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Potential cost savings by minimisation of blood sample delays on care decision making in urgent care services

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HIGHLIGHTS

Conclusion

- Blood sample rejection rate in a single large NHS Foundation Trust is high.
- The highest rate of blood sample rejection is in the Accident and Emergency department.
- Blood sample rejection is associated with increased in-hospital stay.
- Blood sampling technique impacts on rejection rates.
- Reduction in sample rejection rates in emergency care areas in acute hospitals has the potential to impact on patient flow and cost.

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ABSTRACT

Background: Timely availability of blood sample results for interpretation affects planning and delivery of patient care from initial assessment in Accident and Emergency (A&E) departments.
Materials and methods: Rates of, and reasons for, rejected blood samples submitted from all clinical areas over one month were evaluated. Haemoglobin (Hb) represented haematology and potassium (K^+), biochemistry. A prospective observational study evaluated the methodology of sample collection and impact on utility.
Results: 16,061 haematology and 16,209 biochemistry samples were evaluated; 1.4% (n = 229, range 0.5–7.3%) and 4.7% (n = 762, range 0.9–14%) respectively were rejected, with 14% (n = 248/1808) K^+ rejection rate in A&E. Patients with rejected K^+ and Hb had a longer median in-hospital stay of 9 and 76 h respectively and additional stay fixed costs of £26,824.74 excluding treatment. The rejection rate with Vacutainer and butterfly (4.0%) was lower than Vacutainer and cannula (28%).
Conclusion: Sample rejection rate is high and is associated with increased in-hospital stay and cost. Blood sampling technique impacts on rejection rates. Reduction in sample rejection rates in emergency care areas in acute hospitals has the potential to impact on patient flow and reduce cost.

1. Introduction

Over the last ten years Accident & Emergency (A&E) attendances in England have increased to 16 million per year with a 31% increase in emergency admissions and is projected to increase further as the population ages and expands [1]. Managing the throughput of A&E requires minimisation of delays in care provision. The timely availability of blood results is a core component of patient assessment and decision-making. Almost all patients being admitted through A&E have haematology and biochemistry blood samples taken. Early diagnosis allows swift intervention, preventing patient deterioration [2]. Many risk scoring systems rely on blood test results as one or more of their components to help identify patients requiring urgent surgery or intensive care

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admissions [3]. The number of research studies in this area is limited. Previous studies have shown that not all blood samples are clinically indicated, nor will influence management [2,4,5]. A recent publication suggest that overdue blood tests may be an important source of variation in spending by acute hospitals and a substantial potential cost saving [4]. Here, we evaluated the extent and reasons for blood sample rejection, impact on acute decision-making and use of hospital resources.

2. Materials and methods

All Trust staff undertaking phlebotomy attend mandatory training; the standard approach is the Vacutainer® system attached directly to a needle or via butterfly tube (BD Medical, Oxford, UK). All samples are processed in the hospital laboratory. A prospective audit was performed over a one-month period to identify the number of rejected blood samples using the Telepath Systems Ltd electronic laboratory system using predefined criteria. The definition of a rejected sample was one that had reached the laboratory, which could not be processed.

A rejected haemoglobin (Hb) and potassium (K^+) level were chosen to represent haematology and biochemistry respectively. The origin of samples and the reason for rejection was collected. External samples were excluded. The number of samples repeated within 24 h, time from notification of initial rejection to the repeat's sample laboratory receipt, and length of stay of admitted patients were collected. Fixed costs for additional length of stay for patients with rejected samples were calculated using standard tariffs (£7.01/hour or £168.17 a day) excluding investigative and treatment costs.

Additionally, a prospective cohort study was performed to evaluate sampling approaches as a cause of rejection. Blood sampling technique was observed in the Accident and Emergency (A&E) department by senior nurses over a two-week period. The identity of the blood taker, technique, cannula diameter, and any difficulties encountered were documented and correlated with the phlebotomist's sample rejection rates. The Clinical Audit Committee of University Hospitals Birmingham (UHB) approved this study.

3. Statistical analysis

Blood sample rejection rates by clinical area were analysed with a Chi^2 analysis and funnel plots to identify areas with differing test rejection rates of two or more standard deviations. Time delays were reported as medians and ranges, and analysed with Mann-Whitney tests. Statistical analyses were performed using IBM SPSS 19 (IBM SPSS Inc.) and funnel plots produced using the Analytical Tools for Public Health template [6].

