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A mixed methods exploratory case study into the rationale and behaviours underpinning routine blood tests in critically ill patients, and possible strategies to reduce the number performed

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Award date:
2024

Awarding institution:
Bangor University

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Declaration

‘Yr wyf drwy hyn yn datgan mai canlyniad fy ymchwil fy hun yw’r thesis hwn, ac eithrio lle nodir yn wahanol. Caiff ffynonellau eraill eu cydnabod gan droednodiadau yn rhoi cyfeiriadau eglur. Nid yw sylwedd y gwaith hwn wedi cael ei dderbyn o’r blaen ar gyfer unrhyw radd, ac nid yw’n cael ei gyflwyno ar yr un pryd mewn ymgeisiaeth am unrhyw radd oni bai ei fod, fel y cytunwyd gan y Brifysgol, am gymwysterau deuol cymeradwy.’

Rwy’n cadarnhau fy mod yn cyflwyno’r gwaith gyda chytundeb fy Ngrichwyliwr (Goruchwylwyr)’

‘I hereby declare that this thesis is the results of my own investigations, except where otherwise stated. All other sources are acknowledged by bibliographic references. This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree unless, as agreed by the University, for approved dual awards.’

I confirm that I am submitting the work with the agreement of my Supervisor(s)

Acknowledgements

Glan Clwyd Librarians

Dr John Glen, Intensive Care Consultant Ysbyty Glan Clwyd

Reader Sion Williams Bangor University

Abstract

This thesis used a scoping review to identify the main themes underpinning unnecessary routine blood tests in the critically ill. These themes were developed further in a workshop with key stakeholders from an intensive care unit case study. Finally, key themes were further developed into recommendations for local and national guidelines regarding routine blood tests in the critically ill and to propose a set of core outcome measures for future research in this area.

Blood tests, which are routinely conducted in critically ill patients, have been proven to be associated with adverse outcomes such as; iatrogenic anaemia, increased likelihood of blood product transfusion, increased length of stay and increased mortality. By definition these are 'routine' and form part of the norms and culture within an intensive care unit; it is therefore important to thoroughly explore the underpinning rationale and behaviours before developing strategies to attempt to change it.

To establish what is already known on this subject a scoping review of the literatures was conducted in accordance with the six-stage approach as set out by (Arksey & O'Malley, 2003) (Levac, Colquhoun, & O'Brien, 2010). Thematic analysis was conducted on the 17 articles included in the scoping review. The following key themes were identified: patient centred outcomes, costs associated with unnecessary blood tests, behaviours and rationale underpinning routine blood tests, and strategies to reduce routine blood tests in the critically ill.

These 4 themes were then used to inform a workshop with key stakeholders to help understand workplace culture and the factors influencing behaviours, using a single intensive care unit as a case study. Co-production theory was integrated into the design and conduct of the workshop, to explore the utility of this approach in qualitative health research methodology. The 4 themes from the scoping review were validated during the workshop.

Following the workshop the 5 themes were analysed utilising positioning theory to draw conclusions and recommendations including the development of local and national guidelines.

It was concluded that the mixed methods approach; incorporating a scoping review to inform a workshop employing co-production theory, and analysis using positioning theory, was a useful model to explore behaviours in a medical context.

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Chapter 1: Introduction and Background

1.1 Context

This study was undertaken as part of a Masters by Research in Healthcare Sciences at Bangor University as part of an academic foundation year that included a 4 month rotation working in intensive care medicine as a junior doctor. It was conducted from August 2019 to August 2021, during which the COVID-19 pandemic had a major impact on intensive care in the UK, pressures on the NHS, and research within the NHS. As such, this study was adapted to minimise impact of this research on service provision.

1.2 Background

Blood tests have revolutionised modern healthcare and provide a window into the pathological processes going on inside the human body and subsequently have great influence over diagnoses and management strategies. However, as with many interventions within healthcare, they are not without drawbacks.

Unnecessary blood tests can lead to adverse outcomes such as iatrogenic anaemia (Fischer & Zacharowski, 2014), increased likelihood of blood product transfusion, increased length of stay and increased mortality (Cahill, et al., 2016).

The idea of iatrogenic anaemia (also known as hospital acquired anaemia or nosocomial anaemia) first emerged in the early 1970's (Eyster, 1973). This emphasised that the amount of blood lost to phlebotomy purposes is not insignificant, and in fact can be enough to cause anaemia in admitted patients.

Recently, the notion of choosing investigations based on clinical indication, combined with studies illustrating the potential harms that come from unnecessary investigations, has led to increasing momentum behind a minimalist investigative approach (Winkens & Geert-Jan, 2002).

Rationale

Routine blood tests on critically ill patients are often unnecessary, expensive, duplicate POCT results and can lead to iatrogenic anaemia and other adverse outcomes for patients. This study aims to identify the reasons underpinning this practice, and possible strategies to minimise adverse outcomes for patients.

Complexity and Critical Care Context

There are several factors related to the complex and critically ill nature of the patients that can lead to the adverse patient outcomes being exacerbated by interventions made in ICU.

Critically ill patients also have multiple pathogenic mechanisms that contribute towards anaemia. The red blood cells have a reduced life span, and there is reduced production of erythropoietin and a blunted bone marrow response to its action. These patients are often in a high state of inflammation, which greatly increases the synthesis of hepcidin which

drives iron into macrophages and reduces plasma ion concentration and leads to iron restricted erythropoiesis (Page, Retter, & Wyncoll, 2013). In addition to these pathological factors, routine phlebotomy in the ICU makes a significant contribution towards iatrogenic anaemia.

Although unnecessary testing is a recognised problem across the hospital setting, in intensive care this problem is compounded by several factors (Whitehead, et al., 2019). Central venous access, arterial lines, point of care tests (POCT), use of renal replacement/filtration/dialysis mean that it is very easy to collect blood samples at regular intervals without having to perform venepuncture each time a sample is needed.

Point of care tests such as blood gas analyzers have great utility in closely monitoring patients and can be especially useful to providing bedside information to inform clinical decision making. However, POCT is often comparatively more expensive than sending the equivalent test to the laboratory and is frequently duplicated (Cumber, Channon & Wong, 2017). In addition to this, significant differences in electrolytes have been reported between POCT testing and formal laboratory testing. Accordingly, only 48% of ICU clinicians make clinical decisions based on POCT without confirmation from the central laboratory (Auvet, et al., 2016).

Adverse Patient Outcomes

It has been demonstrated that on average, a critically ill patient loses 41.1ml of blood per day (Jones, Spangler, Keiser, & Turkelson, 2019). Additionally, 90% of ICU patients become anaemic by day 3 of their stay in critical care (Society for the Advancement of Blood Management, 2019). This has been shown to be independent of the critical illness itself. Consequently, this can lead to an increased need for blood transfusion and the risks associated with this.

Other problems arise from unnecessary investigations. Aberrant results may require further investigation and testing, which may incur its own risks and potential harms to the patient (e.g. computerised tomography scans exposing the patient to unnecessary radiation). No test is perfect, and there may be false positives or false negatives. There is also a perception that although more tests may seem reassuring, the quantity of data could obscure the truly important results.

Financial impacts

The financial cost associated with unnecessary blood tests should not be underestimated. In an increasingly frugal medical setting, reducing unnecessary blood tests represent a significant potential cost saving. One study estimated that $381,471 (approx. £300,599.15) per year could be saved from unnecessary laboratory tests in one hospital (Raad, Elliott, Dickerson, Khan, & Diab, 2017).

1.3 Study Aims

The primary aim of this research was to establish at individual and organisational levels:

1. The reasons for routine daily blood tests in critically ill patients.

2. The behaviours drive routine daily blood tests in critically ill patients.

3. What possible changes to the process could be made.

4. What are the potential barriers to change.

The secondary aims of this research were:

1. To use this case study to explore the interaction between culture and positioning within this specific case study context

2. To explore using co-production methodology to generate 'buy in' to changing practice and culture

1.4 Methodologies employed and study structure

The study used a mixed method qualitative approach, beginning by establishing the current literature around routine unnecessary blood tests in ICU, building upon this by conducting a workshop with key stakeholders from a case study context, and then using these developed themes to make recommendations for future guidelines, policies and research in this area.

The themes from the scoping review in Chapter 2 were extracted and used to formulate the discussion points of the case study workshop with key stakeholders in Chapter 3. This was undertaken within the case study context of an ICU in a single district general hospital, and involved staff groups identified to be key stakeholders e.g. ICU doctors and nurses. This was an important stage to be able to produce some local outcomes with a co-production approach, and to identify a working model of some of the cultural, leadership and positioning theories applied to this area. The generalisable themes of chapter 3 and the impact on research, policy and guideline application are discussed in Chapter 4, as well as proposing a set of CORE outcome measures to structure future research. CORE outcome measures are a way of standardising research outcomes and making them easily comparable to other research on similar topics.

Study Structure Justification

A qualitative case study method with an exploratory approach, and thematic analysis was used for this study. A strength of this method is the maintenance of a real-world context (and therefore, integrity), to better understand complex healthcare systems. It also allowed the researcher to gain a holistic view of the research area.

Choosing a scoping review rather than a literature review allowed the researcher to include a wide variety of information sources and was not limited to published articles. Analysing that information using thematic analysis allowed the researcher to richly describe and

understand a complex tapestry of overlapping behaviours and rationale underpinning routine blood tests.

The case study allowed the validity of these themes to be explored within the 'real life' context of an intensive care unit. Key stakeholders within the case study context added credibility to the findings of the scoping review and helped to build upon these initial themes through a workshop. A workshop was chosen partially due to necessity, as it could be conducted virtually during COVID lockdowns, but also because by inviting key stakeholders to be part of this workshop they were helping to shape the recommendations that would then be generated. It was hypothesised that through utilising some of the principles behind co-production theory (extensively researched in the context of healthcare professional and patient relationships and behaviours) the same sense of 'buy in' and ownership could be achieved and could help to successfully influence behaviours.

It was recognised that there were likely to be embedded case studies within this case study e.g. within specific sub groups such as the nursing staff or physicians. Therefore a cross case analysis as well as within-case analysis was planned and conducted. Positioning theory was employed as a theoretical scaffold to explore the interactions between these sub-groups and the organisation that they are positioned within to help form the cultural and leadership aspects of analysis.

The concept of a CORE outcome set has been developed to standardise medical research and a set of CORE outcome measures has been developed from this study which could be used as a template for future researchers in measuring outcomes, therefore decreasing heterogeneity, and increasing the overall quality of the published evidence.

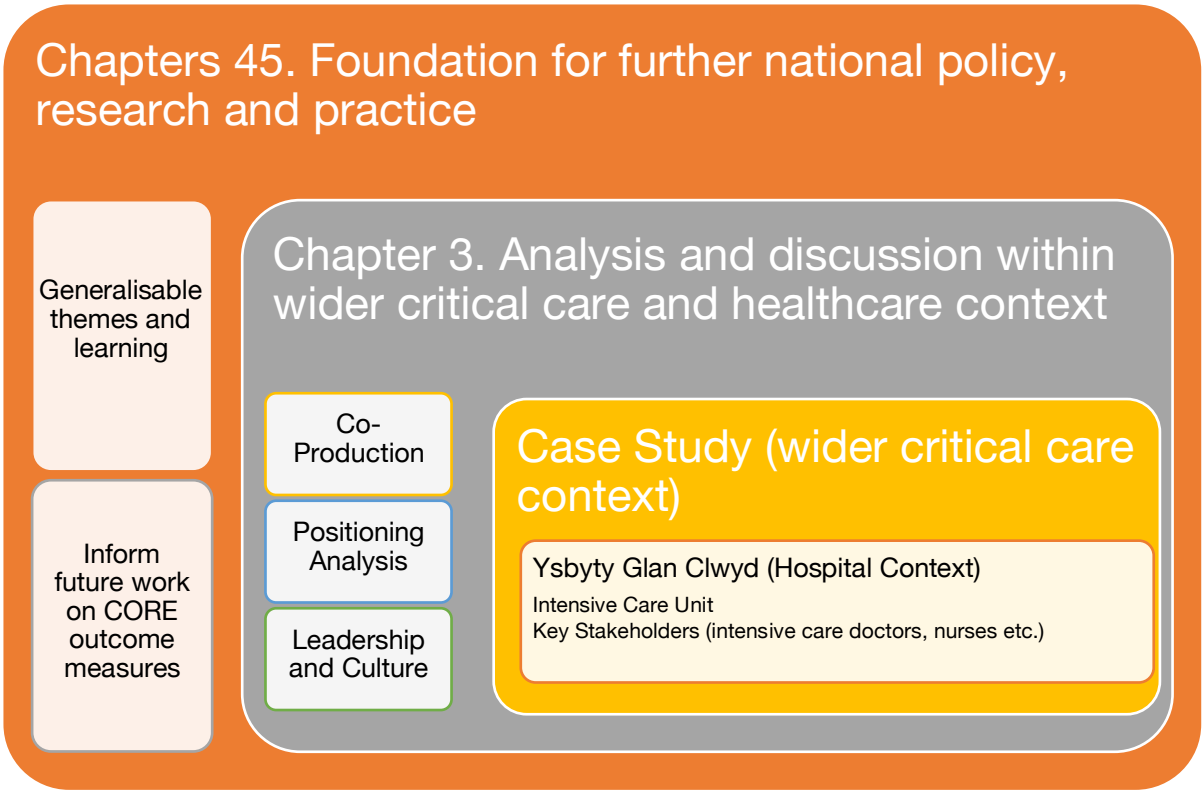


Figure 1. Diagram of Study Structure

Chapter 2: Scoping Review: Reducing routine blood tests in the critically ill / Exploring the reasons behind routine blood tests and their reduction

2. Introduction

The majority of the published literature in this area is qualitative, with some quantitative studies. It was anticipated that there may be other literature that could be included which is not published literature, such as guidelines and stakeholder opinions. As the published and other material was potentially diverse, the flexibility offered by a scoping review best suited the material as opposed to a systematic review (Arksey & O'Malley, 2003). Additionally, the authors were not attempting to evaluate the quality of the literature, but simply to map out and establish the existing evidence base.

Definitions

The following definitions are used in this chapter.

1. ***Phlebotomy Blood Loss:*** blood drawn from patients for diagnostic studies and blood discarded from central venous and arterial lines before sampling to prevent haemodilution and mixed samples. (Jones, Spangler, Keiser, & Turkelson, 2019)

- ***Iatrogenic Anaemia:*** haemoglobin below normal limits caused by phlebotomy blood loss
- ***Critically ill patients:*** adult patients admitted to intensive care unit or high dependency unit
- ***ICU:*** intensive care unit
- ***POCT:*** point of care testing

2.1 Study Design

The study was conducted in accordance with the six-stage approach as set out by (Arksey & O'Malley, 2003) (Levac, Colquhoun, & O'Brien, 2010). This framework is established, critically appraised and well recognised within qualitative data research, and in particular in healthcare research (Levac, Colquhoun, & O'Brien, 2010).

For this study the framework was adapted to include:

- an additional Stage 5 which was thematic analysis, to ensure there was a clear data analysis stage as opposed to what Arksey and O'Malley name 'Collating, Summarising and Reporting the data'.
- an additional Stage 6 'Consultation', as recommended by Levac et al (2010) was included as this suited a subject area with little quality evidence and some opinion biases.

The stages used were:

1. Identifying the research question
2. Search for relevant literature
3. Study Selection
4. Charting the Data
5. Thematic Analysis
6. Consultation
7. Summarising

The review was an iterative process. As new themes or important concepts emerged, the flexibility afforded by the methodology allowed the author to revisit the literature and re-examine the data, with an evolving perspective throughout (Levac, Colquhoun, & O'Brien, 2010). As recommended by Levac et al. the final stage of this scoping review was to include an expert consultation to ensure the validity and accuracy of the findings.

2.2 Stage 1: Identifying the research question

The research question was identified using a Population, Exposure, Outcome (PEO) framework and brainstorming possible research terminology as shown in Table 1.

Table 1: PEO framework

Population	Patients who are critically ill, admitted to the intensive care unit
Exposure	Routine blood tests, daily/frequent blood tests
Outcome	Anaemia, transfusion, length of stay, mortality and morbidity

From this exercise, the research question was modified to become:

> 'A scoping review into the rationale and behaviours underpinning routine blood tests in the intensive care unit, effect on patient outcomes and possible strategies to reduce this.'

2.3 Stage 2: Identifying relevant studies – search terms and inclusion/exclusion criteria

Following the PEO and development of the research question the search criteria was developed based on a blended approach from (Arksey & O'Malley, 2003) and (Levac, Colquhoun, & O'Brien, 2010). In order to identify as many as possible primary studies, several sources were searched for research evidence, including electronic databases, reference lists and existing networks, relevant organisations and conferences.

A literature search was conducted with the help of an experienced librarian of several databases – OVID, Embase and MEDLINE – using the criteria 'intensive care' AND 'routine blood tests' .

There were two pathways to identifying relevant evidence: a literature search and a guidelines search. This was to ensure that a variety of literature was identified including what the current recommended practices are. This is the advantage offered by the methodology of a scoping review as opposed to a traditional literature review and provides added value by incorporating additional evidence.

Guidelines

There were several possible sources of guidelines that were identified and searched, although there were surprisingly few guidelines identified. Within the context of this study, there were no local guidelines for the intensive care unit used as a case study, no guidelines for the hospital it was situated within, and no guidelines for the wider health board on this subject. Within the national context, there are no Welsh guidelines, NICE guidelines, or guidelines from the intensive care society (the equivalent of a royal college).

- The Intensive Care Society (ICS) website was searched for any guidelines but returned no results. (Intensive Care Society, 2020)
- The National Institute for Clinical Excellence (NICE) website was searched but returned no results. (National Institute for Health and Care Excellence, 2020)
- The Welsh Critical Care Network website searched for any guidelines but returned no results. (Wales Critical Care and Trauma Network, 2020)

In a more international context, the 'Choosing Wisely' website, a part of the American Board of Internal Medicine, was identified in one of the studies identified in the literature search. (Society for the Advancement of Blood Management, 2019)

2.4 Stage 3: Study selection

There were four distinct phases to the search strategy. These were as follows:

Identification

Using the identified search terms, the researcher searched the databases. The search was limited to human studies, and from 2010 to present. The time range was chosen to ensure the most up to date and relevant studies only were included. The 'Review' function was chosen as a filter on OVID to identify studies with the best balance of sensitivity and specificity based on the search terms.

Screening

The first 400 titles were then screened for relevance, and 131 articles were selected for the full abstract to be reviewed. Duplicates, studies about non-human subjects, irrelevant studies and studies that were outside the identified time range (2010 to present) were removed.

Availability

In total 59 articles had the full text available through the library resources and a thorough librarian search of other libraries also, including the British Library.

Inclusion

This provided a good selection of relevant papers, so the search was narrowed further to include only the last 5 years to have the full text reviewed. Part of the rationale for this was manpower, as this scoping review had only one part time researcher to review the articles.

In summary, a total of 34 articles had the full text reviewed. Some texts were not relevant, for example they were more specifically about blood gas sampling, some were not specifically about critically ill patients, some were about children rather than adults, and some did not provide sufficient evidence of robust methodology and results to be included in the final scoping review. Boundary cases were discussed and reviewed by the supervisory team, as suggested in the methodology from Levac et al. (Levac, Colquhoun, & O'Brien, 2010).

A Summary of the literature screening process is shown in an analytic chart in Figure 2.

