empty cells are departments used as references in each regression.
Abbreviations: H-BBOS, hospital with blood bank on site; H-NBBOS, hospitals with no blood bank on site; EC, emergency centre; ICU, intensive care unit; M, medicine; OG, obstetrics and gynaecology; S, surgery; iCTR, individualised crossmatch-to-transfusion ratio; iTCR, individualised transfusion-to-crossmatch ratio

Discussion

The overall CTR of the H-NBBOS was 1.19, which was well below the international benchmark of 2.5. This indicated efficient crossmatching of RCC units. Internationally, the overall CTR of our H-NBBOS was found to be superior to tertiary institutions in one HIC and to other LMIC African countries [5,17]. The overall CTR of H-NBBOS also outperformed Uganda's Mbarara Regional Referral Hospital (CTR 1.3), which had a similar background as our study [1]. A possible explanation for our superior overall CTRs may be due to WCBS regulation of only reserving crossmatched blood for 24 hours, while other institutions allowed 48-hour reservations [22,23]. This may also reflect the scarcity of RCC in our setting [24].

In South Africa, KHC demonstrated greater efficiency in blood utilisation compared to the H-NBBOS of our study, with an overall CTR in the range of 1.03-1.07 [19]. However, KHC is a tertiary level hospital with a blood bank on site, and the sample size used in the study was relatively small (99 patients) [19]. Notably, the overall CTR of GSH improved from 1.4 to 1.31 over the past three decades, yet the H-NBBOS was surprisingly more efficient in RCC utilisation with an overall CTR of 1.19 in comparison [18].

Over-transfusion was another prospect to consider regarding the efficient blood utilisation of the H-NBBOS. Patients at the H-NBBOS were 8% (%T) more likely to be transfused than patients at the H-BBOS. Conversely, it can be argued that RCC crossmatched patients must have had compelling indications for requiring blood. Therefore, they should have a higher transfusion probability and would utilise all the RCC crossmatched. Otherwise, a group and screen would have sufficed.

Another consideration was that the H-BBOS used as a control for our comparison is a tertiary institution. The H-BBOS caters for severely ill patients or those requiring complex surgical interventions compared to the regional and district H-NBBOS [16]. Its blood utilisation can therefore be more dynamic in comparison, resulting in anticipatory crossmatching practices and lower transfusion rates from adhering to current restrictive transfusion guidelines [14]. This can translate into poorer H-BBOS blood utilisation indices compared to the H-NBBOS and suggests room for improvement through intervention studies of crossmatching practices.

Wastage of RCC has dire implications, such as the inability to be used in a life-saving situation while burdening an already stretched health economy. The H-NBBOS wastage rate was 1.5 times the international benchmark. During the 12-months of our study, 341 units were discarded and at R1 868.14 (USD133.89) per unit, which equates to R637,035.74 (USD45,657.63) per annum of avoidable losses [25]. The most common reasons for discard were 'broken ties' and 'returning of blood products after 24 hours', which can be readily addressed via further training, a schedule for pick-up schedules and locations for returning blood products.

A further source of silent costs were after-hour requests. The H-NBBOS had more after-hour request than the H-BBOS. Approximately two-thirds of crossmatched RCC requests from H-NBBOS were made after-hours. At R420.04 (USD30.11) additional service fee per request, it equates to R3.2 million (USD229,340.70) per annum, excluding the cost of the blood product ordered [25]. The disparity in practice between the H-BBOS and the H-NBBOS may be due to a difference in burden of work and patient load.

Except for the poor wastage percentage (WAPI) of the H-NBBOS, the overall indices across all specialities for both H-NBBOS and H-BBOS were well within the international benchmark. However, there were certain specialities that did not perform as ideally, such as the Obstetrics/Gynaecology and Surgery departments of the H-BBOS. The Obstetrics/Gynaecology, ICU and Surgery departments of H-NBBOS contributed the most wastage, indicating a need for further investigation. Overall, the specialities of H-NBBOS excelled over their respective H-BBOS counterparts.

