Blood sampling in acute hospital care settings: A Human Factors Review

Laura PICKUP[1], Sarah ATKINSON[1], Sam RAWLINSON[2], Paul BOWIE[3], Sandra GRAY[4], Douglas WATSON[4], Diane SYDNEY[4], Lorna SINCLAIR[4], Catherine INNES[4], Caroline IZATT[4], Jane OLDHAM[4], Katherine FORRESTER[4] & Erik HOLLNAGEL[5]

[1]*The University of Nottingham, UK,* [2]*East of Scotland Blood Transfusion Centre, Dundee, UK,* [3] *NHS Education for Scotland & Institute of Health and Wellbeing, University of Glasgow,* [4] *Scottish National Blood Transfusion Service,* [5]*Center for Quality Improvement, Southern Region Denmark.*

Abstract. Blood sampling is a routine activity within healthcare relied upon for safe patient care. The aim of this pilot study was to apply a Human Factors/Ergonomics systems approach to understand why variability in performance of blood sampling continues to be reported despite various initiatives, procedures and national guidelines (Milkins et al 2012). A multi method approach was adopted and included the application of the Functional Resonance Analysis Method (FRAM) (Hollnagel 2012). The context of an emergency department was analysed and modelled to consider how the concept of systems resilience could be applied to ensuring more things go right first time.

Keywords. Blood sampling, healthcare, resilience, FRAM.

1. Introduction

Blood sampling is a common safety relevant activity within healthcare settings. The accuracy associated with the blood sampling process has implications for patient experience and safety, staff workload and organisational efficiency. A blood sample is the first activity necessary to establish the compatibility of any future blood products administered to a patient (BCSH 2012). Transfusions of incompatible blood products could cause death or serious morbidity. They are classified as a 'Never Event' – an event considered by the Department of Health within the United Kingdom (DOH 2012) to be 'largely preventable'.

The Serious Hazards of Transfusion (SHOT) is an independent haemovigilance scheme set up in 1996 to gather information on adverse events and reactions in blood transfusion within the United Kingdom (UK). In 2013 it published an analysis of 282 reported incidents of incompatible blood product transfusions between the years 1996-2013. 6.7% of these resulted in death, 27% in major morbidity and 66.3% of patients experienced no or minor morbidity. In a 2013 review of 996 near-miss reports, 65% were attributed to the Wrong Blood in Tube (WBIT). The rate of WBIT incidents continues to rise within the UK (Bolton-Maggs et al 2014). Cottrell et al (2013) estimate the prevalence of WBIT incidence at a rate between 1 in 1500 and 1 in 3000.

The work reported in this paper was completed early within 2015 in Scotland. In Scotland during 2014 analysis shows that 495,094 blood samples were completed uneventfully, with a WBIT rate of 1 in 7584. Although this suggests that WBITs are low-frequency incidents, they are still undesirable outcomes from blood sampling with the potential for significant patient harm. Cottrell et al (2013) highlight how, while

combinations of interventions (namely implementations of education and procedures) have some impact on reducing WBITs, the effect is rarely sustained.

Inaccuracies in patient identification or sample labelling are considered to be the greatest contribution to a WBIT (Dzik et al 2003, Gonzalez et al 2008, Murphy and Kay 2004). National guidelines issued within the UK have proposed that unless an organisation has a secure electronic patient identification system in place, a double sampling procedure should be introduced to reduce the risk associated with a WBIT (Milkins et al 2012). Figueroa et al (2006) present data to suggest the second sampling of blood only accounted for the identification of 7% of all WBITs. Furthermore, 23% of blood sampling errors occurred during the second sampling phase. Double sampling does not address the quality of the blood sampling process itself but attempts to manage the associated risk. The Scottish National Blood Transfusion Service, part of the National Services Scotland (NSS), requested an independent Human Factors review of blood sampling processes and practices. This stemmed from concerns over the absence of evidence to support introducing a double sampling procedure which may delay blood transfusions, increase WBIT rates further and encourage practitioners to circumvent procedures by collecting the two samples at the same time (Ansari and Szallasi, 2011, Bolton-Maggs et al 2014). This paper describes the pilot study designed to apply Human Factors/Ergonomics (HFE) principles and a systems approach to understand the variability in blood sampling practices.

2. Methods

A multi method approach was adopted and included the application of the Functional Resonance Analysis Method (FRAM) (Hollnagel 2012). The study, completed in three months, involved four acute Scottish hospitals in three clinical areas: emergency department (n=3), outpatients (n=3) and acute wards (n=3). The methods included: 2 workshops, observations (n=50), semi structured interviews (n=15) and a review of the last 12 months of organisational incident data (n=61, data for 8 incidents were unavailable) from all 15 health boards within Scotland. The incident data only permitted the use of descriptive statistics and limitations are recognised with the current reporting method and culture within healthcare (Taylor-Adams and Vincent 2000).