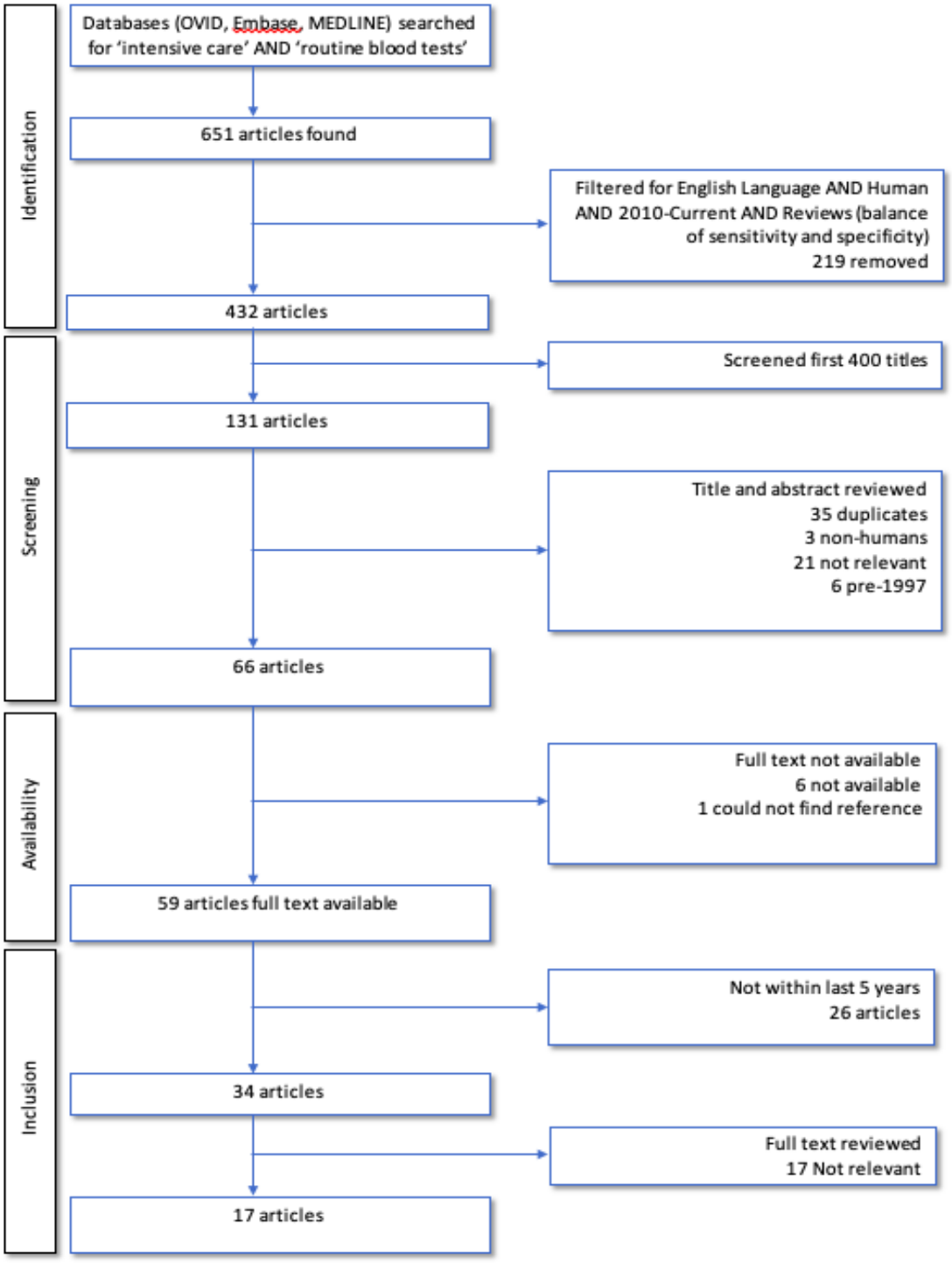


Figure 2: Summary of the Literature Screening Process

2.5 Stage 4: Charting the Data

The papers were collated and then listed alphabetically by author based upon the methodology (Levac, Colquhoun, & O'Brien, 2010). Categories included were the type of

literature, study population, size and place, the authors and the publication year. An alphabetic listing of papers is in Appendix 1.

2.6 Stage 5: Thematic Analysis

The analysis of the literature was conducted using thematic analysis in accordance with the six phases set out by Braun & Clarke (2006). As previously emphasised, this was an iterative process, meaning that a flexible approach was maintained allowing themes to be changed and adapted as the patterns and understanding of the data set evolved.

1. Familiarisation with data
2. Generating initial codes
3. Searching for themes
4. Reviewing themes
5. Defining and naming themes
6. Producing the report

The review used *an inductive approach* to thematic analysis, meaning the themes are strongly linked to the data itself. The aim was to produce a rich description of the data set as a whole, rather than focussing on one particular aspect. This was because the themes generated from the dataset were inextricably linked to each other, and were therefore analysed as a whole set rather than as individual entities (Braun & Clarke, 2006). For the purposes of analysis, prevalence was measured as the number of times a code appeared in the data set but determined that the connections and hierarchy between the themes was more important than the number of times the code appeared. In order to be described as a code, the text needed to either specifically mention the word/s or clearly articulate the code (Miles, Huberman, & Saldana, 1994) (Levac, Colquhoun, & O'Brien, 2010).

Each paper was read thoroughly and actively, with the researcher taking notes and gaining an overall understanding of the patterns and connections within the data (Braun & Clarke, 2006), reference was also made to (Miles, Huberman, & Saldana, 1994). The frequency with which the main themes and sub themes appeared in the evidence was identified and the following five main themes were identified: strategies to reduce iatrogenic anaemia, patient centred outcomes, costs, problems/barriers identified and the consequences of unnecessary investigations. A table summarizing the frequency of occurrence is in Appendix 2.

The themes were colour coded and highlighted within the text in order to quickly identify the prevalence of codes, and to identify important passages of text within the data set. Not

all the codes fitted into these initial proposed themes, and so there remained a miscellaneous category. A table of highlighted text extracts is in Appendix 3.

The final stage of thematic analysis was to develop a thematic map describing the five themes and associated sub-themes.

Figure 3 represents the framework on which the following discussion is based. From thematic analysis of the literature, these were the important themes and sub-themes discussed, and could be broken down and classified into often three subsections: people, process and environmental factors.

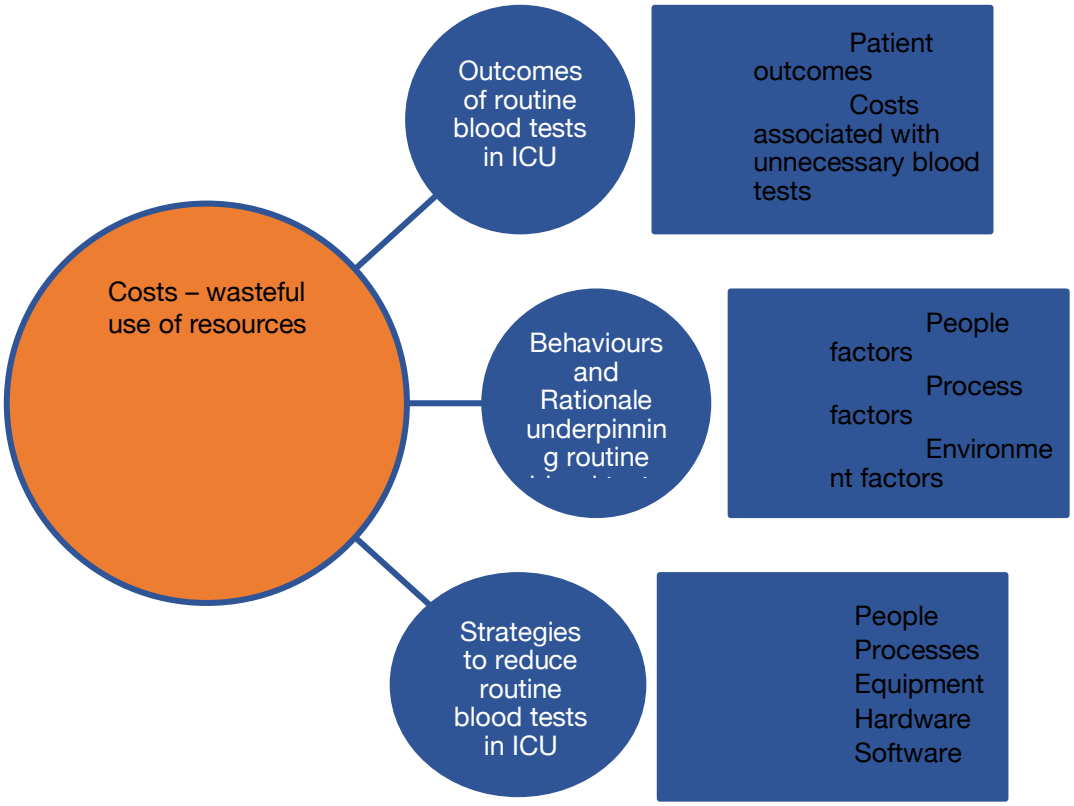


Figure 3. Final Thematic Map

2.7 Analysis of Themes

Theme 1: Patient centred outcomes Figure 4

Patient centred outcomes included any outcomes that were associated with routine blood tests[1], that negatively impacted the patient. Included within this theme were: Iatrogenic anaemia and the resulting complications such as transfusion and the risks associated with it, increased mortality, morbidity, and length of stay. This also included the sequelae of aberrant or superfluous results, such as further investigation for the patient.

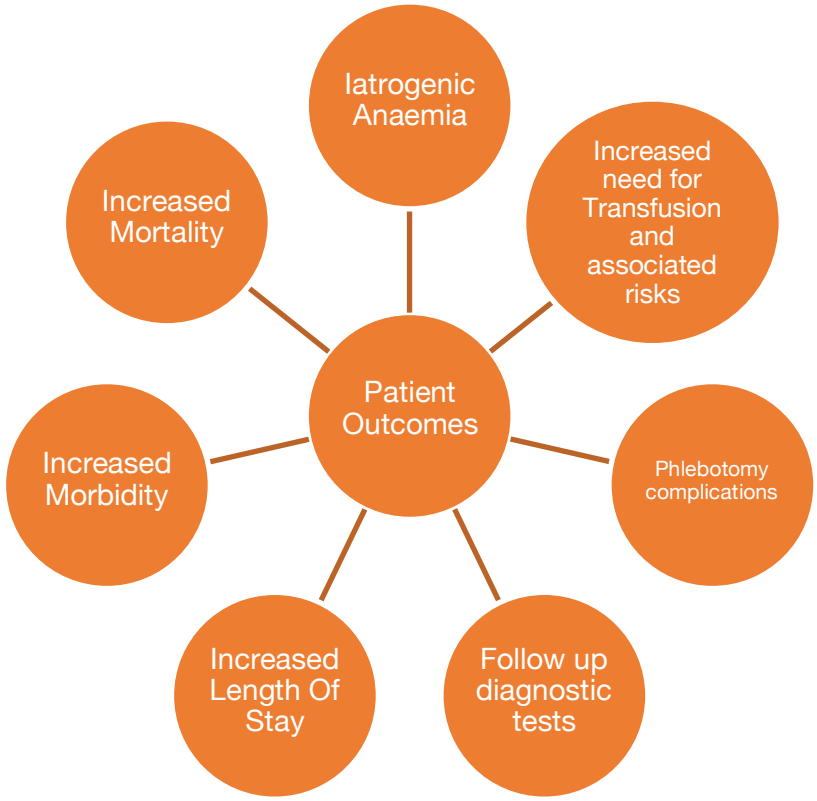


Figure 4: Theme 1 - Patient Centred Outcomes

Analysing Theme 1: Patient centred outcomes

Iatrogenic anaemia, also mentioned as hospital acquired anaemia, was coded for 12 times throughout the dataset (Cahill, et al., 2016) (Coene, Roos, & Scharnhorst, 2015) (Dhanani, Barnett, Lipman, & Reade, 2018) (Jones, Spangler, Keiser, & Turkelson, 2019) (Mackovic, Maric, Udiljak, & Bakula, 2018) (Whitehead, et al., 2019) (Society for the Advancement of Blood Management, 2019). This was defined differently by each data item but was broadly defined by this scoping review as a haemoglobin below normal limits caused by phlebotomy blood loss. This was probably one of the most important patient centred

[1] 'Routine' and 'unnecessary' blood tests are distinct concepts. Routine blood tests are sometimes unnecessary, but not always. Routine blood tests are ordered as a consequence of routine and process, not because of a direct clinical indication. Thus, this can lead to unnecessary blood tests, as they are not requested to inform a clinical decision or influence patient care.

outcomes noted, as it leads to the other complications noted within this theme; increased likelihood of blood product transfusion, organ dysfunction, increased length of stay and increased mortality. The relationship between iatrogenic anaemia and blood product transfusion is not conclusively proven in the literature. Part of the reason for this because it is extremely difficult to differentiate iatrogenic anaemia from anaemia related to other causes such as: anaemia due to critical illness, recent surgery, major haemorrhage, pre-existing anaemia, haemolysis, or anaemia of chronic disease. Increased likelihood of blood transfusion leads to an increase in the risks associated with blood transfusions such as blood borne infection, transfusion associated lung injury, transfusions associated circulatory overload, anaphylaxis and immunomodulation reactions (Page, Retter, & Wyncoll, Blood Conservation Devices in Critical Care: a narrative review, 2013).

Related to this theme are the consequences of routine blood tests for patients. Some of these are related to the act of venepuncture itself – including patient discomfort, cellulitis, phlebitis and superficial haematoma. It should be acknowledged that most patients in critical care will have an arterial or central line, which may be accessed to take blood or blood gases. One study showed that blood collections accounted for 22% of the times a central line was accessed in an average shift (O'Malley, 2018). These carry their own risks to the patient, such as catheter associated infections and associated mortality from severe sepsis (Ziegler, Pellegrini, & Safdar, 2015), increased risk of infection with each blood draw, and increased volume of draw from these lines as they require an initial draw to be discarded (Coene, Roos, & Scharnhorst, 2015).

Other patient centred complications arise from doing routine blood tests. No test is perfect, and each blood test may have false positives (Dhanani, Barnett, Lipman, & Reade, 2018) which may lead to unnecessary treatments with additional risks. Even if the tests are true positives, the result may not influence clinical care. A common mantra is that a blood test should only be ordered if the result will influence clinical care, which is contrary to the practice of ordering a routine blood test in critical care. Many clinicians will be aware that it is easy to become preoccupied with treating the results rather than treating the patient, which does not always result in best care for the patient (Jovey, Squire, & Williamson, 2011) (Coyne, 2014) (Jonklaas & Razvi, 2019). Results may require further treatment or investigation, such as further blood tests, procedures, radiography, or computed tomography scans – all with their own associated risks. All of which may result in more harm than benefit for the patient.

Theme 2: Costs associated with unnecessary blood tests Figure 5

Costs can be subdivided into organisational and personal costs. Organisational costs include the costs of doing routine blood tests (equipment, laboratory costs, employment costs etc.), and the cost of subsequent investigations, referrals and interventions that were done as a result of unnecessary blood tests. Personal costs include the additional time and

workload associated with unnecessary blood tests, as well as the cognitive burden on the clinician who then has to contemplate, discuss and act upon those results.

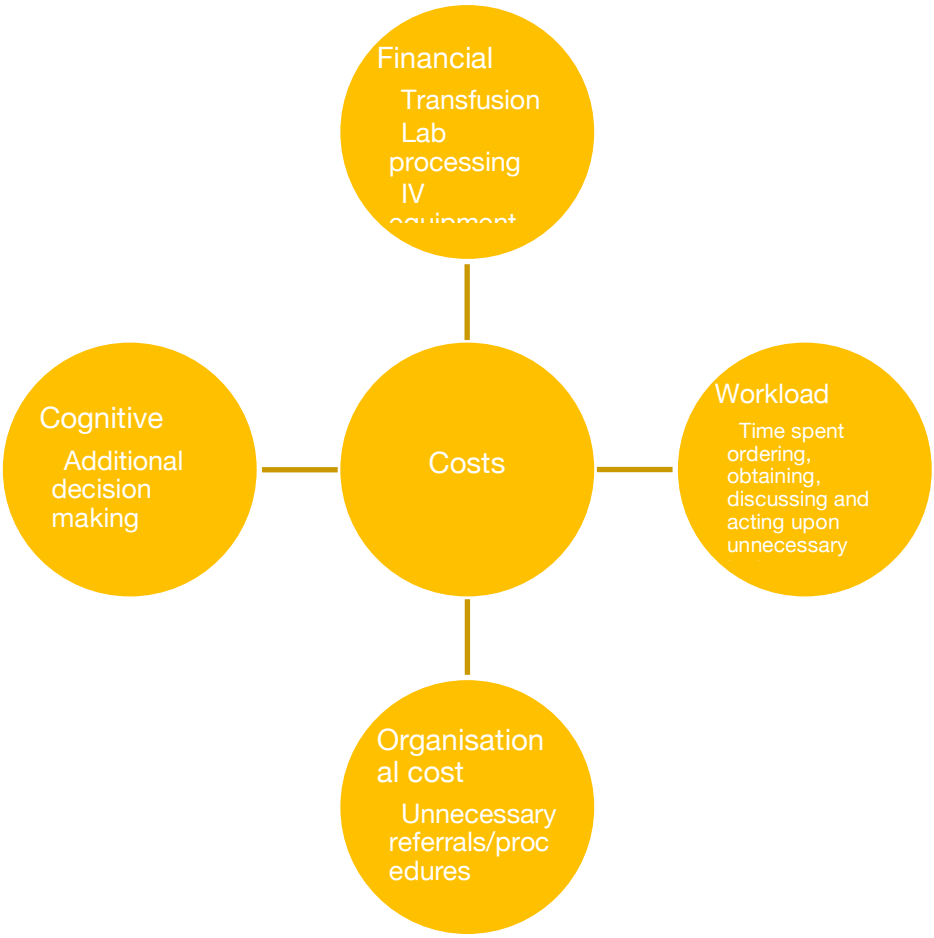


Figure 5: Theme 2 - Costs

Analysing Theme 2: Costs associated with Routine blood tests

Routine blood tests, many of which are unnecessary, come at considerable cost to healthcare organisations. The NHS has published approximate costs of blood tests, based on preoperative blood tests, as shown in Table 2.

Table 2: Financial cost breakdown (Source: National Clinical Guideline Centre 2015)

Test	**Cost (£)**	**Potential Downstream Costs (£)**
Blood Gases	£6.42-£9.84	
Coagulation	£29.42	
	£6.00	Ultrasound scan £49-59

Creatinine, urea and electrolytes		Blood tests £6.00
Full Blood Count	£6.00	£6.00 each
Blood Glucose (HbA1c)	£6.42	

The theme of cost was discussed frequently and was coded for a total of 10 times. In an increasingly frugal and cost sensitive healthcare environment, it is important that a test is only ordered if clinically indicated. It has been reported that up to 42% of laboratory expenditure may be considered wasteful, and costs nearly $5billion USD every year (Cahill, et al., 2016). One of the problems identified in the discussions was the lack of insight by staff into test costs (Cumber, Channon, & Wong, 2017). Additionally, many studies used the savings made as a measure of success and showed a wide range of savings as shown in Table 3.

Table 3: Savings in financial costs reported in studies.

Source	**Cost Saving/year**
Blood tests in the intensive care unit: A necessary cost? (Cumber, Channon, & Wong, 2017)	£26,250
Results of QI project	£68,428.64
Multipronged Strategy (Merkeley, et al., 2016)	£79,323.24
Reduction of Laboratory Utilization (Raad, Elliott, Dickerson, Khan, & Diab, 2017)	£98,675.97 £206,144.16 (including blue collar costs)

The other 'cost' considered was personal costs, or costs to the individual clinician. This meant the costs to somebody's time, workload, cognitive load, decision making or other contributing demand on a clinician that unnecessary blood tests created. This is a double-edged sword. On the one hand, routine blood tests may reduce the amount of decisions that have to be made by clinicians on a daily basis, as it is pre-determined that a routine set will be ordered for every patient. In most ICU's, it may be nurses that actually request the blood tests, and carry out the blood draw, and so this may lead to increased workload for

them. On the other hand, the time it takes to check with a clinician or to check a patients' notes to see what blood tests were specified and then order these for patients on an individual basis may take longer than ordering the same set of bloods for everyone in ICU.

Personal cost is difficult to quantifiably measure, but one study measured this as 'blue collar costs' and attempted to measure this in terms of financial costs. They found that the blue-collar indirect cost savings from reducing unnecessary blood tests related to nursing time totalled US$258,035 – an astonishing amount (Raad, Elliott, Dickerson, Khan, & Diab, 2017).

One of the barriers to changing the practice of routine blood tests was the 'multiple and competing demands for a clinician's time' (Mikhaeil, Day, & Ilan, 2016). Hence it is often less time consuming for clinicians to order routine blood tests, rather than based on clinical need for individual patients.

Theme 3. Behaviours and Rationale underpinning routine blood tests in ICU

People could be subdivided into the different staff groups involved in the decision making and carrying out of routine blood tests. This is defined as the ICU physicians and nursing staff of all grades. Variability between physicians was considered in this theme. A knowledge deficit was demonstrated in the literature, whereby people had a lack of knowledge when it came to the implications of routine blood tests, and lack of awareness of the costs. Inadequate training at an undergraduate level was also included within this sub-theme. Psychological factors such as 'habit', 'routine', ordering an extra test 'just in case' were included within this theme.

If blood tests are ordered as a matter of routine, it is not a conscious decision made by the clinician to order blood tests, but instead it is an automated process that occurs daily. Many processes are automated or protocolled in ICU environments in order to reduce the number of human errors (Chapuis, et al., 2010), decisions that need to be made, and to ensure a comparable standard of care is achieved for all patients.

Patient safety is usually at the centre of all the processes, protocols and decisions that are made in ICU. It is often thought that by performing perhaps excess routine blood tests, important tests are less likely to be missed or delayed. However, this has been disproved by several papers, who demonstrated no adverse outcomes for patients when they reduced the amount of unnecessary blood tests (Merkeley, et al., 2016). Environmental factors that impacted on routine blood tests included some of the less tangible and difficult to define influences, such as 'ICU culture'.

P**oint Of Care Testing (**POCT) means that blood tests are often duplicated, such as glucose, calcium, and bicarbonate (Cumber, Channon, & Wong, 2017). Cumber et al also found that POCT is more expensive than laboratory testing. There is some debate over the validity of POCT – if physicians do not trust the validity of an abnormal result may then result in an additional sample being sent to the lab to verify if it is a truly abnormal result, meaning further blood loss and additional phlebotomy events for the patient.

Figure 6: Theme 3 - Behaviours and Rationale

Analysing Theme 3: Behaviours and Rationale underpinning routine blood tests in ICU

Knowledge deficit was identified as a key factor influencing the decision to order routine blood tests. Physicians with less experience were more likely to order unnecessary blood tests. Not only does a knowledge deficit contribute to the decision to order a blood test, but many clinicians and staff are unaware of the impact of phlebotomy blood loss, strategies to reduce this and the costs of routine blood tests.