Using our proposed iCTR and iTCR, we further demonstrated that the H-NBBOS were more efficient than the H-BBOS. A greater statistical difference in the average iTCR was detected between H-BBOS and H-NBBOS, albeit minimally with the average iCTR, which indicated that both facilities had similar crossmatching practices, but transfusion varied significantly. In comparison to the H-NBBOS, the average iCTR of H-BBOS deviated considerably from its corresponding overall CTR. This may be due to the H-BBOS having approximately double the proportion of RCC requests where zero crossmatched units were transfused in comparison to the H-NBBOS, which were consequently excluded from the iCTR analyses (Table 2).

We found no statistical difference between the respective specialities' iCTR within both the H-BBOS and H-NBBOS, except for the Surgery department. The H-BBOS Surgery department had a greater excess of crossmatched units per transfusion compared to the H-NBBOS. However, there were significant differences in the average iTCR in more than one department i.e. Emergency, Obstetrics/Gynaecology and Surgery. These specialities in the H-BBOS transfused significantly less per crossmatched unit than their respective H-NBBOS counterparts. These departments commonly confront acutely changing clinical situations, which may account for the excess crossmatching and varying transfusion rates.

Our regression analyses on wastage and blood utilisation inefficiencies demonstrated that, in the H-BBOS, Surgery and Obstetrics/Gynaecology departments were more likely to discard crossmatched units and be subject to inefficient blood utilisation in comparison to other departments. Similarly, in the H-NBBOS, Surgery, Obstetrics/Gynaecology and ICU departments had a higher chance of wasting crossmatched units and a substandard blood usage below international benchmarks in comparison to other specialities. Hence, we may determine that these specialities, as mentioned, should be the point of departure for a cost-effective intervention study. This would be valuable given the severe shortage of health sector resources in South Africa.

Limitations

This retrospective research served as a snapshot of what the RCC crossmatching and transfusion practices were during the period of our study. The results may not be representative of current or future practices. Another possible bias may be from the assumption that the RCC units not returned to the blood bank were transfused and not discarded on-site, which would have influenced the ratios. It should also be highlighted, that the H-NBBOS used 16 times more emergency RCC than the H-BBOS. This raises the query whether the H-NBBOS' efficiency may be due to the utilisation of emergency RCC instead of using crossmatched blood, which were not included in the blood utilisation analyses. Moreover, FBH's 188 patients (4.5% of H-NBBOS total) and 385 RCC units (3.5% of H-NBBOS) that were excluded from the H-NBBOS' speciality analyses may have caused exclusion bias. However, its contribution towards the data pool of H-NBBOS was insignificant. Lastly, the indications and appropriateness of crossmatching and transfusion were not investigated, which may have provided some insight regarding the enquiry of possible over-transfusion at the H-NBBOS or over-crossmatching at H-BBOS.

Further Research

Future studies should explore the indications and appropriateness of transfusions, the causes contributing towards the high incidence of wastage and after-hour RCC requests in the setting of regional and district hospitals with no blood bank on-site. This will provide guidance on how and in which areas to improve blood utilisation practices.

Conclusions

Our analyses indicate that both the H-BBOS and the H-NBBOS, with their respective specialities, demonstrated efficient blood utilisation as per international benchmark. The only exception was the high wastage percentage (WAPI) of H-NBBOS. In terms of crossmatching (overall CTR), the H-NBBOS were much more efficient than the H-BBOS. However, through the individualised indices, the average iCTR of H-NBBOS was more ideal, albeit marginally, whilst their average iTCR was significantly better than that of the H-BBOS. Therefore, using the conventional overall CTR alone may not be sufficient to analyse the efficiency of blood utilisation. The individualised indices provided us the opportunity to scrutinise blood utilisation through individual cases, which also permitted further statistical inference for robust conclusions. The latter index also gave rise to a different method to interrogate blood usage.

Our outcomes were within the international benchmark parameters and superior to other HIC and LMIC standards, including Uganda, which has a similar background setting to South Africa.[6–9] Statistically, the H-NBBOS performed more efficiently than the tertiary facility with a blood bank on site (i.e. the H-BBOS), but with room for improvement in the area of blood wastage.

It is also worthwhile highlighting that the accepted benchmark for CTR may be more suitable for developed countries with a well-established health system. However, it is not necessarily acceptable in developing countries, where the health economy is already thinly stretched.