4. Results

There was a statistically significant difference in Hb (Chi^2 $p = 0.006$) and K^+ (Chi^2 $p = 0.001$) rejection rates across clinical areas (Fig. 1, Table 1). Rejection rates were highest for Hb and K^+ from A&E at 1.7% and 13.7% respectively (Table 1, Fig. 1).

The main cause for Hb rejection was failure of sample to reach the laboratory in 83 (36%) (Table 2) where an empty packet without a sample was sent to the lab. Eight of 30 (27%) initial Hb samples taken in A&E were not repeated. The main cause for K^+ rejection was haemolysis in 678/762 (89%) (Table 2). Of 248 A&E rejected K^+ samples, 99 (40%) were not repeated.

After the initial A&E sample was rejected, the time for a second, repeat sample to reach the laboratory after the first was processed was 7 h (range 1–81) for Hb and 9 h (range 0–276) for K^+ samples. In-hospital stay was increased by a median of 9 h for rejected K^+ and 76 h for rejected Hb samples respectively (Table 3).

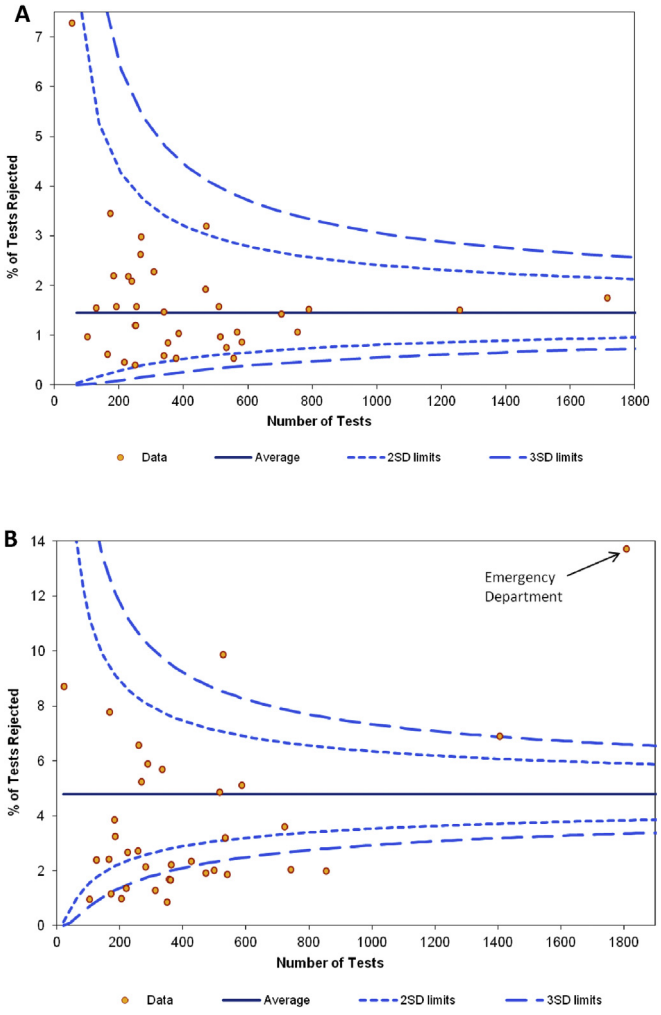

Fig. 1. A: A funnel plot of haemoglobin rejection rate by clinical area. B: A funnel plot of potassium rejection rate by clinical area.

A review of A&E records for rejected Hb samples confirmed delays in antibiotic treatment in three patients, surgery in one, and pulmonary embolus treatment in one. The additional cost for increased length of stay due to rejected blood test from A&E was calculated as £16,286.20 and £10,538.54 for repeat K^+ and Hb sampling respectively.

In the prospective part of the study, blood sampling methodology in A&E was observed in 163 patients. 27 (18%) of 155 K^+ samples were rejected. 7 of 23 patients who met the criteria of 'difficult to bleed' had rejected samples. The nursing staff bled the majority (91/155, 59%) and a variety of methodologies were observed (Tables 4 and 5).

The rejection rate with Vacutainer and butterfly (4.0%) was lower than Vacutainer and cannula (28%) ($p = 0.001$) (Table 5). There was no difference in rejection rates between A&E (4.0%) and combined ward areas (3.5%) ($p = 0.693$) for Vacutainer and needle or butterfly tube (Table 5).