Cognitive loading is another factor that contributes to routine blood tests. Cognitive loading is the amount of information the working memory can hold at any one time (Brunken, Moreno, & Plass, 2010). The day-to-day conduct of blood tests is done by junior clinicians and nursing staff, who are often busy and have 'multiple and competing demands

on their time' (Mikhaeil, Day, & Ilan, 2016) so it is often easier to have one less decision to make.

We are all human, and as such we are prone to psychological shortcuts and becoming creatures of habit. It's easier to do as we have always done, as our previous experiences may have reinforced to us that this is a safe and sensible thing to do, or to employ a 'heuristic decision-making strategy' (Nilsen, Roback, Brostrom, & Ellstrom, 2012). This applies to the idea of 'reflex ordering'. If there is doubt about what blood tests to order, we will usually revert back to what we always order. Our electronic processes of ordering blood tests sometimes seek to break these habits and reflexes as explained by Nilsen et al in their article examining behaviour change and habit breaking in clinical settings.

If clinicians do not have any awareness of the implications or costs of ordering routine blood tests, they are unlikely to engage with efforts to change this process. Stakeholder engagement was identified as a key factor to the success of quality improvement projects (Merkeley, et al., 2016).

Variability between physicians means there is sometimes inconsistencies in blood test ordering, with some physicians being quite minimalistic and others preferring to order a wider range of blood tests. Routine blood sets reduce this variability, but if routine blood tests are eliminated altogether this variability presents a challenge.

Theme 4. Strategies to reduce routine blood tests in ICU Figure 7

Several focus areas were identified as sub-themes which are discussed below. Ideally a multipronged approach combining all three of these strategies seems to be the most important and effective.

People

Strategies targeting people such as education, developing consensus and buy in from key stakeholders.

Processes

Strategies targeting the processes surrounding routine blood tests such as checklists, electronic ordering, computerised prompts, standardising the amount of blood discarded from central lines/arterial lines. Introducing guidelines/protocols was also considered in this theme.

Hardware

Including interventions with equipment such as BCSD's, low volume blood tubes and paediatric blood tubes and the training that is needed to support the use of these. This could also include modifying POCT.

Software

Defined as changing electronic systems such as electronic medical records to include prompts and ask for justifications when ordering blood tests.

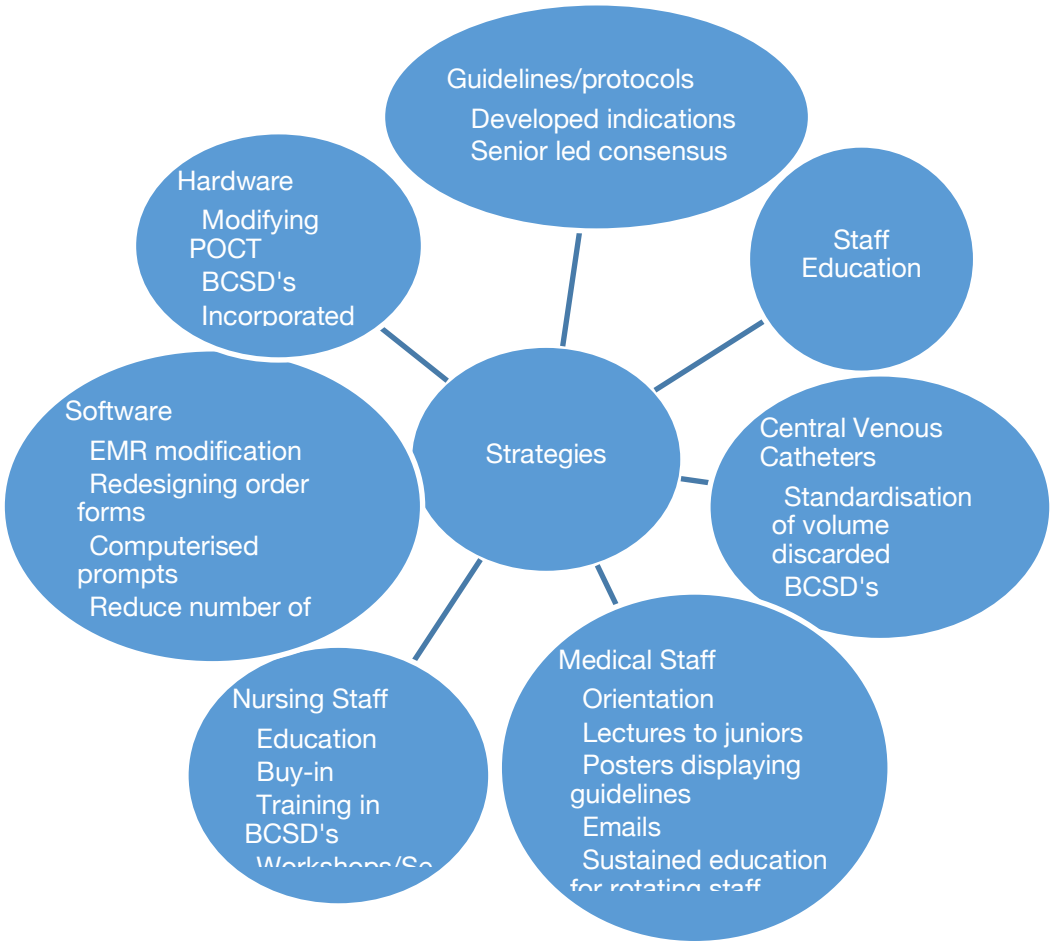


Figure 7: Theme 4: Strategies

Analysing Theme 3: People Directed Strategies

Guidelines/Protocols

The lack of guidelines was coded for six times as a factor contributing to unnecessary blood tests in the critically ill. An Australian study found that only 46% intensive care units had specific guidelines and only 37% followed ICU specialist consultation (Rachakonda, Parr, Aneman, Bhonagiri, & Micallef, 2017). Without explicit guidelines detailing the frequency and which blood tests are needed, this remains up to individual clinicians to

decide (who are often junior clinicians or ICU nurses) and will lead to considerable variability (Gupta, et al., 2017).

Many of the studies used guidelines as an intervention to try to reduce unnecessary blood tests, or they recommended the implementation of standard guidelines as a result of their findings (Jones, Spangler, Keiser, & Turkelson, 2019) (Mikhaeil, Day, & Ilan, 2016) (Rachakonda, Parr, Aneman, Bhonagiri, & Micallef, 2017) (Yorkgitis, Loughlin, Gandee, Bates, & Weinhouse, 2018).

Staff Education

Staff education was coded for nine times in the data set, both as an intervention or recommendation for further research. Education methods included staff lectures, workshops, e-learning, posters and emails. This was in the context of education to nurses and doctors. Interestingly one paper identified that nurses felt inadequately prepared by their undergraduate education regarding blood conservation strategies, so perhaps this is an additional area of education to be targeted.

Crucial to the success of education, was the 'buy in' of the staff. This was mentioned in detail by one paper, which looked at using change theory in nursing education to achieve a sustained result (Jones, Spangler, Keiser, & Turkelson, 2019). They demonstrated that interactive hands-on education sessions were effective ways to contribute to meaningful evidence-based practice change. Reinforcement of these concepts with continuous education was important to sustaining a change. It was also important to celebrate and share successful results with the workforce in an effective way. Some data items were structured as a quality improvement project, where there was a one-off educational intervention, and this tended to produce improvement over a short period but return to status quo in the long term. Thus, introducing education as an intervention was most effective when it was in a sustained and reinforced manner. Including it in orientation was mentioned by data items, in order to try to capture as many rotating physicians as possible. Education was focused on the indications for blood tests, reducing the amount of blood lost to phlebotomy, blood conservation strategies, the use of blood conservation sampling devices and the costs of unnecessary blood tests.

Process Directed Strategies

Across the data set, several items modified the process of requesting blood tests in order to try to reduce the amount of routine/unnecessary blood tests. Modifications included developing specific indications for blood tests, asking senior clinicians to validate which bloods were necessary/unnecessary, and decision support tools.

Electronic medical records were also modified by introducing automated prompts and modifying what blood tests were included in the daily panel.

Some studies identified there was variation in the amount of blood discarded when taken from central lines. Standardisation of these processes, through guidelines and education is essential to prevent unnecessary blood loss in the critically ill.

Equipment Directed Strategies

Equipment forms an important part of strategies to reduce routine blood tests, but perhaps more relevant, iatrogenic anaemia. Blood conservation sampling devices (BCSD's), paediatric blood bottles and low volume blood bottles were the most important equipment identified to reduce blood loss in the critically ill. BCSD's 'decrease rates of PBL by up to 70ml over a 72 hour period,' and one study quoted a reduction of 48% in red blood cell transfusion rate (Jones, Spangler, Keiser, & Turkelson, 2019). Low volume blood tubes (in combination with other process changes) led to a reduction in transfusion rate by 15% and a reduction in average daily blood loss (Coene, Roos, & Scharnhorst, 2015).

2.8 Consultation

As recommended by Levac et al. the final stage of this scoping review was to include an expert consultation to ensure the validity and accuracy of the findings. This was carried out during a critical research review by the researcher and supervisors.

This identified that a limitation of the methodology is that the themes are treated as being discrete,however the relationships between them are complex and multidimensional in practice.

This means that a unidimensional approach strategy is likely to fail as it will not consider all of the factors that influence the decision making and practice within a complex system. Thus strategies for change will need to target this problem at multiple levels – individual, situational and organisational.

Several studies have recognised this relationship, and attempted to address it, but without fully describing or understanding the factors involved (Mikhaeil, Day, & Ilan, 2016) (Merkeley, et al., 2016) (Dhanani, Barnett, Lipman, & Reade, 2018) (Gupta, et al., 2017) (Whitehead, et al., 2019). These studies described 'multi-pronged' or 'multimodal' or 'bundled interventions' and made clear reference to the need for a multidimensional approach but did not consider this in sufficient detail. They recognised that multiple interventions bundled together were more likely to be successful (Whitehead, et al., 2019), but without adequately explaining why.

Overall, in terms of synthesis Figure 8 starts to illustrate the inter relationships identified from the findings of the scooping review. These centre on the relationship between individuals, habits, routines and rootedness within an organisation and depend on the situation. An individual will form their own habits, which may be influenced by the routine processes and situations they commonly find themselves in, and the prevailing organisational culture. It is impossible to separate out when a routine becomes a habit, or when either of these become rooted in organisational culture.

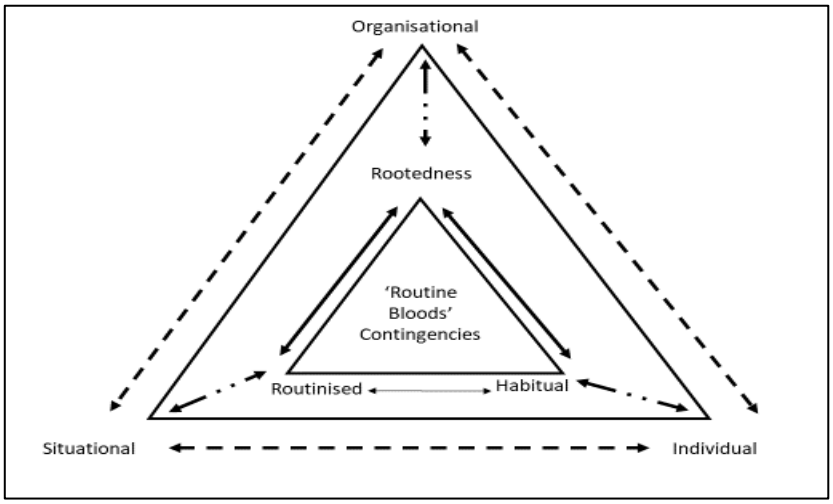


Figure 8: Relationships between individual, habits, routines

It is perhaps easiest to explain this diagram with an example. An individual (junior doctor), may be on a ward round in an ICU (situational). He is aware that every patient has a routine set of ICU bloods done every day, and this is the standard of practice in this particular ICU which he may now adopt, even if he may have had a different practice elsewhere (situational and routine leading to routine bloods). The organisational culture in the ICU may be that it is generally understood by all individuals involved that it is safe, good practice to do this (organisational). This process may have been in place for as long as most people can remember in ICU and has thus become rooted in everyday practice. The junior doctor may try to consult guidelines, local policy, ask colleagues and senior doctors/nurses. There are no guidelines that specify otherwise, and thus this decision becomes a judgmental call by an individual influenced by these other factors. If this particular doctor is new to the organisation and situation, he may well adopt what is the local policy (if this exists) and what the situational standard practice is (what his colleagues/seniors practice), in order to conform and adapt to the prevailing organisational culture.

This illustrates part of the problem in this area – there are no universally adopted guidelines in this area, and often no local guidelines. Thus, the decision-making process is subject to many different influences of different situations and organisations, and there is no clear starting point or standard. Not all of these influencing factors may be weighted equally in an individual's decision-making process, and this is likely to differ based on an individual's personal experience, knowledge, confidence level, and personality. For example, if an individual has had an adverse experience by not ordering a blood test, they are more likely to consider the risks of not ordering a blood test greater than the consequences and risks of ordering a potentially unnecessary blood test. However, if he has recently attended training detailing the adverse patient outcomes that can arise from unnecessary routine blood tests, he may weigh this decision differently. Conversely, if he has been within the organisation and situation for a significant amount of time and has been using this method of ordering blood tests for some time with no perceived adverse effects or information to

the contrary, he may not see a valid reason to change what he sees as safe and effective practice.

Approaching it from another direction, in order for an individual to change their behaviour and form new habits, there must be a favourable environment for this created by the situation (the ward round/the case study/particular ICU) and the organisation (new guidelines, education, senior/consultant led). This links back to the earlier discussions in the analysis of this scoping review, concerning the people factors, process factors, environmental factors in ICU and the wider healthcare context. Figure 9 situates the individual at the centre of the overall wider healthcare context.

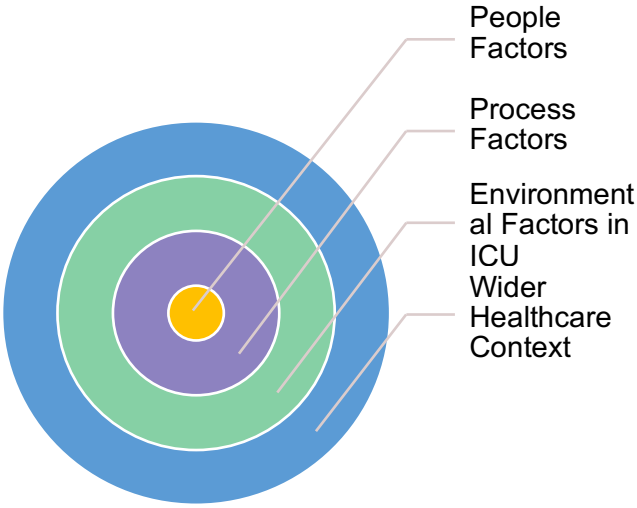


Figure 9. Hierarchy of People, Process, Environmental and Wider Healthcare Factors

A scoping review does not aim to evaluate the quality of the literature, but to synthesise some of the main themes from currently published evidence. Some of these studies are fairly small in size, there was a mixture of positive and negative studies with extremely mixed methodology including qualitative and quantitative. No attempt was made by this scoping review to critically analyse the methods and quality of the published evidence, and therefore may be at risk of bias and incorrect conclusions.

There are multiple confounding factors when it comes to evaluating anaemia in the critically ill such as recent major surgery, major haemorrhage, anaemia of chronic disease, anaemia due to acute haemolysis and sepsis (Page, Retter, & Wyncoll, Blood conservation devices in critical care: a narrative review, 2013). It can therefore be difficult to try to measure the impact of any interventions to reduce iatrogenic anaemia or adverse patient outcomes. These patients are by nature, critically ill, and therefore outcomes are not always favourable, and they have confounding conditions which will affect attempts to look at pathological/biochemical/physiological outcomes.

Findings may not be generalisable to other settings outside of critical care. There are several factors that are discussed in the introduction that make critical care particularly

vulnerable to the effects of unnecessary routine blood tests, but this fails to acknowledge that routine blood tests happen in many other settings across a hospital as well. ICU's often have their own particular culture and processes which is very different to the rest of the hospital, and thus findings may not be generalisable to other settings.

One of the main strengths of a scoping review methodology is its ability to consider a wide range of literature including guidelines, advice, policies and published literature. This enables it to take into account the wider context of practice that this subject exists within. This allows the review to produce a reasonable synthesis of the different themes, to structure further investigation and discussions around reducing the amount of blood tests in ICU.

Chapter 3: Case Study and Workshop

3. Introduction

The scoping literature review in Chapter 2 identified four important themes in the context of routine blood tests in critical care patients. These themes were patient centred outcomes, costs, behaviours and rationale, and strategies to reduce routine blood tests.These were used to inform a structured workshop discussion with key stakeholders in a pre-identified case study. The reason for choosing stakeholder workshop s was to generate not only understanding of the contextual issues within the case but also 'buy in' for change. I n this way, the case study work based on Yin (2014; 2018) in a single case context alongside using through co-production (The Health Foundation 2010), approach enabled the researcher to identify themes that could be extrapolated to wider contexts. .

3.1 Background

The Case Study Context: profile

The case study used for this project was an intensive care unit within a district general hospital in North Wales. Wales is subdivided into 7 Trusts, whose role it is to deliver primary and secondary healthcare services within that region. North Wales is served by Betsi Cadwaladr University Health Board, which serves a population of approximately 678,000 people. It encompasses 3 district general hospitals: Wrexham Maelor Hospital, Ysbyty Glan Clwyd and Ysbyty Gwynedd. In addition to this there are several community hospitals operating across the region, and the health board employs approximately 18,000 staff members. Ysbyty Glan Clwyd is the local primary percutaneous coronary intervention centre, and the lead on vascular services and the subregional neonatal intensive care unit, as well as the regions oncology centre.

Ysbyty Glan Clwyd Intensive Care Unit has 13 fully staffed level 3 beds in their intensive care unit and sees approximately 850 patients per year. Approximately 50% of these are medical admissions, 30% are intubated, with a standardised mortality ratio of 1, mean APACHE score 17, mean age 60, mean length of stay 3 days. This means that this intensive care unit is broadly comparable to others across the UK according to ICNARC data.

Standard Practice

Standard practice for an unquantifiable number of years (due to lack of historical data) has been for the nurses to take a routine set of blood tests from every patient on ICU and HDU at approx. 5am in the morning, to allow the results to be back for the morning ward round at 0830am. This has been the case for at least 5 years, but exactly how long is not

documented anywhere. Before this became standard practice the junior doctors on nights would take the blood sample. Thus, the established practice has been for every patient on ICU and HDU to have a standard set of blood tests taken, with some variation as to who and when these bloods may have been taken.

Methodology

Two main theories underpinned the methodology and analysis of this workshop: Coproduction theory and positioning theory. It is necessary to discuss coproduction theory in order to understand the methodology of the workshop and the rationale for applying it to this project.

Co-production Theory

Co-production is an idea that has its historical origins in civil rights and social care in the USA, but has been further developed in the UK to become a collaborative model between service users and clinicians to jointly develop healthcare and social systems.

This can be on a micro level, in an individual consultant between a patient (service user) and their clinician, or it can be on a much larger scale talking about the development and structure of healthcare services on a regional or national basis using service user input.

The key principles of co-production is that it is a meeting of two experts, each with respective knowledge and skills. Through effective information exchange, and shared decision making, it can affect truly transformative change in healthcare systems. Whereas in previous models, end service users may have been consulted, or had input into a system, co-production is about empowering both service users and frontline health care staff to change processes and healthcare services.

In previous models', clinicians had more of a role as a 'fixer', co-production encourages them to be facilitators, giving service users the tools and information needed to solve problems themselves, whilst recognising that the service user is the expert in their experience of their condition and social circumstances.

There are three variations of co-production: co-governance, co-management, and co-production. Co-governance refers to organisations that help in the planning and design of public services. Co-management refers to production of a service by a third part organisation, and co-production however "is restricted to user involvement in the

production of public services directly, with or without state intervention" (The Health Foundation, 2010).

There are several advantages to this approach. It empowers frontline staff and promotes their importance by making them 'facilitators' to fixing the problem rather than the 'fixers'. It permits the development of individualised solutions. It aims to address the problem of compliance amongst patients by attaining an agreement between the clinician and service user through shared problem definition, and the design and implementation of solutions.

Relevance to the research

The principles of co-production theory were used in the development, design and implementation of the workshop. In this context, the 'service users' described above are the ICU staff and the 'clinician' is the researcher. The adoption of this study design and promoting the importance of the ICU staff in facilitating and solution to the problem of routine blood tests in critically ill patients, was expected to generate 'buy in' and realise the benefits of co-production as described above.

In this way, the application of co-production theory to the Workshop was intended to contribute to departmental transformation and facilitate the introduction of effective change.

Application of the principles of co-production to the workshop

The principles of co-production from a clinician and patient perspective about a health consultation were adapted from The Health Foundation (2010), to a researcher and participants in a qualitative research context for this investigation.

Key skills of the researcher

The researcher needs to exhibit many similar skills to a clinician in a consultation. There needs to be a mutual respect and recognition of expertise that forms the basis of a co-productive encounter. This means the research must be non-judgemental, facilitative, reflective, ask open questions and actively listen, use summaries to clarify points, and to share information and provide context where appropriate.

Key skills of the participants

Participants should feel empowered, respected and able to openly communicate their feelings and perspective. They must recognise the limitations or parameters of the discussion which will be set by the researcher, but these can be flexible and adapted if the researcher or participant feels it is relevant.