A literature review was completed early on in the study to inform the methods, the data collection tools and the analysis of the interview and observation data. Interviews and observations were completed by 2 investigators and included Phlebotomists, Nurses and Doctors. The interviews were recorded with permission and transcribed. The observations were completed using an observation tool developed specifically for the study. Convenience sampling was necessary as workload, access and timing of blood sampling determined the availability of practitioners throughout the study.

Thematic analysis of interview and observation data was completed to identify and describe the core functions, their interactions and the sources of variability associated with the output of each function – variability might be in timing or quality. The Systems Engineering Initiative for Patient Safety (SEIPS) model (Carayon et al 2006) provided descriptive codes to analyse data from all of the methods. This ensured that factors identified as influencing the blood sampling process considered the whole sociotechnical system.

FRAM requires each function relevant to a blood sampling activity to be described according to six aspects: Time, Control, Resources, Preconditions, Inputs and Outputs. FRAM presents the functions necessary to obtain a blood sample and dependencies between functions within a model (using visualisation software (http://functionalresonance.com/tools-visualisation/index.html). The FRAM model

represents the observation and interview data to present a graphical representation of how work might be done in the 'real' world. Adjustments made by clinical staff to accommodate specific situations or working environments are considered using the FRAM model and identify where positive or negative variability may influence an output from one or several functions. Analysis using FRAM can show why procedures may not always be followed and explain why the output of a function may influence the safety and performance of a blood sampling activity.

3. Results

3.1 Incident Data

Incident data analysis considered the timing and frequency of incidents in relation to job roles and type of incident. In the period of reporting for 2014, there were 69 WBIT events. The data suggest that the majority of reports are for events that occur during normal working hours, with peaks at around 12.00, and 15.00-16.00 hours. This may reflect when the majority of samples are taken or could be linked to other factors, such as the time elapsed since having had a break, or time on duty. The timing and taking of breaks or shift patterns are not currently reported upon in the context of incident data, hence further analysis was not possible. This study confirmed a trend in job roles with the greater number of WBIT incidents similar to the SHOT data (Bolton-Maggs et al 2014): Doctors (n=26), Midwife and Nurses (n=14), Phlebotomists (n=2). A lack of data to compare the frequency with which different job roles complete samples means that these findings cannot be fully interpreted. Analysis using categories proposed by the SEIPs model were presented for the three outcomes identified within the incident data: wrong label (n=38), wrong patient (n=18) and wrong information (n=5). 'Wrong label' was influenced by the nature of the 'task' and likely demands, which included time pressures, interruptions and distractions during blood sampling tasks. This is unsurprising, given blood sampling requires fine motor control and attention to ensure accuracy.

3.2 FRAM Analysis

Workshops with the Better Blood Transfusion Team developed a generic FRAM model, the complete model included 31 functions. A final workshop, involving the Clinical Director of East of Scotland Blood Transfusion Centre and Quality Managers, allowed for a calibration exercise to be completed. This verified the appropriateness and completeness of the model. The FRAM model was used to describe how blood sampling activities could potentially, or typically, be completed in the three clinical areas. This highlighted how different contexts influenced the variability in the sequence in which functions are completed, the number of people involved and the different job roles involved in a single blood sampling activity. Table 1 presents a selection of the core functions within the FRAM model (1st column). The 2nd, 3rd and 4th highlight a difference in sequencing of core functions across different locations as described or observed during the pilot study (2nd, 3rd, 4th columns). The shading illustrates which job roles were involved, however, within the job roles there were multiple individuals (outpatients = 3 Nurses, ED= 2 Doctors) involved in completing a sequence.

A FRAM model can be the basis for multiple instantiations. This can assist in understanding why adjustments occur in the way work is done and the implications to the blood sampling activity in a particular context. One such instantiation within an ED was completed and is illustrated in Table 1 to highlight sources of variability in the output of blood sampling functions.

Table 1 Variability in the sequence of blood sampling functions and practitioners involved