5. Discussion

This study confirms blood sample rejection rate variation across clinical areas with the highest in A&E. Sample rejection is often related to problems arising prior to analysis and laboratory errors are rare [7,8]. In this study there was no evidence of transportation

Table 1
Rejected blood samples by clinical area.

Hb	Wards	CCU	CDU	A&E
Total (range)	8955 (21–787)	1804	1260	1711
Number Rejected (% of total)	143 (1.6%)	13 (0.72%)	19 (1.51%)	30 (1.75%)
K^+	Wards	CCUs	CDU	A&E
Total (range)	8956 (23–856)	1724	1406	1808
Number rejected (% of total)	323 (3.61%)	28 (1.62%)	97 (6.90%)	248 (13.7%)

Abbreviations: CCU, Coronary Care unit; CDU, Clinical Decision unit; A&E, Accident and Emergency.

Table 2
Causes of haemoglobin and potassium sample rejection.

Haemoglobin			Potassium		
Cause	Number	Percentage	Cause	Number	Percentage
No sample sent	83	36.2%	Haemolysed	678	89.0%
Clotted	61	26.6%	Lipaemic[a]	38	5.0%
Unlabelled	28	12.2%	Unsuitable for analysis	23	3.0%
Mislabelled	18	7.9%	Insufficient sample sent	11	1.4%
Wrong bottle	18	7.9%	Contaminated[b]	5	0.7%
Insufficient	18	7.9%	Specimen left on cells[***]	3	0.4%
Unknown reason	3	1.3%	Mislaid in lab	2	0.3%
			No sample with form	1	0.1%
			Mislabelled	1	0.1%
Total	**229**		**Total**	**762**	

[***]Samples being left too long or taken more than 8 h to reach the labs so potassium leaches out of cells.
[a] High lipaemic level rendering analysis not possible; not a technical fault.
[b] Contaminated sample, usually with preservatives from other Vacutainer bottles, used in an incorrect order of draw.

Table 3
Median inpatient hospital stay.

Median inpatient hospital stay	Accepted initial sample n, median stay in hours (quartiles)	Rejected initial sample n, median stay in hours (quartiles)	P value
K^+	1286 patients, 41 h (13–137)	261 patients, 50 h (18–168)	0.007
Hb	20 patients, 114 h (31–292)	1,389, 38 h (12–142)	0.018

Table 4
Potassium sample rejection rate by A&E clinician group.

Acceptability	Blood taker							
	Nurse	Junior Doctor	Registrar	Consultant	Medical student	Phlebotomist	HCA	Total
Haemolysed	16	5	3	0	3	0	0	**27**
Non haemolysed	75	31	9	2	10	0	1	**128**
Rejected samples (%)	**18%**	**14%**	**25%**	**0%**	**23%**	**0%**	**0%**	**17%**

[^]A difficult patient to bleed was defined as a patient with one or more of the following criteria: blood pressure less than 80/40 mmHg, two or more individuals attempting sampling before success, four or more sampling attempts, or the need for an arterial puncture.

Table 5
Potassium rejection and acceptance rates by sampling methodology.

Technique	Rejected	Accepted	Overall	% Rejected
Cannula with syringe	1	10	11	10%
Cannula with Vacutainer	24	63	87	28%
Not Recorded	0	1	1	0%
Needle or butterfly with syringe	0	7	7	0%
Vacutainer with needle or butterfly	2	48	50	4%
Total	27	128	155	17%

or sample processing delays. Although the main cause for K^+ rejection was haemolysis, the findings do not support difficulties obtaining samples from acutely unwell patients [9]. The specialist renal and oncology wards typically associated with poor venous access maintained a low rejection rate [10].

We recognise the limitations of this retrospective, uncontrolled before and after, single institution study. The findings corroborate previous reports and the institution has similar emergency care provision processes to other large acute NHS Trusts [9,11]. We recognise that the outcomes could be influenced by secular trends and confounders. It is clear that a number of aspects of patient care cannot be disclosed including indications and experience of individuals drawing blood.

We observed low rejection rates of 3% in ward areas where Vacutainer and butterfly use is standard practice. A statistically significant increase in K^+ rejection rate was observed in A&E with cannula attached to Vacutainer. This is consistent with previous publications implicating technical approach in observed variations in quality, and the occurrence of differing approaches in A&E [7,9,11,12]. Sample rejection resulted in a statistically significant increase in hospital stay and additional costs of £26,824.73/month.