Key events that need to happen during the workshop

The information was provided at the start of the workshop rather than in the middle of the discussion as per the model; in order to provide context and discussion points, and also to help set parameters for this specific workshop.

Purpose of the relationship

The purpose of this relationship is to create an environment that is participatory, informative, facilitative, educational and receptive.

Outcomes of a co-productive relationship

In a research context, this could mean generating buy-in amongst the participants through the process of the research itself, thereby becoming an intervention. Through establishing an environment of mutual respect and expertise, in order to produce honest and open answers in the workshop, and result in quality research data, and more accurate research conclusions.

This method of research could become the model for transformational research and the implementation of new policy regarding routine blood tests in the future.

3.2 Aims

The aim of the workshop was to explore and enrich the themes identified in the scoping review in the context of a district general hospital case study with key stakeholders.

There were several additional aims supporting this primary aim, discussed further in chapter 4:

- To produce a set of core outcome measure for future research in this area
- To produce local and national recommendations for reducing routine blood tests in ICU
- To use this case study as a way to explore culture and positioning within this specific case study context, and how this might be relevant to wider qualitative healthcare research
- By involving key stakeholders in the workshop, it was hoped that some 'buy in' to changing practice and culture may be generated through co-production methodology

3.3 Method

Sampling and Recruitment

Purposive sampling techniques (Lavrakas, 2008) were used to identify and approach participants for this study. The group involved in the workshop was selected to represent as many different staff groups (and by proxy subcultures and positions) as possible. It was

hoped this would generate a variety of opinions, perspectives, positions and discourse. The main objective of a purposeful sampling method is to generate a sample that can be logically assumed to be representative of the population, so it was hoped by inviting a key stakeholder from each staff group that this would be realised.

Key stakeholders were identified and invited to the workshop, and this included an ICU consultant, advanced critical care practitioner, senior sister ICU, and anaesthetic registrar.

Key stakeholders from each staff group (ICU consultants, senior nurses, ICU junior and senior clinicians) were identified. It is acknowledged that not all of the key stakeholders in routine blood tests in critical care were included in the Workshop. Other key stakeholders include the nurses involved in patient care on a day-to-day basis, laboratory staff, healthcare support workers and domestics, all of whom may have key insights into this subject. However due to time constraints of this project, there was only time to conduct this workshop with a limited number of stakeholders, especially as this was conducted in Jan 2021, amongst the COVID pandemic.

Exclusion criteria

Participants who withdrew consent to participate in the workshop or declined to participate when initially invited.

Modification to study design due to COVID-19 pandemic

From the initial design of this research project to the delivery of it, the COVID-19 pandemic happened in the UK.

Initially, it was planned to hold multiple face to face workshops that would then be transcribed. However this initial plan had to be modified in line with Bangor University and Betsi Cadwaladr University Healthboard COVID-19 guidelines. This meant making the workshop virtual.

This introduced limitations including lack of body language cues and visual signs of communication via a virtual Microsoft Teams platform which may have inhibited discussion. However, participants who may not have previously been able to participate due to schedules and rotas were also able to attend, as they did not need to appear in person e.g. post night shifts or in-between other meetings where travel times would not have normally allowed that person to attend.

3.4 Case Characteristics

Of the staff members identified, 5 responded and attended, 2 hoped to attend but unfortunately were unable to due to other commitments on the day (a senior ICU registrar

and junior ICU doctor). They were provided with a consent sheet and information sheet via email.

3.5 Data Collection: Workshop via Teams

The Workshop was carried out over Teams due to COVID19 restrictions and was recorded with participants consent. The workshop commenced with introductions, a review of the purpose, previous work and patient centred outcomes. A Problem Tree was introduced as a vehicle to promote discussion.

The proceedings were transcribed by the researcher to enable full thematic analysis. The PowerPoint presentation slides used and the transcript of the workshop are at Appendix 4.

3.6 Ethics

Ethical approval was sought and approved by the Bangor University Healthcare and Medical Sciences Academic Ethics committee, with further approval from NHS Research and Development.

Participant consent and care

Consent was implied by attendance, and no formal verbal or written consent process took place. A declaration was made at the start of the presentation that anything said within the workshop was confidential, that the workshop would be recorded and transcribed, and that any personally identifiable data would remain confidential and stored on a password protected laptop for the purposes of research only.

Data Management

Participants were informed that their data was confidential and that the workshop would be recorded and saved on password protected laptop.

No confidential information was available to persons other than the lead investigator and academic supervisors.

Identifiable data will be deleted within 12 months following completion and publication of the study.

Governance Issues and Risk Assessment

After ethical approval and before conducting the study, new restrictions were put on the conduct of research, requiring all non-COVID 19 related research to be halted, and any face-to-face contact to be minimised. Although originally anticipated that the workshop would be face to face, this was conducted via Microsoft Teams as previously explained.

3.7 Data Analysis

A thematic analysis, guided by the scoping review (Chapter 2), was used to examine the data. The relevant parts of the transcript can be found at Appendix 5.

To develop these descriptive themes into more analytical themes, positioning theory was incorporated into the analysis to provide a theoretical framework. The thematic analysis was used to analyse what was said, and positioning theory to understand why it was said. Positioning theory was used as a framework for analysis, in order to develop an understanding beyond what was said (which is explored in thematic analysis), to explore why it was said (positioning theory) and how this contributes to organisational culture.

Themes / Review Themes

Five main themes were identified in this workshop:

Habitual behaviour, incorporating routines

'Habit' was mentioned several times throughout the workshop and is important to try to define. Habit is traditionally defined as 'a settled tendency or manner of behaviour'. 'Routine' is defined as habitual performance of an established procedure. In this case the established procedure is daily blood tests. It can therefore be said that the 'routine' of the nurses taking a full set of daily blood tests is part of the 'habit' of not only the individuals working on the intensive care unit in this case study, but a habit of the unit as a whole entity. Understanding some of the reasons underpinning habits also folds into this theme, including historical precedent. On a couple of occasions, the phrase 'what we've always done' was used, and also 'since I've started working on the unit…' implying long term culture and habit. In this way, a habit ties into the culture of a workplace. One definition of culture 'how we do things around here' (Mannion & Davies, 2018). Routines become habits that contribute to culture.

Factors that influence the decision to do routine bloods

This theme made up the bulk of the discussion in the workshop as it is important to understand the rationale behind routine bloods. Without understanding the process and reasons underpinning established practice, it will not be possible to inform change, generate buy-in or make effective change. The key factors identified were: Time constraints and seniority of the decision maker, patient factors such as whether they are critically unwell, presence of an indwelling vascular device such as an arterial line or central line, particular interest in a particular blood result due to patient pathology, length of stay on ITU, conscious vs unconscious decision making, triggers that make the decision conscious, and guidance controlling how often patients need blood tests.

Consequences of routine blood samples

This was briefly discussed in the workshop, and one comment mentioned that indwelling vascular devices such as arterial lines seemed to have a tendency to clot off early, and not last as long when they are accessed regularly. Line infections were discussed, but this was

balanced out with the clinical need for a line and line bundles that are in place to try to minimise risks to patients.

Culture change in ITU

This theme allowed us to explore some of the current cultural insights into practice on ITU, but also how these might be approached in terms of cultural change. We discussed what happens in other units, and how the established baseline is different elsewhere. The default in the ITU in this case study is that every patient gets a full set of routine blood tests, whereas elsewhere it may be that bloods are only done on Monday, Wednesday and Friday, or that patients require a 'ticket' to get bloods tests in the form of a printed A5 request. It was discussed that the current default is important as it promotes patient safety, so that blood tests and important results are less likely to get missed.

The unit has recently introduced updated daily review paperwork, with a tickbox on the back of it which is meant to be completed indicating which bloods are to be requested for that patient the following day, however when discussed it seems this is being used inconsistently – due to lack of awareness and other factors. The tick box does act as a trigger, to make the clinician think whether they do need a full set of bloods or not, changing the decision from being unconscious to conscious decision making. One participant said, 'the culture just becomes instead of 'I'm automatically going to take all these blood tests every morning' it becomes 'I'll have a look at the blue sheet to see which ones need to be done for this patient'.

Another participant went on to note that 'transformational research' and a multipronged approach was one way to change the culture of a department, such as the workshop which they were all a part of. Some of the other potential interventions discussed were education for doctors and nurses in induction to the unit, guidance in bedside booklets, and awareness/compliance with ICNARC guidance.

Barriers to culture change

Barriers to change were recognised in discussion at the end. The main barriers to change identified are perceived need for change, patient safety, breaking habitual practice and routine.

3.8 Discussion

Analytic themes

To develop these descriptive themes into more analytical themes in keeping with the principles of thematic analysis, the researcher incorporated positioning theory into the analysis to provide a theoretical framework. A thematic analysis was used to analyse what was said, and positioning theory to understand why it was said. Positioning theory was used as a framework for analysis, in order to develop an understanding beyond what was

said (which is explored in thematic analysis), to explore why it was said (positioning theory) and how this contributes to organisational culture.

Positioning theory

Positioning theory forms a part of social constructivism, (Slocum & Van Langenhove, 2003) which is a psychological theory built around framing reality. Positioning theory proposes that people position themselves and others within the context of discourse using words (Moghaddam & Rom Harré, 2010, p. 2). For example a person is in a position of 'trust', 'responsibility', or 'with us', and these have direct moral implications (Moghaddam & Harré, 2010, p. 2).

The position they take, is determined by a cluster of 'short-term disuputable rights, obligations and duties' (Harré 2012, pg 193). It is helpful to understanding positioning theory to break down this definition into its components – rights, obligations and duties.

Duties are what one owes another, referencing personal attributes such as vulnerabilities. Harre uses an example of a short person trying to put a parcel on a high shelf – a tall person has a duty to put it up there (*Rom Harré Positioning Theory Symposium Bruges 8 July 2015*, 2015).

Rights are what the other owes you by reference to his/her individual powers. An example used by Harre is a belief in a right to free healthcare, which acknowledges the vulnerability to falling ill (*Rom Harré Positioning Theory Symposium Bruges 8 July 2015*, 2015).

In addition to rights, obligations and duties, there is also the storyline or context in which the interaction is taking place. For example the content and positioning of a discourse within the storyline of a teacher-student interaction within a classroom will be very different to what it will be for the same teacher-student interaction within a pub. Positions are situation specific and context sensitive (Rom Harré & Moghaddam, 2003).

Positioning theory has been expanded from the analysis of individual interactions, to organisations and even between nation states (Harré et al., 2009). It helps explain the positions, tensions, paradoxes and complexity of the social interactions at an intrapersonal, interpersonal and intergroup levels.

Application of the principles of positioning theory in the study

Each individual's position was analysed and sought to be understood, through their contribution to the discourse in the workshop, and their position. This is detailed below:

Storyline: context, previous interactions/conversations

The storyline in this situation is the workshop that is being undertaken. The participants were invited as part of this case study of a district general hospital in order to further research the themes identified in Chapter 2.

With regards to previous interactions and conversations, this is impossible to quantify except to say that everybody involved in the workshop has worked within the case study ICU for many months together, and will have built working relationships with each other through many previous conversations.

Speech-act/actions = transcription of the workshop

In this episode, the speech-act/actions of the individuals are considered to be expressed through speech-act and discourse.

The Researcher: Ffyon Davies

Positions identified: ITU Doctor, Junior Doctor, MRes Researcher

Rights and duties: duty to deliver research workshop, duty to be impartial to participants and results to reduce bias

Relevance: perhaps willing to steer the conversation in order to make the output fit

John Glen

Positions identified: ITU consultant, author of many ITU SOP's and protocols.

Rights and duties: right to be listened to, duty to patients and colleagues

Relevance: position of responsibility, hierarchy, respect, experience, knowledge

Nathan Littley

Positions identified: anaesthetic registrar, ITU fellow

Rights and duties: provide more of a 'on the ground' opinion than a consultant, but with more experience and knowledge than a junior doctor, duty to colleagues, duty to consultant, duty to patients

Relevance: moderator between senior and junior hierarchy, provides more realistic perspective of what actually happens rather than what should happen

Kerry Angus

Positions Identified: advanced critical care practitioner, ITU nurse

Rights and duties: duty to advocate for patients, duty to colleagues, duty to patients

Relevance: moderator between nurses and doctors,

Lynne Slater

Positions Identified: senior ITU nurse

Rights and duties: duty to advocate for nurses, duty to advocate for patients and duty to patients

Relevance: keeps the doctors in check, support senior management decision making, provides nursing perspective to senior management of the unit, helps disseminate and implement changes in policy and culture amongst ITU nursing staff.

Positioning and Culture

The findings indicate how the positioning of individuals may influence culture (defined as 'how we do things here') (Mannion & Davies, 2018), as positioning theory attempts to explain the gap between what people think, and what people say and do. This will be explored further in Chapter 4.

3.9 Overview of findings

The themes identified in this workshop broadly correlated with the themes identified in chapter 2. They were:

1. Habitual behaviour, incorporating routines
    i. Strongly influenced by historical precedent and culture
    ii. Routines become habits that contribute to culture.
2. Factors that influence the decision to do routine bloods
    i. Time constraints of the decision maker
    ii. Seniority of the decision maker
    iii. Whether a patient on ICU is considered to be critically unwell
    iv. The presence of an indwelling vascular device such as an arterial line/central line
    v. Particular interest in blood result due to ongoing pathology
    vi. Length of stay on ICU
    vii. Conscious vs unconscious decision making
    viii. Triggers that make the decision conscious
    ix. Guidance controlling how often patients need blood tests
3. Consequences of routine blood samples
    i. Indwelling vascular devices tended to clot off early, and not last as long when accessed regularly
    ii. Risk of Line infections balanced by clinical need for a line and line bundles that are in place to minimize risk
4. Culture change in ICU
    i. Practice elsewhere is variable

ii. Paperwork e.g. checklists are used inconsistently, but can act as a trigger to making the decision a conscious one instead of unconscious

iii. Transformational research

iv. Multipronged approach

5. Barriers to culture change

i. Perceived need for change

ii. Patient safety thought to be put at risk by some changes

iii. Breaking habitual and routine practice is difficult

Chapter 4: Discussion and Local Recommendations

4.1 Introduction

This chapter will discuss the outcomes of the primary aims and secondary aims of this study.

4.2 Discussion of Primary Research Outcomes

The primary aim of this research is to establish at individual and organisational levels:

1. The reasons for routine daily blood tests in critically ill patients.
2. What behaviours drive routine daily blood tests in critically ill patients?
3. What possible changes to the process could be made?
4. What are the potential barriers to change?

The scoping review literature identified four key themes in the context of routine blood tests in critical care patients. These themes were used to inform a structured workshop discussion with key stakeholders in an intensive care unit within a district general hospital in North Wales which identified five key themes.

The themes identified in the scoping review, were supported by the workshop discussions, and were expanded upon within the workshop. The themes identified in the Workshop map onto the Scoping Review themes and to the Study Aims as shown in the table below.

Table 4. Primary aims and relation to scoping review and case study workshop.

Study Aims	Scoping Review	Case Study & Workshop
What behaviours drive routine daily blood tests in critically ill patient	Behaviours and rationale underpinning routine blood tests in ICU	Habitual behaviour, incorporating routines
What are the reasons for routine daily blood tests in critically ill patients?	Costs of routine blood tests in ICU	Factors that influence the decision to do routine bloods
	Outcomes of routine blood tests in ICU	Consequences of routine blood samples
What possible changes to the process could be made?	Strategies to reduce routine blood tests in ICU	Culture change in ITU
What are the potential barriers to change?		Barriers to culture change

4.3 The behaviours that drive routine daily blood tests in critically ill patients

Culture, Habit and Routine

The scoping review and the Workshop both emphasise ICU culture as being a significant factor. 'Habit' and "Routine' were mentioned several times throughout the workshop. Routines become habits that contribute to culture. The nurses' routine of taking a full set of

daily blood tests is part of the habit of the unit as a whole entity. The phrase ‘what we’ve always done’ was used, and also ‘since I’ve started working on the unit…’ implying long term culture and habit. In this way, a habit turns into the culture of a workplace.

Knowledge

The scoping review also identified knowledge deficit as a key factor influencing the decision to order routine blood tests. Physicians with less experience were more likely to order unnecessary blood tests. Not only does a knowledge deficit contribute to the decision to order a blood test, but many clinicians and staff are unaware of the impact of phlebotomy blood loss, strategies to reduce this and the costs of routine blood tests. The day-to-day conduct of blood tests is done by junior clinicians and nursing staff, who have multiple and competing demands on their time so it is often easier to have one less decision to make.

The literature indicates that there has been a shift from the traditional approach to investigations, based on routine sets and a ‘this is what we have always done’ attitude, to a more targeted and individualised approach. Medical school curriculums often advocate and emphasise the importance of ordering tests where the result will directly influence the patient’s care.

The reasons for routine daily blood tests in critically ill patients

Automation

Many processes are automated or protocolled in ICU environments in order to reduce the number of human error decisions that need to be made, and to ensure a comparable standard of care is achieved for all patients. If blood tests are ordered as a matter of routine, it is not a conscious decision made by the clinician to order blood tests, but instead it is an automated process that occurs daily.

Time

It is often more inexperienced clinicians who are uncertain what to order, and don’t want to miss something important to the patient's care. This has become, perhaps, less prevalent, with the innovation of laboratories being able to ‘add on’ tests to blood samples within a certain time period, so that if an additional test is required, no further blood sample needs to be taken and sent to the lab. It does however still require some time on the part of the clinician adding on the test, and this is often a busy junior member of the team, who may be more inclined to order more tests in the first instance, to save themselves time down the line.

“Just in case”

Another observation highlighted by the literature, is the practice of taking a blood bottle of every colour, in case a test is needed later (Humble, Hounkponou, & Krasowski, 2017). An example of this is taking a coagulation blood bottle ‘just in case’, and it is seen as saving the patient another needlestick if it later becomes required. However, this practice more often than not leads to the majority of patients having excess blood drawn.

The possible changes to the process could be made

Guidelines / Standardisation

The lack of guidelines identified as an important factor contributing to unnecessary blood tests in the critically ill in the scoping review. Without explicit guidelines detailing the frequency and which blood tests are needed, this remains up to individual clinicians to decide (who are often junior clinicians or ICU nurses) and will lead to considerable variability. Strategies identified in the scoping review pertaining to the routine blood test processes included checklists, electronic ordering, computerised prompts, standardising the amount of blood discarded from central lines/arterial lines. Introducing guidelines/protocols was also considered in this theme.

The default in the ITU in the case study was that every patient gets a full set of routine blood tests. The current default was felt to promote patient safety, so that blood tests and important results are less likely to get missed.

Nevertheless the unit had recently introduced updated daily review paperwork, with a tickbox to be completed indicating which bloods are to be requested for that patient the following day. The tick box requires the clinician to make a conscious decision as to whether a full set of bloods is required.

Consistency

However this is being used inconsistently due to lack of awareness and other factors. The scoping review identified the need for explicit guidelines, the use of software prompts and the requirement for justification when ordering blood tests as a possible means to address this.

Other processes

Other process directed strategies identified in the scoping review included developing specific indications for blood tests, asking senior clinicians to validate which bloods were necessary/unnecessary, and decision support tools.

Some studies identified there was variation in the amount of blood discarded when taken from central lines. Standardisation of these processes, through guidelines and education is essential to prevent unnecessary blood loss in the critically ill.

Equipment

Equipment forms an important part of strategies to reduce routine blood tests, but perhaps more relevant, iatrogenic anaemia. Blood conservation sampling devices (BCSD's), paediatric blood bottles and low volume blood bottles were the most important equipment identified in the literature to reduce blood loss in the critically ill.

What are the potential barriers to change?

The main barriers to change identified in the Workshop were the perceived need for change, patient safety and culture ('breaking habitual practice and routine'). Education, culture and time are emphasised in the literature.

Education

In the literature, staff education focussed on the indications for blood tests, reducing the amount of blood lost to phlebotomy, blood conservation strategies, the use of blood conservation sampling devices and the costs of unnecessary blood tests was identified as an important factor in the scoping review. Some of the other potential interventions discussed in the Workshop were education for doctors and nurses in induction to the unit, guidance in bedside booklets, and awareness/compliance with ICNARC guidance.

Patient safety and Cost awareness should form part of education to establish the need for change, as if clinicians don't have any awareness of the implications or costs of ordering routine blood tests, they are unlikely to engage with efforts to change this process.

Culture

The Scoping Review identified that the 'buy in' of the staff is crucial to the success of education, again emphasising the importance of culture.

Cultural change can be addressed in a variety of ways, some of which were noted in the Workshop. One participant noted how the introduction of the tick box form had changed the culture from automated to individual patient need. Another participant went on to note that 'transformational research' and a multipronged approach such as the Workshop, was one way to change the culture of a department.

Time

One of the barriers to changing the practice of routine blood tests was the 'multiple and competing demands for a clinician's time' (Mikhaeil, Day, & Ilan, 2016). Hence it is often less time consuming for clinicians to order routine blood tests, rather than based on clinical need for individual patients.

4.5 Local Recommendations – Case Study Context.

The results of the scoping review were presented at an ICU governance session with local recommendations made. Figure 10 shows the recommendations slide.

After presenting the findings in the local ICU governance session, several of the recommendation were implemented. Documentation was changed, new guidelines were implemented, and this topic was included in the junior doctors and nursing induction package.