Doctor Phlebotomist Nurse Health Care Assistant

Blood sampling functions	**Ward**	**Out-patient**	**ED**	**ED Variability in output from function**
Decide to take a blood sample	**1**	**1**	**2**	On time –first intervention Acceptable-immediate to establish intervention
Collect relevant information	**2**	**2**	**X**	Omitted –identity unknown
Complete request process	**3**	**3**	**6**	Imprecise – inaccuracy Too late – delayed temporary identifier
Print labels and collect	**4**	**4**	**7**	Too late – labels printed after blood sampling Imprecise – wrong labels printed or collected
Check the form/request	**5**	**5**	**8**	Omitted – no request
Locate intended patient	**6**	**6**	**1**	Accurate
Gather blood sampling equipment	**7**	**8**	**3**	Too late – interrupts/delays if equipment unavailable
Check patient identity	**8**	**7**	**X**	Omitted–identity unknown
Inform patient and consent	**9**	**9**	**X**	Omitted
Prepare oneself for taking a sample	**10**	**10**	**X**	Omitted –time pressure/ patient's condition/ clinician preference to locate vein
Perform venepuncture	**11**	**11**	**4**	On time –blood sampling knowledge is high
Take blood samples	**12**	**12**	**5**	On time - blood sampling knowledge is high
Label blood sample	**13**	**13**	**9**	Imprecise - incorrect data attached/completed
Record samples completed	**14**	**14**	**10**	Imprecise - record
Bag samples	**15**	**15**	**11**	Accurate
Send samples to lab	**16**	**16**	**12**	Omitted – pod system malfunctions and may require hand delivery

When an unidentified patient is admitted to an ED, it is highly likely that a blood sample will be taken. In this situation practitioners may be unable to access minimal core identifiers e.g. CHI/NHS number for the patient to enable access to the IT system for the patient's details. Therefore, a temporary identifying number has to be created to enable blood tests to be processed. However, once the identity of the patient is established their unique identifiers will be used and at some stage, the patient will have two identifying numbers and consequently the potential for two blood samples to be

labelled differently. Practitioners reported that, in an emergency situation, several practitioners might attempt to take a blood sample and, when successful, the sample would be passed to another practitioner who would then initiate the request process and label the bloods. Labels are either printed or handwritten for samples intended to establish a patient's blood type.

Variability in this situation comes from two sources: firstly, the functions may be completed by different practitioners in an order not reflected in the national guidelines (BCSH 2012); and secondly an absence of the checks in information relied upon to match the right patient to the right blood sample. These checks are not possible, as the completion of a request for a sample (used to complete the check) is likely to come later in the sequence of blood sampling as the request can only be commenced once a temporary number has been issued (Table 1).

The variability in printing and collecting labels can result in blood samples being left without labels. The nature of an ED, where patients may require urgent treatment from other departments and organisational targets e.g. discharge within 4 hours, means the patient may be geographically separated from their blood sample before labelling has been possible. This may occur if equipment is not functioning or issuing of a temporary number is delayed. In this scenario there is a time pressure to establish an accurate diagnosis as early as possible; blood samples often essential to this. A delay in this process is undesirable, and variability that reduces the accuracy of labelling and sending the sample influences both the efficiency and reliability of the blood sampling process in this situation.

In summary, thematic analysis of organisational, observation and interview data the following HFE issues within ED are suggested as influential to the variability in the output (Table 1) of blood sampling functions:

- Patient complexity and compliance to enable identification;
- Availability of equipment e.g. blood sampling tools, technical systems;
- Design of equipment for user and context e.g. interface usability, handwriting
- labels in spaces approximately 2mm high on curved bottles, figure 1;
- Work environment e.g. interruptions, distractions, physical constraints;
- Work demands and conflicting priorities;
- Procedures not representing common clinical demands and work context;
- Management of technical system e.g. maintenance and timely repair.

4. Discussion and Conclusion

This study has highlighted how blood sampling requires practitioners to adjust the way they work in terms of the number of people involved in each sample and the timing or sequence of the core functions required. FRAM has contributed to understanding *why* practitioners adjust their practice and suggests variability may have positive and negative implications.

The concept of system resilience is a developing approach which assumes variability in human performance is normal but aims to support positive performance variability whilst dampening the negative (Hollnagel et al 2011). There are four pillars central to the concept of resilience: ability to respond, ability to monitor developments, ability to anticipate future threats and opportunities and ability to learn from failures and successes alike. The factors influencing variability within an ED are related to the need to respond to the clinical context, the accessibility of patient information and the availability of technical systems relied upon to request and label blood samples. This study has presented evidence on why variability in these functions may occur.

Limitations in the potential to learn from existing healthcare reporting systems has been noted mainly due to the absence of a systems approach to data collection and analysis. However, the positive affect that variability provides is also not recognised within healthcare reporting systems which focus on practitioner variability as the 'cause' of incidents.

The FRAM analysis has provided evidence on blood sampling functions to highlight where, and why variability positively accommodates fluctuations in organisational demands and constraints. However, adjustments made by practitioners can negatively influence the success of functions currently heavily relied upon to achieve blood sampling activities e.g. checks, labelling. Resilience within healthcare systems requires the ability to understand which core functions can provide clues to identify drift in the safety of the system. This study has provided the first evidence of a realistic model of a blood sampling system in order to consider how to promote system resilience in the future.

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