We recognise a surprisingly long delay between blood draws for patients whose blood was rejected and a high proportion of lost samples. In England 5,581,548 patients were admitted through A&E between 2/3/14 and 1/3/15 [13]. If the observed sample rejection rates are experienced at other Trusts the financial implications for the NHS are significant.

While the reasons cannot be clearly defined, delays in commencing appropriate treatment were observed. Repeat sampling was not performed in up to 40% of rejected samples. This finding in itself highlights the problem of inappropriate sampling which were not necessary in patient management decisions and represents another area for cost efficiencies [2,4,14,15].

6. Conclusion

Reduction in sample rejection rates in emergency care areas in acute hospitals has the potential to impact on patient flow and cost. Further work is required to evaluate if standardised use of the Vacutainer and butterfly system in emergency areas results in a reduction in sample rejection rates, with evaluation of the evidence that this quality improvement initiative makes a difference to patient flow and cost.

Ethical approval

The Clinical Audit Committee of University Hospitals Birmingham approved this study.

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This work was not supported by any funding.

Author contribution

DMB conceived the study and initial design with refinement from OT and MH. DMB, SL and DM undertook the study. Data analysis and interpretation was undertaken by DMB, RC, and JH. DMB drafted the manuscript. SEL, RC, JH, OT and MH revised it critically. All authors gave final approval of the version to be published.

Conflicts of interest

The authors do not have any conflicts of interest.

Guarantor

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References

[1] N. England, High Quality Care for All, Now and for Future Generations: Transforming Urgent and Emergency Care Services in England - Urgent and Emergency Care Review End of Phase 1 Report, 2013.
[2] J. Callen, A. Georgiou, J. Westbrook, The safety implications of missed test results for hospitalised patients: a systematic review, BMJ Qual. Saf. 10 (1136) (2011).
[3] M. Braband, L. Folkestad, N. Clausen, T. Jnudsen, J. Hallas, Risk scoring systems for adults admitted to the emergency department: a systematic review, Scand. J. Trauma Resusc. Emerg. Med. 18 (8) (2009).
[4] A. Faulkner, M. Reidy, J. McGowan, Should we abandon routine blood tests? BMJ (2017) 357.
[5] J.L. Callen, J.I. Westbrook, A. Georgiou, J. Li, Failure to follow-up test results for ambulatory patients: a systematic review, J. General Intern. Med. 27 (10) (2012) 1334–1348.
[6] P.H. England, Health Analysis Package, 2013. Available from: http://www.apho.org.uk/resource/item.aspx?RID=47240.
[7] J.A.P. Berg, J.D. Berg, Variation in phlebotomy techniques in emergency medicine and the incidence of haemolysed samples, Ann. Clin. Biochem. 48 (2011) 562–565.
[8] A. Romero, A. Cobos, A. Lopez-Levn, G. Ortega, M. Muoz, Preanalytical mistakes in samples from primary care patients, Clin. Chem. Lab. Med (2009) 1549.
[9] M.E.H. Ong, Y.H. Chan, C.S. Lim, Reducing blood sample hemolysis at a tertiary hospital emergency department, Am. J. Med. 122 (11) (2009), 1054.e1-.e6.
[10] T.V. Saad, TM. Venous acess for patients with chronic kidney disease, J. Vasc. Interv. Radiol. 15 (2004) 1041–1045.
[11] R. Burns, N. Yoshikawa, Hemolysis in serum samples drawn by emergency department personnel versus laboratory phlebotomists, Lab. Med. 33 (5) (2005) 378–380.
[12] M.A. Halm, M. Gleaves, Obtaining blood samples from peripheral intravenous catheters: best practice? Am. J. Crit. Care 18 (5) (September 1, 2009), 474-8.
[13] N. England, A&E Attendances and Emergency Admissions 2014-15, 2015 [cited 2015]. Available from: http://www.england.nhs.uk/statistics/statistical-work-areas/ae-waiting-times-and-activity/weekly-ae-sitreps-2014-15/.
[14] J. Hampton, M.J. Harrison, J.R. Mitchell, J.S. Prichard, C. Seymour, Relative contributions of history-taking, physical examination, and laboratory investigation to diagnosis and management of medical outpatients, BMJ 2 (5969) (1975) 486–489.
[15] S.A. Bhandari, single-centre audit of junior doctors' diagnostic activity in medical admissions. J. R. Coll. Phys. Edinb. 39 (4) (2009) 307–312.