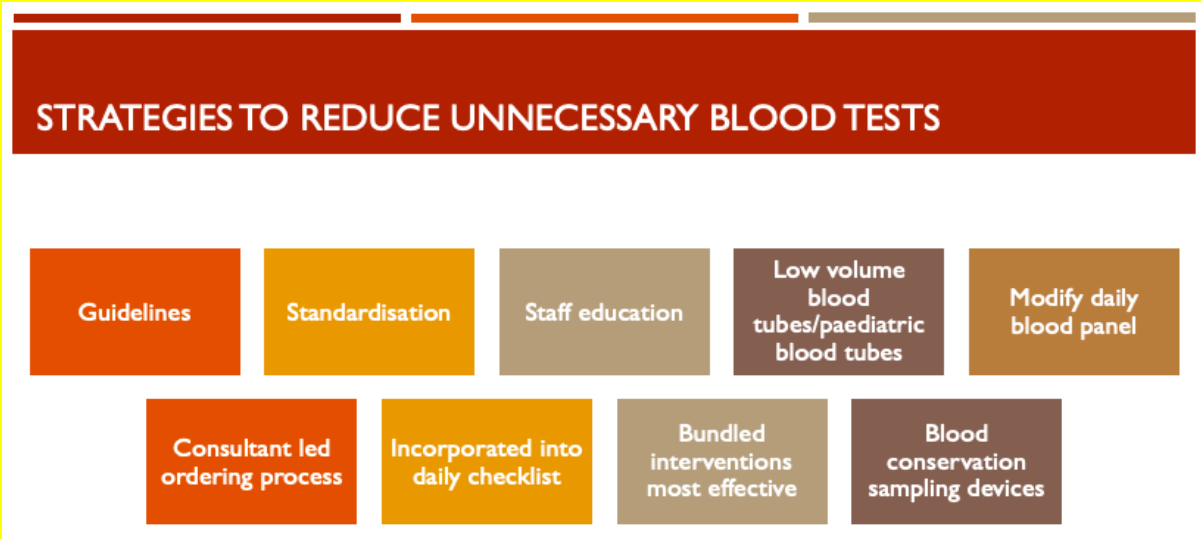


Figure 10. Strategies to reduce unnecessary blood tests

4.6 Changes implemented as a result of this study

The following changes have been implemented within the General Hospital as a result of the recommendations of this study and the buy-in which was achieved through the approach adopted.

- A Tick Box has been added to the daily review proforma with the option to specify blood tests needed for the following day.
- Bedside Guidelines have been created and made available. These are at Appendix 6.
- Guidance on ordering tests has been Incorporated into junior doctor and nursing induction education packages.

Chapter 5: Development of CORE outcome measures and Global Recommendations

This section describes the process by which the findings of the scoping review and workshop can be standardised to facilitate further research and to generalise the recommendations. The process is through the creation of the concept of a core outcome set which was developed to standardise medical research.

5.1 What are Core Outcome Sets?

It has been recognized for some time by authors of systematic reviews and meta-analysis that there is a wide variety of outcome data in a given area of research. This heterogeneity of data makes comparing evidence very difficult, and even more difficult to produce quality recommendations based on this evidence. Because of these difficulties, the concept of a core outcome set was developed to standardise medical research. The definition of a core outcome set is:

> *"A core outcome set (COS) is an agreed standardised set of outcomes that should be measured and reported, as a minimum, in all clinical trials in specific areas of health or health care."*
>
> (*COMET Initiative | Home*, n.d.)

COS's also aim to increase the relevance of research by involving key stakeholders in the development of COS. This helps to bridge the gap between research and practice (Tyler et al., 2020).

This is an emerging area of study, however, there have been some attempts to standardize the process for COS development, particularly from Kirkham et al., 2015. They describe a 5-stage process for this.

1. "Establish a preliminary checklist of reporting items to be considered for inclusion in the COS reporting guideline (Stage 1).
2. Conduct a Delphi survey to gain consensus opinion on reporting items to be considered within a standardised reporting guideline for COS development studies (Stage 2).

3. Hold a consensus meeting to identify the main items to be included in the definitive reporting guideline for COS development studies (Stage 3).

4. Develop a high-quality reporting guideline and a detailed explanatory document (Stage 4).

5. Post-development activities: pilot-testing and dissemination (Stage 5).”

The scope of producing a fully developed COS that has gone through the process of a Delphi Study is beyond the scope of the current study. However this study can be used to begin the process of developing COS Stage 1 (developing a preliminary checklist of reporting items) for the following research question:

‘What measures should be used to measure the impact of strategies to reduce routine blood tests in critically ill patients?’

5.2 Selection of Measurable Outcomes

To begin to develop the answer to this question, we must first describe what measured outcomes were used in the scoping review literature and their measured outcome frequency.

The most frequently occurring outcomes are highlighted in red.

Table 5. Measured Outcomes

Title (listed by author alphabetically)	Measured outcomes
Less is More: ‘not to do’ recommendations in the intensive care unit	None, opinion piece.
Program to reduce redundant laboratory sampling in an intensive care unit leads to non-inferior patient care and outcomes.	Number of Laboratory Orders Number of Blood Specimens Number of POCT Specimens Patient care days Medical ICU Length Of Stay Average daily Hgb (g/dL) RBC transfusion (Units)

	RBC Units/patient
Iatrogenic anemia/Twenty-five million liters of blood into the sewer.	Blood tube collection volume POCT Blood gas volume POCT Blood glucose volume Haemoglobin level at end of ICU admission period Erythrocyte transfusion requirements
Blood tests in the intensive care unit: A necessary cost?	All blood tests performed for the preceding 7 days Cost per blood test in our centre (£) Cost per blood test in District General Hospital (£) Survey on of ICU multidisciplinary staff
Reduction in Number of Reported Laboratory Results for an Adult Intensive Care Unit by Effective Order Management and Parameter Selection on the Blood Gas Analyzers	Central laboratory orders (all blood tests ordered) Number of orders for blood gas analyzers Individual tests ordered on blood gas analyzers
Strategies to reduce inappropriate laboratory blood test orders in intensive care are effective and safe: before and after quality improvement study.	Cost of test reduction (Australian $) Mortality Number of tests performed Haemoglobin differences

A Targeted, Evidence-Based Clinical Decision Support Intervention to Reduce Unnecessary Complete Blood Count Orders	Complete Blood Count Order number
Results of a Quality Improvement Project aimed at Eliminating Healthcare Waste by Changing Medical Resident Test Ordering Behaviour	Number of Complete Blood Counts Ordered Number of PT/INR Orders Number of BMP Orders Mortality Rate
The "rainbow" of extra Blood Tubes – Useful or Wasteful Practice	Number of: Citrate blood tubes EDTA blood tubes PST blood tubes Serum blood tubes
Impact of Nursing Education on Phlebotomy Blood Loss and Hospital Acquired Anemia	Phlebotomy Blood Loss (mL) Hospital acquired anaemia (HAA) Hb trend Nurses' knowledge with regard to PBL, HAA, and blood conservation strategies (BCS)
Anaemia in the ICU – impact of phlebotomy	Mean volume of blood draw Blood volume drawn daily Number of Blood Tests per day (unknown if ordered/performed) Drop in Mean Haemoglobin concentration Overall mortality

Multipronged strategy to reduce routine-priority blood testing in intensive care patients	Routine/priority CBC's Routine/priority electrolyte/renal panel Nonroutine CBC's Nonroutine electrolyte/renal panel Adjusted savings ($) Demographics Severity of illness Length of stay Number of red cell transfusions
Drop by drop: Rationalising routine blood tests in an intensive care unit	Summary of number of tests performed The length-of-stay, number of patients per month, APACHE III severity score, adverse events, number of high-volume tests were recorded and compared to that of the historical data.
Non-essential blood tests in the intensive care unit: a prospective observational study	Blood tests processed Patients' age, sex, mechanical ventilation status, and treatment with vasoactive drugs
Reduction of Laboratory Utilization in the Intensive Care Unit	Total number of laboratory tests per patient-day Number of duplicated tests per day Percentage of patients who had daily laboratory tests Indirect cost savings ($)

Rational Clinical Pathology Assessment in the Intensive Care Unit	Overall laboratory test costs Compliance with test authorization protocol Cost of frequently ordered tests Blood gas analyses Number of simple chemistry tests consisting of electrolytes, liver function, calcium, phosphate magnesium, coagulation and full blood count Protocol related adverse events
Interventions to prevent iatrogenic anemia: A Laboratory Medicine Best Practices Systematic Review	Impact on blood loss (mL/day) Impact on haemoglobin decline (g/L/day) Transfusion risk (greater than or equal to one transfusion per admission)
Laboratory Tests and X-Ray imaging in the Surgical Intensive Care Unit: Checking the Checklist	Number of tests ordered per day Sex, Age, Sequential Organ Failure scores, Charlson Comorbidity Index scores, elective admission status, surgical procedures, number of days of mechanical ventilation, ICU length of stay, and in-hospital death (mortality). CXR Coagulation Complete blood cell county Chemistry panel Arterial blood gas Red blood cell transfusion
Five Things Physicians and Patients Should Question	No measured outcomes, recommendations only

NOTE: Without conducting full statistical analysis on this data in line with systematic reviews and meta-analysis processes, we cannot conclusively say that the data is significantly heterogenous.

Table 6. Measured outcome frequency

	Relevant Outcome Measure	Frequency Used % of total studies (Total Number=19)
Number of Laboratory Tests Ordered/Performed	Total Number of Laboratory Orders	21% (n=4)
	Number of Blood Specimens/Tests performed/processed	26% (n=5)
	Number of laboratory tests/patient day	5% (n=1)
	Number of tests per day (unknown if this is tests ordered or tests performed)	5% (n=1)
	Number of duplicated tests (POCT and Lab)	5% (n=1)
	Percentage of patients who received daily laboratory tests	5% (n=1)
Number of Blood gases performed	Number of Blood Gases	5% (n=1)
	Individual tests on blood gas analyser (e.g. K)	5% (n=1)
	Number of POCT	5% (n=1)
Breakdown of Laboratory blood tests performed	Full Blood Count/Complete Blood Count	32% (n=6)
	Metabolic Panel/Renal/Electrolytes	21% (n=4)

	Coagulation/PT/INR	21% (n=4)
	Routine/priority CBCs	5% (n=1)
	Nonroutine CBCs	5% (n=1)
	Routine/Priority electrolyte/renal panel	5% (n=1)
	Nonroutine electrolyte/renal panel	5% (n=1)
Length of Care	Patient Care Days	5% (n=1)
	Length of Stay in ICU	15% (n=3)
Transfusion related	RBC units transfused	21% (n=4)
	RBC units/patient	5% (n=1)
	Transfusion risk (greater than or equal to one RBC unit per admission)	5% (n=1)
Blood Volume Measures	Blood tube collection volume	5% (n=1)
	POCT Blood Gas Volume	5% (n=1)
	Mean volume of blood draw	5% (n=1)
	Blood volume drawn daily	5% (n=1)
	Blood loss (ml/day)	5% (n=1)
	Phlebotomy related blood loss	5% (n=1)
	POCT Blood Glucose Volume	5% (n=1)
Haemoglobin Measures	Average Daily Haemoglobin	5% (n=1)

	Haemoglobin level at end of ICU admission period	5% (n=1)
	Haemoglobin differences (pre and post ICU admission)	5% (n=1)
	Haemoglobin decline (g/L/day)	5% (n=1)
	Hospital acquired anaemia	5% (n=1)
	Haemoglobin trend	5% (n=1)
	Drop in mean Hb concentration	5% (n=1)
Cost Measures	Cost per blood test	5% (n=1)
	Reduction in test costs	5% (n=1)
	Indirect cost savings	5% (n=1)
	Overall laboratory test costs	5% (n=1)
	Cost of frequently ordered tests	5% (n=1)
	Adjusted savings	5% (n=1)
Mortality	Mortality	21% (n=4)
Other	Nurse Knowledge	5% (n=1)
	Compliance with protocol	5% (n=1)
	Protocol related adverse events	5% (n=1)
	Survey of ICU multidisciplinary staff	5% (n=1)

When choosing a measurable outcome, a researcher must take into account several factors:

- Quality of measured outcome

- Relevance of measured outcome
- Importance of measured outcome
- Ease of measurement and time available

Quality of measured outcome

Some measurable outcomes may be affected and confounded by multiple other factors, and therefore may not be considered a high quality measurable outcome.

Relevance of measured outcome

There must be a relevance to the outcome, either to the patient, the staff or the organization. For example, measuring units of blood transfused is relevant to all of these staekholders. The patient, who receives the transfusion and is exposed to the risks associated with this e.g. TACO, TRALI (Narayan & Poles et al. 2022). This outcome is relevant to the staff involved in cross matching, requesting, prescribing, retrieving, checking and giving the unit of blood as this can be time and resource consuming. .

Importance of measured outcome

Mortality is a very important outcome for the patient and the organization, whereas cost measures do not necessarily hold much importance to a patient in the National Health Service (NHS) where care is free at point of provision.

Ease of measurement and time available

Statistics such as the number of blood tests ordered and processed/performed are relatively easy to obtain from laboratory measurements. Individual patient related phlebotomy blood loss volume is a very time consuming resource, as it will require an individual to be at the bedside to observe every blood test taken, blood gas taken, and every time an arterial line/central line is accessed. However it might be considered a high quality measure, as it is a direct measure of iatrogenic blood loss, unlike haemoglobin measurement or transfusion related measurements, both of which are surrogate measures of iatrogenic blood loss and there is high risk of confounding these measures due to other factors e.g. transfusion for massive haemorrhage, transfusion post surgery, haemoglobin loss due to anaemia of the critically ill.

If we assume there is some relationship between these factors and the frequency with which the measured outcome appears in the scoping review dataset, we can begin to develop our proposed COS. Figure 11 below demonstrates the number of studies that used an outcome measure from each category.

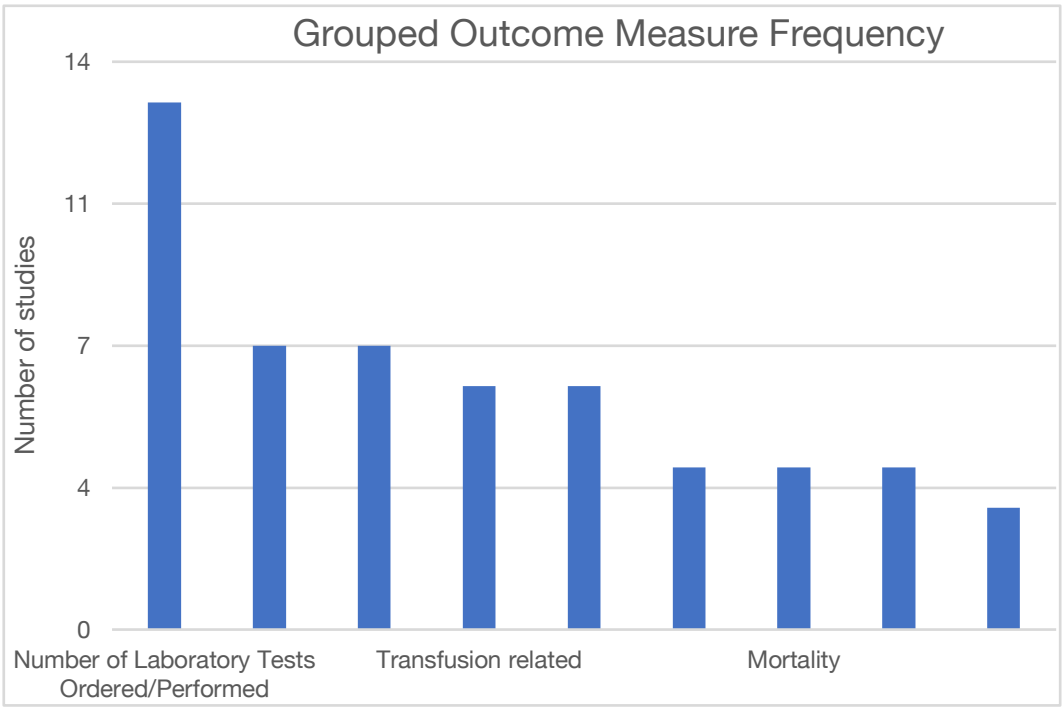


Figure 11. Graph showing Grouped Outcome Measure Frequency.

From this we can see that the most frequently used are the number of laboratory tests ordered/performed, blood volume measures and haemoglobin measures, closely followed by transfusion related outcomes, length of care and mortality.

Based on this initial reflection, it is proposed that one outcome measure from each category be developed, with the exception of the 'other' category. We can see that most of the 'other' category outcomes are study specific (Appendix 3 Table 3), involving adverse events related to the protocol or deviation from the protocol.

5.3 Proposed Outcome Measures

Proposed Outcome Measure 1: Number of Blood Tests Ordered/Performed/Processed

The number of blood tests ordered is not necessarily equal to the number of blood tests performed on the patient or processed in the lab. The sample may not make it to the lab, or if it does it may be unusable, (haemolysed/clotted), or the lab may refuse to run the sample based on ordering protocols or documentation (e.g. sample not dated/timed, patient detail discrepancy). In terms of what is important for the patient, the most important measure is the number of blood tests *performed,* or more specifically the number of blood tubes taken as this directly relates to the amount of blood loss.

Should this be broken down into constituent blood tests?

Some studies used the total number of blood tests performed as their outcome, and some used individual tests such as full blood count, electrolyte profile and coagulation screen.

As each of these constituent blood tests are usually processed in a separate blood tube, there is perhaps value in breaking this down in the data, as it may demonstrate whether particular blood tubes (and by association, blood test) is requested more often than others. It is also far easier to measure the tests performed, than it is the blood tubes taken from the patient,

Constituent blood tests give more information in terms of the costs involved, as this can be broken down into constituent blood tests, therefore allowing organisations to target reducing the most expensive interventions (usually coagulation screens).

Over what time period?

Some studies ran over several months, and some over several days. It is therefore proposed that this should be reported as the number of blood tests performed on the patient per day.

Proposed Outcome Measure 1: the number of blood tests performed on/taken from the patient per day, broken down into full blood count/complete blood count, electrolyte profile/renal panel/basic metabolic panel, and coagulation screen.

Proposed Outcome Measure 2: Blood Volume Measures

Important to measure as there is significant variation in the volume of blood taken from patients for the same test (Coene et al. 2015). Some nurses may take 5mls for a blood gas and some may take 1ml. Some may fill a full blood count to the top and some may fill it halfway.

Although this is a potentially difficult outcome to measure, as it requires significant time and manpower, I believe it is worthwhile measuring as it is the only direct measure of iatrogenic blood loss, as discussed above. Haemoglobin and transfusion related outcomes are surrogate measures of blood volume loss.

Proposed Outcome Measure 2: the total volume of blood draw (including blood gases, POCT, laboratory blood tests, and discarded blood) measured in milliliters per patient per day (mL/patient/day).

Proposed Outcome Measure 3: Haemoglobin measures

Although influenced by many other factors as alluded to, it could also be influenced by iatrogenic blood loss and is an important patient-centred outcome. Vincent (2002) comments on the results of their large prospective cohort study in european ICU's:

"This large, epidemiologic study in European ICUs validates the common occurrence of anemia in critically ill patients and also reports that lower mean hemoglobin levels were associated with higher SOFA scores, longer lengths of stay, and higher mortality rates."

If a study were to compare two comparably sick groups of critically ill patients, with one cohort being the subject of strategies to reduce iatrogenic blood loss, haemoglobin would undoubtedly be an outcome of interest, and would be interesting to compare this to the control group. Hence it has been included as a proposed outcome measure. Not only this, but transfusion is generally triggered by a preset haemoglobin level (usually 7g/dL), however this varies across the world, with some countries having a higher threshold for transfusion than others. It is therefore important to include haemoglobin as part of the COS in order to accurately interpret the transfusion related outcome measures.

Proposed Outcome Measure 3: the haemoglobin level per patient per day*

NOTE: This must be corrected for confounding factors if possible. From this data, haemoglobin trend, pre and post ICU admission haemoglobin and haemoglobin decline could all be calculated. The author suggests that the pre-ICU and post-ICU haemoglobin should be measured, and the differences in the data set compared using a paired t-test. If the study is incorporating a control arm and an interventional arm, this should be reported using a chi squared test.

Proposed Outcome Measure 4: Transfusion related outcome measures

Transfusion is an important outcome for patients, staff and organisations as discussed above. Transfusion is also independently associated with increased mortality and increased organ dysfunction in critically ill patients (Vincent, 2002). This is especially important in a time of critical blood stock shortages (NHS Blood and Transplant, 2022).

Proposed Outcome Measure 4: units of red blood cells/erythrocytes transfused per patient

Proposed Outcome Measure 5: Cost Measures

Costs are an important outcome measure for organisations. They are also not too difficult to measure, as many healthcare systems already know how much it costs to process each blood test, so if we already have the number of constituent blood tests this should not be difficult to achieve.

It also provides further motivation to the senior decision makers and executive members of an organization who are undoubtedly very interested in achieving cost effective care. It may not be as important to frontline staff, however it helps to inform decision making. Staff may think twice if they know a particular blood test iscostly. Often in healthcare systems there is

a finite amount of financial resources, and so to choose to spend the money on one particular intervention is often to the detriment of others. Although this cannot always be directly demonstrated, the implication of financial decisions is not lost on frontline staff who are often directly influenced by this.