Results from our regression analysis may be utilised as guidance to investigate avenues of more cost-effective intervention studies to improve blood utilisation. This could be particularly beneficial given the economic background of South Africa as a LMIC.

Inasmuch as blood utilisation indices provide information regarding the efficiency of an establishment, the patient's welfare is the cornerstone of healthcare. Variation in crossmatching and transfusion may be due to different clinical settings and levels of expertise. Regardless of the reasons, the decisions were made in the best interest of the patient by the attending doctors, which is not highlighted in these indices.

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Statement of Ethics

Ethical approval was obtained from the University of Cape Town Health Sciences Human Research Ethics Committee and additional permission was obtained to collect data from the Western Cape Blood Service.

Funding

None

Conflicts of interest

None

Author Contribution

All authors contributed towards the research and preparation of the manuscript.

Data Availability

Data set is available following WCBS permission.

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Appendices

Appendix A: Ethical Approval Letter

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room G50- Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6492
Email: hrec-enquiries@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

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31 January 2020

HREC REF: 845/2019

Dr E Cloete
Department of Anaesthesia & Peri-Operative Medicine
D-23, NGSH

Dear Dr Cloete

PROJECT TITLE: ONE-YEAR RETROSPECTIVE ANALYSIS OF RED CELL CONCENTRATE REQUISITION AND UTILISATION PRACTICES AT REGIONAL AND DISTRICT HOSPITALS WITH NO BLOOD BANK ON-SITE: A MULTI-CENTRE DESCRIPTIVE STUDY (MMED DEGREE - DR CHIAN-JIA EDEN CHIU)

Thank you for your response letter dated 21 January 2020, addressing the issues raised by the Faculty of Health Sciences Human Research Ethics Committee (HREC).

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

Approval is granted for one year until the 30 January 2021

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

The HREC acknowledge that the student: - Dr Chian Chiu will also be involved in this study.

Please quote the HREC REF in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval, where necessary, before the research may occur.

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON, FHS HUMAN RESEARCH ETHICS COMMITTEE

Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938

HREC 845/2019sa

HUMAN RESEARCH
ETHICS COMMITTEE

2 6 JAN 2021

HEALTH SCIENCES FACULTY
UNIVERSITY OF CAPE TOWN

UNIVERSITY OF CAPE TOWN

FACULTY OF HEALTH SCIENCES
Human Research Ethics Committee

FHS016: Annual Progress Report / Renewal

HREC office use only (FWA00001637; IRB00001938) **This serves as notification of annual approval, including any documentation described below.**			
☑ Approved	Annual progress report	Approved until/next renewal date	30.01.2022
☐ Not approved	See attached comments		
Signature Chairperson of the HREC/ Designee		Date Signed	28/1/2021

Note: Please note that incomplete submissions will not be reviewed.
Please email this form and supporting documents (if applicable) in a combined pdf-file to hrec-enquiries@uct.ac.za.
Please clarify your plan for research-related activities during COVID-19 lockdown

Comments to PI from the HREC

Principal Investigator to complete the following:

1. Protocol information

Date (when submitting this form)	25 January 2021		
HREC REF Number	845/2019	Current Ethics Approval was granted until	30 January 2021
Protocol title	One-year retrospective analysis of red cell concentrate requisition and utilisation at regional and district hospitals with no blood bank on-site: A multi-centre descriptive study		
Protocol number (if applicable)			
Are there any sub-studies linked to this study?	☐ Yes ☑ No		
If yes, could you please provide the HREC Ref's for all sub-studies? **Note:** A separate FHS016 must be submitted for each sub-study.			
Principal Investigator	Esther Cloete		

(Note: Please complete the Closure form (FHS010) if the study is completed within the approval period)

Appendix B: Data Collection Documents

The consent of usage of the retrospective data was obtained from the CEO of Western Cape Blood Service, Dr Greg Bellairs. Subsequently, anonymised data from their existing database was received from the Western Cape Blood Service. Given the anonymity of the data set with no further risk of harm to patients involved, no further consent was required following ethical approval from the University of Cape Town Human Research Ethics Committee (HREC REF: 845/2019).