Proposed Outcome Measure 5: the financial cost reduction (£/$/€) achieved by reducing unnecessary blood tests in critically ill patients, where financial costs are defined as the cost of obtaining a blood test result

Proposed Outcome Measure 6: Length of Stay in ICU

This is an easily measurable outcome measure as this data is already collected by most organisations e.g. in the UK it is collected by ICNARC (Intensive Care National Audit and Research Centre, n.d.).Length of stay is also important to patients, who generally want to be discharged from ICU and hospital as soon as possible. Organisations are interested in length of stay in ICU, as it is directly related to costs incurred, and to ICU bed capacity and occupancy. Any intervention that reduces the length of stay in ICU will also improve ICU bed capacity.

Proposed Outcome Measure 6: the length of stay in ICU, measured as mean length of stay in days

Proposed Outcome Measure 7: Mortality

Mortality data is important to patients, staff and organisations. In addition to being another measure that is already routinely collected, it is also important when comparing control groups to intervention groups in future research in this area, as any strategy to reduce iatrogenic blood loss must be proven to be non-inferior (and therefore not worsen mortality) to the current standard of care.

Proposed Outcome Measure 7: Mortality measured in %

Chapter 6: Conclusions and Recommendations

The research was designed to address the cultural and leadership aspects which the literature emphasizes and a qualitative case study method combined with an exploratory approach, and thematic analysis was adopted in order to maintain a real-world context (and also therefore, integrity), in order to better understand complex systems. A scoping review was used to identify and extract themes in the literature to formulate the discussion points in a case study workshop with key stakeholders in an ICU in a single district general hospital. Positioning theory was selected for analysis of the case study, in order to explore the interactions between embedded sub-groups and the organisation that they were positioned within.

The methods adopted were successful in identifying themes and there was close alignment between those identified in the scoping review of literature and the themes developed in the case study.

Coproduction and Positioning theory were found to be helpful approaches and there was key stakeholder 'buy in'. This is evidenced by the implementation of the specific recommendations generated at the Workshop in order to improve processes, training and culture within the ICU. These are detailed in Chapter 4.

Further analysis of the data has resulted in the development of a set of proposed CORE outcome measures (Williamson, et al., 2021), which are intended to reduce the amount of daily blood tests in ICU. These are detailed in Chapter 5.

In addition the following recommendations are made:

Consideration is given to adopting the methods outlined in this study to provide a basis for future explorations of guideline, policy and research in this area.

The Intensive Care Society (national body for intensive care practice in the UK) should consider producing national guidance on this topic, and recommend that interventions like blood conservation sampling devices and paediatric blood tubes become standard practice.

The 7 specific Outcome Measures proposed in Chapter 5 are adopted and implemented.

Appendices

Appendix 1 Alphabetic list of papers by author

Title (listed by author alphabetically)	Type of Literature	Study population, sample size, location	Author/s	Publication Year
Less is More: 'not to do' recommendations in the intensive care unit	Observational study (abstract)	16 bed Intensive Care Unit, Spain	Bosque, M.D., Martinez, M.L., Moreno, O., Barbadillo, S., Tomas, R., Irazabal, M., … Lema, J.	2018
Program to reduce redundant laboratory sampling in an intensive care unit leads to non-inferior patient care and outcomes.	Prospective study (abstract)	University of Rochester Medical Centre	Cahill, C., Blumberg, N., Pietropaoli, A., Maxwell, M., Wanck, A., & Refaai, M. A.	2018
Iatrogenic anemia/Twenty-five million liters of blood into the sewer.	Observational Study	The Netherlands	Coene, K. L. M., Roos, A. N., &Scharnhorst, V.	2015

Blood tests in the intensive care unit: A necessary cost?	Observational Study	Oxford, United Kingdom	Cumber, E., Channon, L., & Wong, A.	2017
Reduction in Number of Reported Laboratory Results for an Adult Intensive Care Unit by Effective Order Management and Parameter Selection on the Blood Gas Analyzers	Quality Improvement Project	Academic Medicine Centre, The Netherlands	De Bie, P. P., Tepaske, R. M. D. P., Hoek, A., Sturk, A. P., & van Dongen-Lases, E. P.	2016
Strategies to reduce inappropriate laboratory blood test orders in intensive care are effective and safe: before and after quality improvement study.	Single centre pre and post-study using multimodal interventions	Royal Brisbane and Women's Hospital 22 bed tertiary academic ICU	Dhanani, J. A., Barnett, A. G., Lipman, J., & Reade, M. C.	2018

A Targeted, Evidence-Based Clinical Decision Support Intervention to Reduce Unnecessary Complete Blood Count Orders	Meeting Abstract, American Society for Clinical PAthology	Emroy University Hospital, Atlanta, Georgia.	Feldhammer, M., Menasco, D., Zhang, W., & Ritchie, J.	2017
Results of a Quality Improvement Project aimed at Eliminating Healthcare Waste by Changing Medical Resident Test Ordering Behaviour		711 bed tertiary hospital New York.	Gupta, S. S., Voleti, R., Nyemba, V., Demir, S., Lamikanra, O., Musemwa, N., …Kamholz, S. L.	2017
The “rainbow” of extra Blood Tubes – Useful or Wasteful Practice	Retrospectiv e study	Conducte d over 6 years at the University of Iowa Hospitals and Clinics	Humble, R. M. B. S., Ms, Hounkponou, H. G. B. B. A., Krasowski, M. D. M. D., &PhD.	2017

Impact of Nursing Education on Phlebotomy Blood Loss and Hospital Acquired Anemia	Quasi-experimental design	20 bed ICU in 376-bed acute care community hospital in the Midwest.	Jones, S. D. N. P. R. N. A. -B. C., Spangler P. D. N. P. R. N. A. -B. C., Keiser, M. D. N. P. R. N. A. -B. C. N. P. C., & Turkelson, C. D. N. P. M. S. N. R. N. C. C.	2019
Anaemia in the ICU – impact of phlebotomy	Single-center, prospective cohort study	Clinical Hospital Sveti Duh, Zagreb, Croatia	Mackovic, M., Maric, N., Udiljak, N., & Bakula, M.	2018
Multipronged strategy to reduce routine-priority blood testing in intensive care patients	Quality improvement initiative	15 bed ICU within a tertiary care hospital in Vancouver, Canada.	Merkeley, H. L., Hemmet, J., Cessford, T. A., Amiri, N., Geller, G. S., Baradaran, N., … Dodek, P. M.	2016
Drop by drop: Rationalising routine blood tests in an intensive care unit	Prospective observational study	6 bed ICU in DGH East Kent Hospitals University NHS Foundation Trust	Mian, A., & Kapoor, R.	2019

Non-essential blood tests in the intensive care unit: a prospective observational study	Prospective observational study	33 bed intensive care unit at a tertiary-care teaching hospital in Ontaria, Canada	Mikhaeil, M., Day, A. G., &Ilan, R.	2017
Reduction of Laboratory Utilization in the Intensive Care Unit	Single centre prospective quality improvement study	Academic 18 bed medical intensive care unit Indianapolis University Health Hospital		
Rational Clinical Pathology Assessment in the Intensive Care Unit	Single centre prospective interventional study in a multidisciplinary ICU	30 bed ICU Liverpool Hospital, Sydney, Australia	Rachakonda, K. S., Parr, M., Aneman, A., Bhonagiri, S., & Micallef S.	2017
Interventions to prevent iatrogenic anemia: A Laboratory Medicine Best Practices Systematic Review	Systematic review and meta-analysis		Whitehead, N. S., Williams, L. O., Meleth, S., Kennedy, S. M., Ubaka-Blackmoore, N., geaghan, S. M., … Graber, M. L.	2019

Laboratory Tests and X-Ray imaging in the Surgical Intensive Care Unit: Checking the Checklist	Quality Improvement Project	18 bed surgical ICU University of Florida College of Medicine, Jacksonville	Yorkgitis, B. K., Loughlin, J. W., Gandee, Z., Bates, H. H., & Weinhouse, G.	2018
Five Things Physicians and Patients Should Question	Guidelines	American Board of Internal Medicine Foundation	Choosing Wisely, An initiative of the American Board of Internal Medicine Foundation	2018

Appendix 2 Frequency of theme occurrence

Table 1: Theme 1 Strategies

Strategies to reduce iatrogenic anaemia	
Code	Number of times coded
Guidelines/Policy/Protocols	6
- **Indications for blood tests**	1
Staff education	9
- **Staff education**	4
- **Lectures to medical staff**	1
- **Targeted education in high use areas**	1
- **Nursing education**	1

- **Formal education for medical staff**	2
- **E-learning**	1
- **Providing information about the cost of tests**	1
- **Multidisciplinary education**	1
Interventions to decrease frequency, sample size and waste	1
- **Once daily blood draws**	1
Standardisation	
- **Standardise amount of blood flushed from central venous catheters**	1
- **Standardised amount of blood withdrawn into gas syringe for BM's**	1
Introduced low volume blood collection tubes	2
Electronic checklists	1
Daily checklist	3
Rubber stamp reminder	1
Reduce the daily blood panel	1
Changed protocol	1
Training to medical and nursing staff	1
Targeting tests	2
Redesigning form	1
Consultant led ordering process	1
- **Involvement of senior colleagues**	1

- **Decision making by the most senior clinician**	1
EMR modification/introduction	1
- **Removed option for daily order sets**	1
- **Automated prompt asking for specification**	1
Blood conservation sampling devices	2
Removed unnecessary point of care testing	1
Daily nursing rounds	1
Orientation and mandatory education about hospital acquired anaemia	1
On demand blood test ordering	1
Artificial intelligence	1
Bundled interventions	1

Table 2: Theme 2 Patient Centred Outcomes

Patient Centred Outcomes	
Code	Number of times coded
Iatrogenic Anaemia (hospital acquired anaemia)	12
Patient discomfort	7
Reduction in transfusion rate	1
False positive results	2
Increased need for transfusion	4
Increased risks associated with transfusions	4

Infection risk	2
Follow up diagnostic tests	2
Prolonged length of stay	3
Incorrect diagnoses and treatment	1
Patient safety	1
Morbidity	1
Adverse patient outcomes	3
Mortality	2
Increased potential for hospital acquired infections due to access of central lines unnecessarily	1

Table 3: Theme 3 Costs

Costs	
Code	Number of times coded
Financial costs	10
Work Overload	5
- **Nursing staff labour**	3
- **Work overload**	1
Lack of staff insight into costs	1
Organisational burden	2
Cost of transfusion	1
Time cost discussing unnecessary tests	1

Wasteful spending	1

Table 4: Theme 4 Problems/Barriers Identified

Problems/Barriers Identified	
Code	Number of times coded
ICU Culture	1
Habit	1
Duplication of tests between laboratory and point of care tests	3
Nursing workload	1
Time constraints on the decision maker	1
Variability between physicians	1
Knowledge deficit	1
Central venous catheters associated with more pronounced change in Hb	1
Sustaining success	1
- **Guidelines developed based on consensus**	1
Cultural shift	1
Stakeholder engagement	1
Team factors	1
Process factors	1
No explicit guidelines	2
Busy ICU environment	1

Competing demands on clinician's attention	1
Routine ordering	1
ICU specialist consultation	1
Catheter associated infection with blood sampling devices	1
Physician uncertainty	1
Lack of physician experience	2
Failure to understand costs associated with excessive testing	1
Reflex ordering	1
Checklist fatigue	1
Excess ordering	1
Nursing buy in	1
Strategies continuous and reinforced, results celebrated	1

Appendix 3 Highlights of occurrences

Key to Table 8: Themes and Colour Codes

1. PATIENT OUTCOMES -

a. Patient centred outcomes

b. Consequences of unnecessary investigations

2. COSTS - Costs associated with unnecessary blood tests

3. BEHAVIOURS- Barriers to change identified

4. STRATEGIES - Strategies to reduce iatrogenic anaemia

5. MISCELLANEOUS

TITLE	KEY FINDINGS	CODING
Less is More: 'not to do' recommendations in the intensive care unit Bosque, M.D., Martinez, M.L., Moreno, O., Barbadillo, S., Tomas, R., Irazabal, M., … Lema, J. 2018	Unnecessary/unjustified blood tests leading to patient discomfort, work overload and increase in cost. This preliminary observational study was in a 16 bed ICU in Spain. They compared with the Ministry of Health for Spain's project Commitment for Quality, which produced 'not to do' recommendations with the Spanish intensive care society. These recommendations are: 1. Do not continue with empirical antibiotic treatment without assessing daily its need and possible de-escalation 2. Do not perform blood tests routinely 3. Do not perform chest x-rays routinely 4. Do not maintain isolation measures when they are no longer needed 5. Do not transfuse RBC in haemodynamically stable, non-bleeding, critically ill patients, without cardiological or central nervous system involvement with Hb greater than 7g/dl They interviewed physicians and reported compliance with the recommendations. 15% had routine blood tests and 3.5% had routine chest radiographs. This can lead to patient discomfort, work overload and increase in costs.	Unnecessary blood tests Increased costs Work overload Patient discomfort

Program to reduce redundant laboratory sampling in an intensive care unit leads to non-inferior patient care and outcomes.	Laboratory sampling in ICU patients accounts for blood loss of 50-90ml/day/patient. This exposes ICU patients to higher risk of anaemia. This may contribute to increased rates of transfusion, complications, and higher health care expenditures. It has been report that up to 42% of laboratory expenditure may be considered wasteful. In the US it is estimated to cost nearly $5billion/year. A laboratory sample reduction guideline was developed for use in the critically ill. Interventions were to decrease frequency, sample size and reduce waste, as well as incorporate iatrogenic anemia focus into ICU culture, as well as education. There was a significant reduction in laboratory ordering, blood sampling and point of care testing. There was no significant difference in average MICU length of stay. The RBC transfusion rate was similar between both groups.	Blood loss Iatrogenic anaemia Increased rates transfusion Guidelines Staff education Interventions to decrease frequency, sample size and waste Cost ICU culture

Iatrogenic anemia/Twenty-five million liters of blood into the sewer.	Especially in vulnerable populations such as the critically ill, iatrogenic anaemia can be a significant problem. During the average ICU stay of 3.5 days, 140mL of blood is lost for laboratory purposes. The risk for developing iatrogenic anaemia was demonstrated to increase by 20% with each 50mL of collected blood. Flushed volume taken from central lines contributes to blood loss for phlebotomy. There is a high variation between nurses in the flushed volume – between 13.8mL to 0.8mL. 5mL sufficient to flush the line. Blood gas glucose measurement were monitored frequently using point of care testing. However, the blood was not taken via fingerstick but using a gas syringe. The filling volume of gas syringes is highly variable between different nurses also. This study introduced low volume blood collection tubes – they were a similar size but with a smaller vacuum. They instructed nurses to flush central lines with 5mL of blood, and to fill blood gas syringes with 0.2mL of blood. This led to an average daily reduction of blood loss per ICU patient of 10mL, which equals a reduction of 25%. They showed a reduction in amount of erythrocyte transfusion requirement by 15%, 12 months after these strategies were introduced.	Iatrogenic anaemia Interventions Standardise amount of blood flushed from central venous catheters. Standardised amount of blood withdrawn into gas syringe for BM's. Introduced low volume blood collection tubes. Reduction in transfusion rate

Blood tests in the intensive care unit: A necessary cost?	Tests are often requested by nurses on a daily basis with no clinician input as a matter of routine. These include clotting, full blood count, urea and electrolytes, CRP and liver function. The authors propose this is potentially costly, clinically unnecessary and may be driven by a lack of understanding of the cost implications. They obtained the costs for each test, looked at how many tests were run per patient on average, and extrapolated these findings. They found that on average patients have 3.7 laboratory blood tests and 7.3 point of care tests per day. That averaged to a total cost of £362,587.80 per year (£266,841 was point of care testing). They surveyed their staff and found a complete lack of insight into test costs. It was felt that clotting is requested most often despite previously normal results. Requesting clotting once every 3 days instead of daily would save £23,360 a year. Removing calcium from daily requests would save a further £2890. Using clinical judgement to break the habit of daily routine blood requesting could save significant amounts of money. The process could be enhanced through use of electronic checklists which could have financial benefit without any impact on patient safety.	Cost Lack of staff insight into costs of tests Habit Electronic checklists Duplication of tests between laboratory and point of care tests

Reduction in Number of Reported Laboratory Results for an Adult Intensive Care Unit by Effective Order Management and Parameter Selection on the Blood Gas Analyzers	Overutilization of laboratory investigation…without demonstrable benefit effects to the patient. Obscuring of the actually relevant data by superfluous ones. Changes to medical protocols: 1. Daily morning blood panel reduced (albumin, urea, calcium, chloride, and C reactive protein omitted) 2. Postoperative cardiothoracic surgery care. Creatine kinase, creatine kinase MB isoenzyme, prothrombin time/INR, aPTT, and thrombocytes are requested upon admission and subsequently after 3 hours. These are now requested every 3 hours until a decrease is seen (previously every three hours). PT is now only requested during morning laboratory round or aPTT is requested every 6 hours. Troponin T is no longer standard included in cardiac care protocol. 3. Continuous renal replacement therapy protocol. Measurement of urea is omitted from the daily monitoring and renal replacement protocol. Creatinine only requested as part of morning round laboratory investigations rather than twice per day. An elaborate training program was offered to the medical and nursing staff of the ICU. They demonstrated a decrease in 24% in the number of results reported by the central laboratory. The training of the nursing staff seemed to have a profound effect	Unnecessary blood tests Obscuring relevant data with superfluous results Reduced the daily blood panel Changed protocols for postoperative cardiothoracic surgery to rationalise and reduce tests requested CRRT protocol changed to omit the measurement of urea on the daily monitoring. Creatinine requested once daily as part of morning panel. Staff education Training to medical and nursing staff of ICU

	as several parameters that were not part of the adjusted medical protocol were requested to a much lesser extent than before the intervention e.g. magnesium requests were reduced by approximately 50%. New order management for the blood gas analysers.	

Strategies to reduce inappropriate laboratory blood test orders in intensive care are effective and safe: before and after quality improvement study.	ICU treatment comes at a substantial opportunity cost to the rest of the healthcare system. Pathology tests account for at least 5% of total care cost. Between 30% and two-thirds of laboratory testing in hospital is likely wasteful. Higher frequency of testing introduces greater risk of false-positive test results. Unnecessary testing also leads to unnecessary blood loss through phlebotomy, causing clinically significant anaemia and transfusion requirement. Transfusion and associated complications are well known. Additionally, there may be other costs of transfusion such as infection risk, nursing workload, and patient discomfort. Substantial financial burden of daily unnecessary laboratory testing. Multimodal strategy including education, modification of the laboratory test ordering form, senior medical staff-guided ordering, and implementation of a change management strategy. Coagulation screen and biochemistry panel were identified as the tests to be targeted for patient specific indications alone. Redesigning the laboratory form – tick boxes to limit ordering. Medical staff education. There was poor understanding of the costs of the various test panels. Patients transferred from other units often had tests that had already been performed earlier the	False positive results Higher risk of transfusion and associated risks Infection risk Nursing workload Patient discomfort Unnecessary blood tests Multimodal interventions: Review and targeting tests Redesigning the laboratory form Medical staff education Consultant intensivist-led ordering processes Intensive monitoring Duplicate/repeated tests

	same day needlessly repeated. Comprehensive orientation program for juniors. Forums used were routine weekly administrative staff meetings, scheduled education sessions, email and posters. Consultant intensivist-led ordering practices. The intensivists planned the next day's laboratory test ordering during their afternoon ward round. ICU senior registrar could add tests if indicated.	

A Targeted, Evidence-Based Clinical Decision Support Intervention to Reduce Unnecessary Complete Blood Count Orders	Frequent phlebotomy can put patients at risk for iatrogenic anemia, infection, or additional unnecessary testing…guidelines… advise against serial blood counts on stable patients. Analyzed past ordering practices and identified that repeat complete blood counts (CBC) on patients admitted to internal medicine were responsible for most repeat CBC orders. Created a list of indications for appropriate repeat CBC orders within 23 hours. Showed that 27% of repeat orders were unnecessary and 45% of repeat orders within 23 hours were unnecessary. Notified clinicians if ordering a repeat CBC within 23 hours or if there was an outstanding CBC order. 15% of alerts clinicians cancelled CBC order. The volume of testing did not significantly alter.	Unnecessary blood tests Iatrogenic anemia Risk of Infection Additional unnecessary testing acting on results Guidelines advise against routine blood tests in stable patients EMR modification to notify if ordering repeat within 24 hours

Results of a Quality Improvement Project aimed at Eliminating Healthcare Waste by Changing Medical Resident Test Ordering Behaviour	Results of unwarranted lab tests prompt follow-up diagnostic tests, prolong length of hospital stay, and promote unnecessary referrals/procedures, patient discomfort, and iatrogenic anemia. Blood tests often ordered by interns who may ‘ not be able to determine the ideal frequency for monitoring specific parameters’. Busy inters face time constraints that make it difficult to weight the rationale for each individual test. Attending physician variability. Targeted complete blood count, basic metabolic profile and coagulation profile. Included patients admitted to internal medicine. Lectures for residents outlining the high value cost conscious care approach to lab ordering and introduced an algorithm designed by the study team. They conducted regular surveillance and assessed progress. Primary outcome was mortality. Secondary end points included changes in laboratory costs and changes in length of stay. Results showed a 5.3% mortality rate in pre-intervention phase and	Patient Outcomes Follow up diagnostic tests Prolonged length of stay Patient discomfort Iatrogenic anemia Greatest benefit in hospice patients where blood tests wont necessarily affect management Costs False positive tests Organisational burden Unnecessary referrals/procedures Time constraints on the decision maker Variability between physicians Interventions - Lectures to residents

	5.8% mortality rate in intervention phase (P = 0.44). Complete blood count orders decreased by 9.3%, basic metabolic panel orders by 12.4%, and coagulation panel by 20.6%. This resulted in a cost saving of $21,400. Extrapolation to a full year yielded an estimated $85,600 savings per year. Eliminates false positive results and unnecessary downstream testing. Benefits to patient include elimination of painful phlebotomy attempts and associated complications such as haematomas, superficial vein thrombosis, and skin infections. 'The elimination of excessive venepunctures is perhaps of greatest benefit in hospice patients, since diagnostic lab testing did not necessarily improve outcomes and cause discomfort. ' Small increase in length of stay (0.8 day) observed, but there were other factors during the study period which may have accounted for this.	

The “rainbow” of extra Blood Tubes – Useful or Wasteful Practice	This study observed that often one blood tube of each color is drawn from the patient just in case an extra test needs to be added on. There is virtually no peer-reviewed literature on this. During the study period, 370,601 extra blood tubes were collected. Overall, only 7.0% of the extra tubes were used for add-on testing. Extra serum tubes were used for add-ons in less than 0.4% of the cases for the ED, outpatient and inpatient units. Electronic requesting was implemented during the study period, which required an additional electronic request to be generated if an extra tube was required. Two clinics with very high extra tube usage were identified and through collaboration with the laboratory and medical and nursing leadership, reduced the extra tube usage. ‘Excessive use of extra tubes may contribute to iatrogenic anemia, patient discomfort, and risk of biohazard exposure. Extra tubes also consume phlebotomy and laboratory resources.’ Ongoing education and changes in the electronic medical record may help address the use of extra tubes.	Iatrogenic anemia Patient discomfort Risk of biohazard exposure Wasteful use of phlebotomy and laboratory resources Education in areas where there was high extra tube usage Electronic Medical Record introduction

Impact of Nursing Education on Phlebotomy Blood Loss and Hospital Acquired Anemia	This paper defines phlebotomy blood loss (PBL) as including the 'blood drawn from patients for diagnostic studies and blood discarded from central venous and arterial lines before sampling to prevent hemodilution and mixed samples.' Current guidelines for blood conservation strategies (BCS's) recommend the use of blood conservation sampling devices (BCSDs) to reduce phlebotomy associated blood loss. BCSDs proven to help 'decrease rates of PBL by up to 70ml over a 72hour period.' They have 'also demonstrated a statistically significant reduction in Hgb level decrease between ICU admission and discharge.' One study quoted had a 48% reduction in PRBC transfusion requirements in patients with a BCSD. They identified several main themes from the available literature: 1. Phlebotomy blood loss (PBL) contributes significantly to hospital acquired anemia 2. Hospital acquired anemia (HAA) is a significant problem in the critically ill population associated with increased hospital length of stay and increased mortality 3. Blood conservation sampling devices are underused in target populations 4. Knowledge deficits exist among healthcare providers regarding the impact of phlebotomy blood loss and blood conservation strategies with regard to hospital acquired anemia	Iatrogenic anaemia Patient outcomes associated with increased hospital length of stay and increased mortality increased rate of transfusions increased risks associated with transfusions Costs cost of transfusions Interventions Blood conservation sampling devices Nursing education about BCSs and BCSDs using change theory Findings support value of dedicated BCS education to nurses focusing on PBL and HAA to promote increased BCSD utilization to decrease central and arterial line phlebotomy waste Recommend daily nursing rounds to

Anaemia in the ICU – impact of phlebotomy	Iatrogenic anemia defined as lowered Hb due to large/frequent veneuncture. Decline in Hb most pronounced in first 3 days of ICU stay. It correlates with need for RBC transfusion. No significant association of change in Hb with overall survival. Central venous catheter presences associated with a more pronounced change in Hb.	Iatrogenic anaemia Correlates with need for transfusion Interventions Central venous catheters associated with more pronounced change in Hb

Multipronged strategy to reduce routine-priority blood testing in intensive care patients	Routine-priority diagnostic tests that are not based on a clinical question or intention to change management contributes significantly to the problem of waste in healthcare. Unnecessary blood draws contribute to anemia and the need for transfusion of red blood cells. Minimizing routine priority blood tests can be cost saving and does not adversely impact patients care. Minimizing blood draws can decrease transfusion requirements, and therefore, adverse outcomes associated with transfusing critically ill patients. Several interventions identified and implemented - Developed accepted indications for blood tests - Formal education for rotating ICU residents, fellows and staff physicians - Item added to daily rounds ICU checklist - A rubber stamp reminder that read “routine blood work NOT indicated for tomorrow” - Multipronged strategy to reduce routine-priority blood testing in intensive care patients An automated prompt on computerized orders compelling staff to specify accepted indication - A second educational session for rotating ICU residents Results	Wasted healthcare resources Cost saving Financial Nursing staff labour Cost of time taken discussing unnecessary tests Intervention does not adversely impact patients care Indications developed in partnership with all staff physicians based on consensus Interventions Developed accepted indications for blood tests Formal education for rotating ICU residents, fellows and staff physicians Item added to daily rounds ICU checklist A rubber stamp reminder that read “routine blood work

	- Total number of CBC decreased from 1/35 to 1.23 per patient-day (15%) - Total number of electrolyte/renal panels decreases from 1.27 to 1.18 (13%) - This translates to a cost saving of $11200.24 canadian dollars per year - Not associated with adverse patient outcomes (increased length of stay or mortality)	NOT indicated for tomorrow” An automated prompt on computerized orders compelling staff to specify accepted indication A second educational session for rotating ICU residents Cultural shift away from ordering unnecessary routine-priority blood tests Engagement of stakeholders

Drop by drop: Rationalising routine blood tests in an intensive care unit	Some blood tests are done 'by default without any clinical indication'. Inappropriate use of blood tests contributes to anaemia, may lead to incorrect diagnoses and treatment as well as increasing cost. Rationalising blood tests can…significantly reduce laboratory costs but also reduce workload without compromising patient safety. Intervention: introducing a paper-based blood test request form for ICU with the aim of the clinician choosing specific blood tests that were required the following day. 38.5% reduction in blood tests per patient 60% less LFTs done. Total cost of unnecessary blood tests was reduced by almost 50%. No complications associated with the reduction in blood tests were noted, (but the paper doesn't say what complications they looked for).	Blood tests without clinical indication Inappropriate blood tests Anaemia Incorrect diagnoses and treatment Cost Reduce workload without compromising patient safety. Substantial cost savings with causing negative outcomes for the patient.

Non-essential blood tests in the intensive care unit: a prospective observational study	Non-essential blood testing in the acute care setting can be a prominent source of morbidity, patient discomfort, increased workload….and wasteful spending. This study asked ICU physicians what blood tests they considered essential for their patients, then compared it to what blood tests were actually carried out. Technological advancements have contributed to increasing costs – some estimated to be 25-30% due to wasteful practices. This study tried to quantify the extent of non-essential blood testing. They also tried to estimate additional costs incurred by performing non-essential blood tests. No explicit common acceptable process identified for discussing and ordering lab tests for the following morning. Asked attending physicians “what blood tests do you consider to be essential for tomorrow morning to maintain appropriate care for this patient?” Hypothesize that process and team factors are major reasons for the observed results.	(patient) Morbidity Patient discomfort Increased workload Wasteful spending Blood tests overprescribed without adding value – this may be harmful Hospital induced anemia, need for transfusion, discomfort, work overload and added cost. Unnecessary phlebotomy Team factors Process factors No explicit guidelines Busy ICU environment Multiple and competing demands on clinicians attention Not considered additional costs such as lab processing charges, intravenous

		access equipment, test tubes, and other technological and human resource. Increased phlebotomy can lead to adverse patient outcomes

Rational Clinical Pathology Assessment in the Intensive Care Unit	No widely accepted guidelines 87% of blood tests routinely ordered in ICUs in Australasia Of these 46% of units have specific guidelines and only 37% followed ICU specialist consultation. In the background of this paper the authors mentioned several strategies that have been used previously to reduce blood tests in the ICU-including an on demand strategy, artificial intelligence, an e-learning tool, movement of senior colleagues, providing information about the cost of tests, and a written guideline. The average monthly cost of laboratory tests for ICU was AU$210,000. Strategies included senior clinician authorisation of test, rationalisation of high-volume test orders, displaying test costs at the bedside and education of staff and the relevance of testing the clinical context. Total laboratory costs were reduced by 12.3%. The cost of high-volume test was reduced by 20%. Blood gas analysis contributed most to the overall cost (17%) followed by simple chemistry (14%), coagulation tests (12%) and full blood count (11%). A 4.8% reduction in the contribution of high volume tests translated into an overall cost reduction of 12.3%. Transferring decision-making to the most senior person managing patient care resulted in a reduction of blood tests in the study. This study suggested that	No guidelines Routine ordering ICU specialist consultation Ordering blood tests on demand Artificial intelligence E-learning Involved of senior colleagues Information about the cost of tests Written guidelines Education of staff Transferring decision making to the most senior clinician Targeting high-volume tests

	rationalise ordering may help further reduce the need to add on test orders.	

Interventions to prevent iatrogenic anemia: A Laboratory Medicine Best Practices Systematic Review	Evaluated the efficacy of interventions to reduce phlebotomy related blood loss, haemoglobin levels, transfusions, and instance of anaemia. Iatrogenic anaemia… Is a universal concern among critically ill patients. Much of the blood drawn for laboratory testing is discarded. Small volume tubes have been found to reduce the total volume of blood drawn per patient per day. It has been hypothesised that perhaps iatrogenic anaemia is in fact due to impaired arrest). However mathematical modelling suggest that it would take 40 to 70 days of 53 mL per day of blood loss for adults with a normal bodyweight normal haemoglobin at admission and active erythropoiesis to become anemic. The models indicate that typical ICU patients who are exposed to increased phlebotomy made a client of 70 g/L or less by 9 to 14 days. Many ICU patients require transfusion which can increase the risk of infection, vascular overload, lung injury, sensitisation and transfusion reaction. “the best strategy is to prevent the phlebotomy of anaemia from the start”. Interventions to minimise phlebotomy blood loss include non-invasive testing, blood conservation devices and techniques, point of care testing, and education or decision support tools to guide testing decisions. This systematic review asked the following questions with regards to interventions to minimise phlebotomy related blood loss and iatrogenic anaemia. Does the intervention - reduce the volume of blood drawn?	Iatrogenic anaemia Transfusion need Blood discarded Small volume blood tubes Transfusion risks – infection, vascular overload, lung injury, sensitisation and transfusion reaction. Closed blood sampling devices Point of care testing Staff guidance Bundled interventions Patients with anaemia have poorer outcomes and increased risk of mortality Barriers to intervention – catheter associated infection with blood sampling devices Lack of consistency with reported outcome measures Limited clinical value of blood tests

Laboratory Tests and X-Ray imaging in the Surgical Intensive Care Unit: Checking the Checklist	Introduced two questions to daily ICU checklist, asking 'Is a CXR needed for clinical management tomorrow?' and 'What laboratory tests are medically necessary for tomorrow?'. Advertised this with a poster in clinical fellows office, displaying professional society recommendations from American Board of Internal Medicine's Choosing Wisely campaign. Total of 307 patients. They did not measure adverse outcomes. They did not identify any statistically significant change in test ordering. They conclude that providing these guidelines to experienced clinicians only, to avoid adverse outcomes if less experienced clinicians begin ordering less tests. They suggest checklist fatigue may have been a factor, they could not ensure the checklist was being performed, and that tests were already being ordered at a minimalist level.	Overuse of testing Physician uncertainty Lack of experience Hospital Protocols Failure to understand costs associated with excessive testing Reflex ordering Iatrogenic anemia Patient discomfort Positive/spurious results that lead to further testing Additional burden on healthcare system Increased costs Extraneous biohazardous waste Unnecessary testing Checklist Checklist fatigue

Reduction of Laboratory Utilization in the Intensive Care Unit	Health expenditure is becoming a growing concern in the US. ICU care is roughly 4 times more costly than regular care. These costs can be attributed to multiple factors…excess ordering of laboratory tests and chest radiographs. Unnecessary and/or inappropriate ordering of laboratory tests is widespread. Physician dependent. The authors believe this is due to lack of transparency of point-of-are versus central laboratory costs and modalities. Can lead to increased workload on nursing staff and increased potential for hospital acquired infections. May be more prevalent in academic hospitals where less experienced house staff are responsible for ordering. This article aimed to describe the initiative undertaken at Indiana University Health University Hospital medical ICU, through combination of physician education and change in electronic medical record design. Interventions were as follows: 1. Removed the daily laboratory labs options 2. Placed a 24 hours time limit of scheduled laboratory test results (e.g. lactic acid every 6 hours for 24hours) 3. Routine Laboratory tests ordered during morning rounds were drawn at 1400 each day 4. They removed various cartridges from their POCT	ICU particularly expensive care setting Excess ordering of lab tests Increased workload on nursing staff Increased potential for hospital acquired infections due to access of central lines unnecessarily. Less experienced staff likely to order more unnecessary and/or inappropriate tests Removed option for daily order sets on electronic medical record Removed unnecessary point of care tests Routine blood draws to once daily Checklist Multidisciplinary education Nursing buy-in

	machine to allow just ABGs to be run 5. Added laboratory and chest X-ray order review to the daily rounding checklist 6. Educated residents and staff about laboratory costs and posted a list of costs in the MICU. Education was in the form of e-mails and flyers They also estimated the 'blue dollar' or nursing time costed doing unnecessary tests. Physician and house staff education seems to have short-lasting effects but the biggest effects seen are with EMR and order set alterations. The protocol did not alter morbidity, mortality or length of stay. The extrapolated cost savings for the laboratory test reductions were US$123,436, and the blue dollar indirect cost savings related to nursing time totalled US$258,035. They believe their simple yet comprehensive approach was successful because it involved education, nursing buy-in and involvement, modification of laboratory tests and chest radiograph EMR orders including admission order sets, and removing unnecessary point of care testing. They showed a 32% reduction in unnecessary laboratory test ordering. They note that their protocol did not result in a reduction in blood transfusion rate, but hypothesize that switching to pediatric size tubes might lead to a reduction in blood transfusion rates. They believe their sustained success may also	Strategies were continuous and reinforced, results were celebrated

	be due to the fact that their education was implemented for physicians, house staff, nurses and respiratory therapists. It was continuous, reinforced on a monthly basis and results were always celebrated over time. Additionally, they had ‘major nursing involvement’, which helped reinforce the importance of reviewing test ordering on a daily basis at the bedside. They acknowledge their protocol may not work elsewhere, as they are a ‘tightly knit medical ICU’, so they do not know if their results would be replicable in open ICU’s (medical and surgical).	

Choosing Wisely campaign American Board of internal medicine	‘Don’t perform laboratory blood testing unless clinically indicated or necessary for diagnosis or management in order to avoid iatrogenic anaemia’ Up to 90% of patients become anaemic by day 3 in ICU. A significant number of tests are inappropriate or unnecessary. Anaemia secondary to iatrogenic blood loss causes an increased length of stay and mortality. Also increases the odds for transfusion and its associated risks. Unnecessary testing also adds to the cost of care through laboratory test charges and also by increasing downstream costs due to unnecessary interventions, prescriptions etc. Testing should not be performed in the absence of clinical indications.	Iatrogenic anaemia Unnecessary blood tests Increased length of stay and mortality Increased odds of transfusion and associated risks. Increased costs Clinically indicated tests only

Appendix 4 Workshop Guide

CO-DESIGN WORKSHOP GUIDE

This document provides information about the co-design online workshop

Date: 11th January

Time: 1300-1400

Venue: Online via Microsoft Teams

Plan for the workshop:

Time	Activity
13:00 – 13:05	Brief Introduction & Workshop Overview
13:05 – 13:15	Overview of previously collected data
13:15 – 13:30	Task 1: Problem Tree
13:30 – 13:45	Task 2: Discussion
13:45 – 14:00	Closing remarks & de-brief

Please have at hand: Pen and paper for any individual note taking. **Although ideally, you will mainly discuss and contribute to the tasks using your microphone.**

What to expect?

- Brief Introduction by myself & a workshop overview using PowerPoint slides (I have also attached these via e-mail just in case they do not work during the day)
- Overview of previous collected data – I will provide an overview of my previous findings & hopefully help prompt discussion for **Task 1**
- **Task 1:** Problem tree. Using the previous collected data & your own thoughts, you will be encouraged to discuss key **problems**
- **Task 2:** Discussion. During task 1, key problems were discussed. Using these key problems, we will further discuss them.

- **Closing remarks:** I will conduct a de-brief and allow you to ask any questions or express any concerns you may have

If you were to have any problems before or after the workshop, my contact details are as follows

After the workshop ends: Please send me any notes you have taken throughout via e-mail

Thank you for taking part!

Appendix 4 Workshop Presentation

INTRODUCTIONS

- Dr Ffyon Davies
  - A&E Clinical Fellow
- Dr Sion Williams
  - Facilitator

WORKSHOP OVERVIEW

- What is the main purpose of the workshop?
  - Explore some of the reasons why we do routine blood tests and strategies to reduce them
  - It is not to solve all the problems
- Consent: This workshop will be video and audio recorded
- Overview of previous data
- Task 1
- Task 2
- Debrief

OVERVIEW OF PREVIOUS DATA

PATIENT CENTRED OUTCOMES

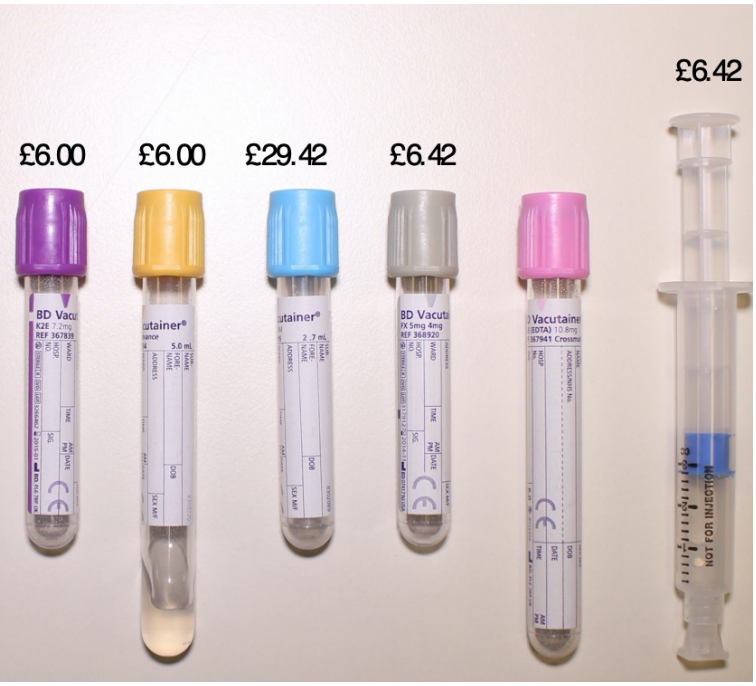
- **Iatrogenic anaemia**
- Increased need for **blood transfusion**
- Increased **length of stay**
- Increased **mortality**
- Positive correlation between **organ dysfunction**, number of blood draws and volume of blood drawn ($p<0.0001$)

PATIENT CENTRED OUTCOMES

- **Iatrogenic anaemia**
  - 90% of ICU patients become anaemic by day 3
- Volume of phlebotomy is a strong predictor of Hb
  - 41.1ml/patient/day on average
- Multifactorial pathogenesis but there is a significant contribution from phlebotomy

COSTS

- One UK study in ICU estimated that **£362,587.80** was spent on blood tests, of which **£266,841** was POCT
- Requesting coag every 3 days instead of daily would save **£23,360/year**
- Calcium is duplicated on POCT. Removing it from daily requests would save **£2890**



CONSEQUENCES OF ROUTINE BLOOD TESTS

- Many are unnecessary, costly and don't contribute to clinical decision making
- Waste of phlebotomy, laboratory and POCT resources
- Nursing Workload
- Obscuring relevant data with superfluous results
- Risk of biohazard exposure
- May lead to additional unnecessary testing

No explicit guidelines

Routine/habit/ reflex ordering

Cognitive offloading

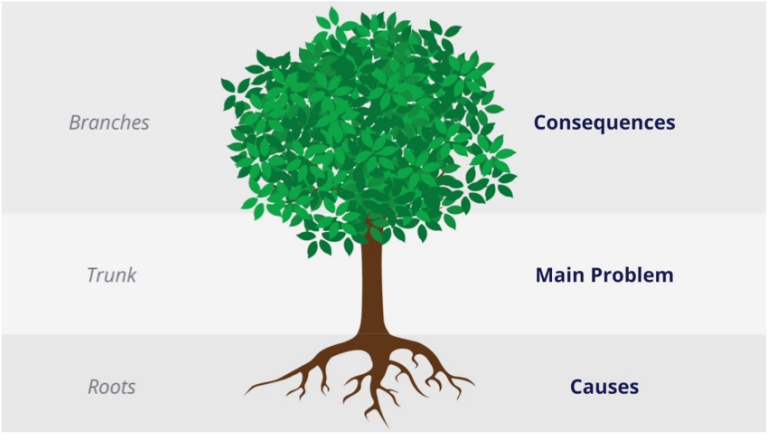
Increased ordering by less experienced clinicians

RATIONALE/BEHAVIOURS IDENTIFIED – WHY DO WE DO ROUTINE BLOOD TESTS?

STRATEGIES TO REDUCE UNNECESSARY BLOOD TESTS

- Guidelines
- Standardisation
- Staff education
- Low volume blood tubes/paediatric blood tubes
- Modify daily blood panel
- Consultant led ordering process
- Incorporated into daily checklist
- Bundled interventions most effective
- Blood conservation sampling devices

TASK 1: ROUTINE BLOOD TESTS PROBLEM TREE

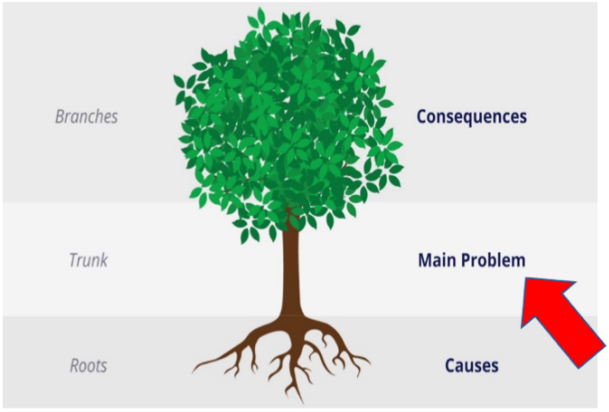


TASK 1: WHAT IS A PROBLEM TREE?

Group activity… Total of THREE steps!

- **STEP ONE:** 'Main problem' The trunk of the tree… 1. What are the main problems?
- **STEP TWO:** 'Causes' The roots of the tree… 2. What are the causes of the main problems?
- **STEP THREE:** 'Consequences' The branches of the tree… 3. What are the consequences of the main problems?

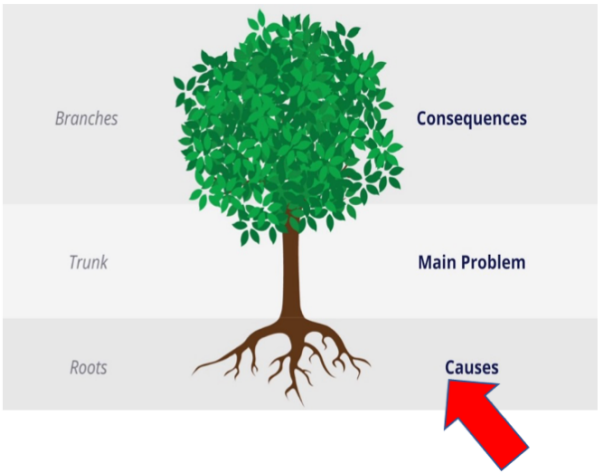
TASK 1: PROBLEM TREE, PART 1. THE MAIN PROBLEM(S)



PART 1: Focusing on the 'main problem' of the tree & of routine blood tests in ICU **In your experience, what are the main problems?**

You can refer to the previous collected data.

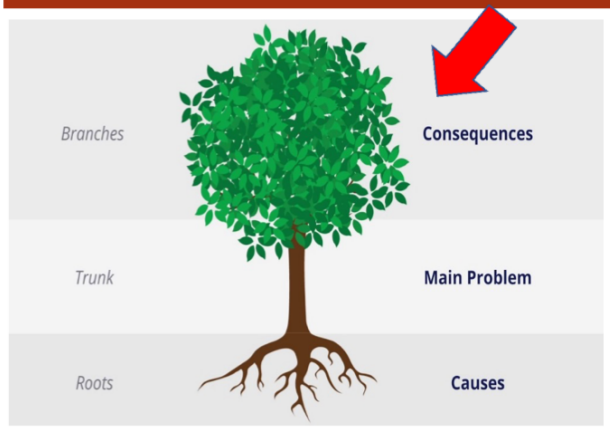
TASK 1: PROBLEM TREE, PART 2. THE CAUSES



PART 2: Focusing on the 'causes' of the tree & routine blood tests in ICU

In your experience, what are the causes of the 'main problems' mentioned above?

TASK 1: PROBLEM TREE, PART 3. THE CONSEQUENCES



PART 3: Focusing on the 'consequences' of the tree & routine blood tests in ICU

In your experience, **what are the consequences of the 'main problem(s)' mentioned above?**

TASK 2: DISCUSSION

- What did we gather?
- What important points were raised?
- Does this tree represent reality?

DEBRIEF

- Any questions or concerns? Contact:
  - Dr Ffyon Davies: ffyon.davies2@wales.nhs.uk
  - Dr. Sion Williams: sion.williams@bangor.ac.uk
- Please send me any notes you have from the workshop

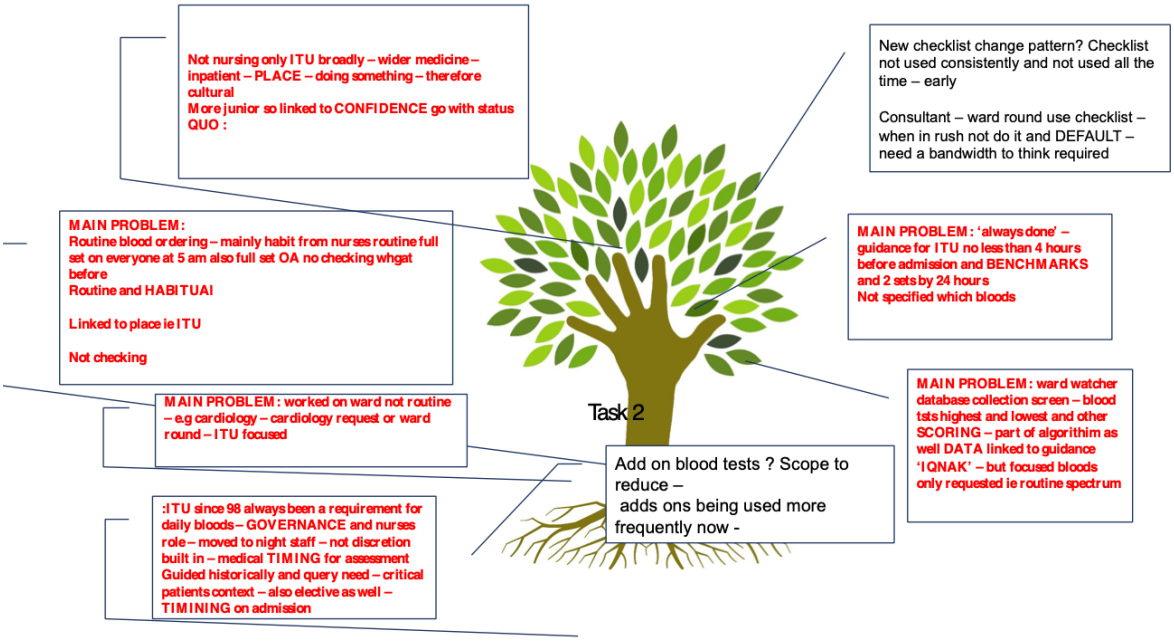
REFERENCES

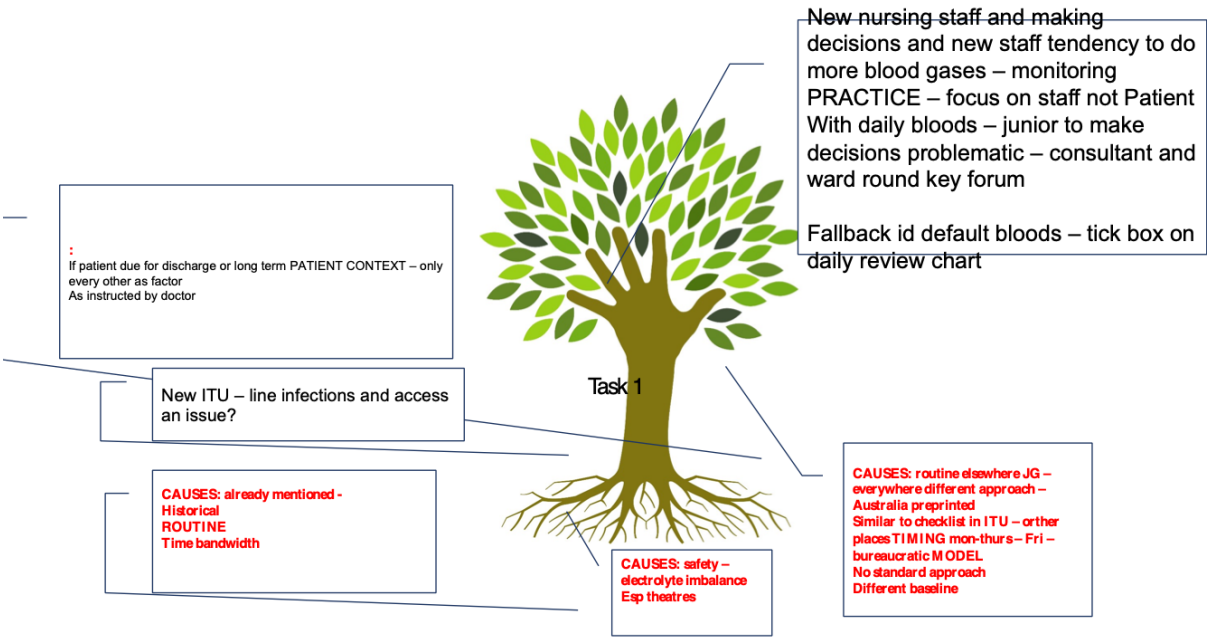
- Image 1, Problem Tree: https://i.ytimg.com/vi/-j-_Y7D35H4/maxresdefault.jpg

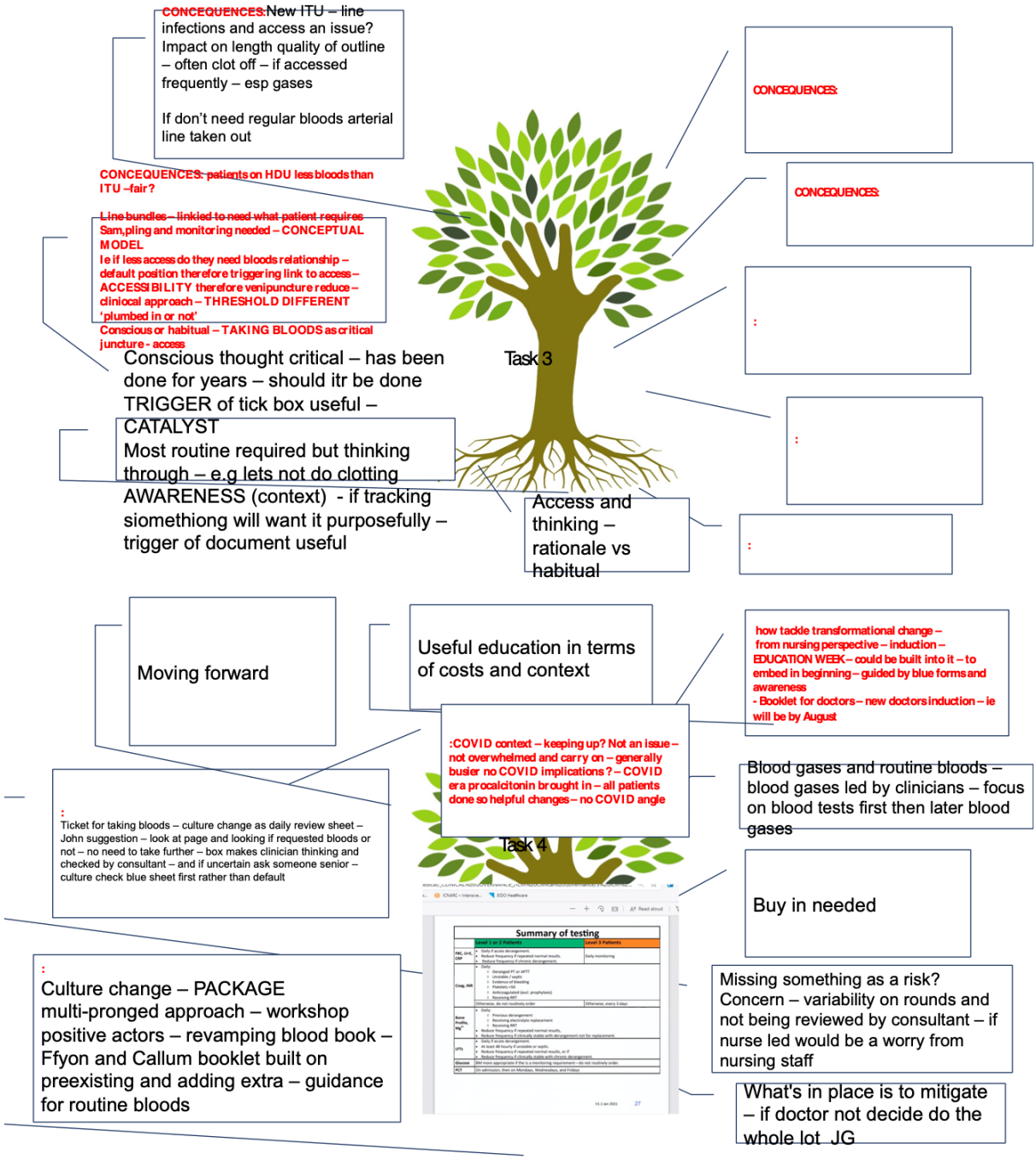
- Figures: Emma McLorie, 2020

- Candelo, C. R., Ortiz G. A. R. and Urger, B. (2003), Organising and running workshops, WWF - InWEnt (DSE) – IFOK, Colombia, ISBN 958-95905-4-3

Appendix 4 Tutor Feedback on Workshop







Workshop References

- Image 1, Problem Tree: https://i.ytimg.com/vi/-j-_Y7D35H4/maxresdefault.jpg
- Figures: Emma McLorie, 2020
- Candelo, C. R., Ortiz G. A. R. and Unger, B. (2003), Organising and running workshops, WWF - InWEnt (DSE) – IFOK, Colombia, ISBN 958-95905-4-3

Appendix 5 Transcribed Workshop

Participants: Sion Williams, Ffyon Davies, John Glen (joined after intro), Kerry Angus, Lynne Slater (joined after intro), Nathan Littley

Ffyon ….first part of my thesis, and then we'll go through a couple of tasks which are just aimed to sort of structure discussion around it, and then a quick debrief at the end.

Thank you very much, both of you for taking the time to take part, and I will adequately reward you in some way.

Really appreciate you giving your opinion on this for me.

So first of all, an overview of the previous data.

So. The main themes that came out of the scoping review that I've done on this particular topic was that the main outcome of routine blood tests was that iatrogenic anaemia in critically ill patients in ICU.

There's an increased need for blood transfusion, length of stay, and mortality also associated with routine blood tests.

There's also a correlation with organ dysfunction and the amount of blood that we draw from our patients with a statistically significant P value on that as well.

2 seconds just got John Glen giving me a quick message.

So, aside from the patient centered well continuing with the patient centered outcomes, each unit of blood that we *transfuse (corrected)* is approximately just over 525 millilitres.

And when you compare that to how much the average patient loses on ITU every day, that's about 40mls per day, so it only takes 10 days or so before you are starting to look at them having lost nearly a unit of blood by that point. So it does get quite significant. And it's quite a striking statistic that 90% of ICU patients become anaemic by day 3.

Obviously it's quite difficult to separate this out from all the other reasons that somebody becomes anaemic, but it is clear from the literature that we make a significant contribution to patient anaemia through blood draws and routine blood tests as well.

So aside from the patient outcomes, there's also the costs to factor into this. So one UK study estimated its over £300,000 that gets spent on blood tests and interestingly most of this is point of care testing, so that's blood gas analysis.

Coag is also a particularly expensive blood test and could easily save the hospital over £20,000 a year if they just did it every three days instead of every day.

And you do end up asking yourself how, how often a daily coag actually influences what you do with the patient?

Calcium is also duplicated on a bone profile and the U's and E's that we send off and the blood test also. Just removing that duplication would also make a big difference, so you can see from the figures there, that coag is extraordinarily expensive nearly £30 per bottle and everything else is around the £6 per bottle mark, but I had no idea of these costs before I started looking into this. So it's quite interesting to see how much each bottle roughly costs.

Not only are there the patient outcomes and the costs of these blood tests, but many of these are unnecessary. We just do them out of habit. We o them because we always do them, and that's the rule, and they don't necessarily contribute to decision-making like I think when I was on ITU, there was a….you get a chloride every single day. And yeah, I'm sure some of the time a chloride does make a difference with what you do with a patient but, every day? I'm not so sure about that.

It's a waste of phlebotomy, lab resources and point of care resources. You know for the cartridges for those point of care machines are quite expensive, and it's additional workload for the nurses in terms of they then have to go and draw blood off every single patient every day.

Sometimes you might get so much data that you can't actually separate what's the important data from the superfluous or not needed data.

There's also an increased risk of biohazard exposure, needlestick injuries.

From this it also may lead to additional unnecessary testing. So if for example a result comes back and it's not what you expected, you maybe then have to investigate that further, which may lead to further investigations for the patient and maybe perhaps further blood testing and blood loss as well.

So some of the behaviours that I've identified already about why we do this from the scoping review, there's not always explicit guidelines about what we should be doing. It's often easier to do routine or habitual ordering rather than taking the time to think about it for every single patient, because that's time consuming and it's a cognitive offload for clinicians as well cause we don't have to think about that, it's just 'Yep, that's what we do for everybody everyday and that's safe'. You know we're not going to miss anything by doing it that way, and we also get increased ordering by less experienced clinicians, myself included. So with the junior doctors on ITU, it's often if they're not sure, they'll order more and not less.

And then some of the strategies that have been employed to reduced unnecessary blood tests or some of the ones that have been suggested I should say, um, some of them are quite obvious, like introducing guidelines or trying to standardise the process or educating staff on the potential harms of it. Reducing the volume of the blood tubes and some of it is process centered, and some of it is equipment centered. So we could also introduce things like blood conservating sampling

devices or incorporating it into a daily checklist which I know ITU have already changed their checklist as well. So those are some of the suggestions on strategies we could use to reduce the amount of unnecessary blood tests that we do, but obviously I'd love to get your thoughts on that as well.

So this is going to be the first task that I'm going to ask you guys to have a discussion about. So three main parts of this, first of all looking at the main problem, second of all, looking at the causes of the main problem, and third of all looking at the consequences and we'll have discussed some of this but I want to go into a bit more detail about why do we do this? How can we change it? And what are the, what are the problems of routine blood test ordering.

And Sion I think we should have Dr Glen and Richard joining us as well at some point, so if they appear in the waiting room, could you let them in.

Sion Yes

Ffyon Thanks

Sion John has joined now

Ffyon What is going on? Who's that in the background, is that Lynne?

Kerry Its Lynne

Ffyon Oh fine okay. So first of all, part one of the problem. In your experience on ITU, what are the main issues with routine blood tests? Can you think of any examples or situations where you've come across problems with routine blood ordering that goes on at the moment.

Kerry In my experience I think it's just um habit from the nurses, you know from the nurses which is even from when I've started there its been routine that we do a full set of bloods on every patient at 5 o clock in the morning, and that was including glucose until quite recently. And also a full set of bloods on admission that, that's without taking you know, looking back, when did they last have bloods taken. You know even if patients had had bloods taken you know within the last couple of hours being admitted into A&E, then the routine practice would still be to take a full set when they came to ITU.

Ffyon Thanks Kerry, so um, not always checking whether or not the patient has already had patient has already had bloods that day or preadmission.

Kerry Yeah

Ffyon Ok. Yeah go ahead Nathan.

Nathan Not just a nursing problem at all. Its not, not just an ITU problem, and I think it's a habit from wider medicine in general that if we've got a hospital inpatients, we feel the need to check their bloods every day. Because that means we're doing something, and I think that habit just comes through from that a little bit and I think

we've alluded to part of it, I think is particularly the more junior members of staff, they're less confident to say no we don't need to do it, and so they'll just go with the status quo. They will accept what has been done. Particularly, you know people who are there for shorter periods of time.

Ffyon So have either of you ever worked in other places where this is done differently?

Kerry On the ward, it wouldn't be routine, in my experience. Prior to working in ITU I worked on a cardiology ward, and we would only request bloods on the request of the consultants after a ward round. So it wouldn't be routine for nurses to request bloods.

Ffyon Yes yeah. And so what is it about ITU that makes this the case then?

Lynne Can I just say something? Is that okay? I'm sorry I didn't realise we were starting at 1 o clock. I've worked in ITU since 1998 and it's always been a requirement as far as I've been aware that we take daily bloods every morning. It used to be the doctors who initially took it first thing in the morning when I very first started and then it went over to our role, and then because the bloods were coming back so later when they were taken about 8.30 in the morning, then it went to the night staff. So from what I can see, it's not been sort of, you know at the discretion of the nursing staff, it's something that's always come through medically, and they've always wanted bloods for the assessment. As far as patients who have been admitted into ICU, some were correct as far as we don't assess to see when they were last done, but a lot of the time they're incomplete. It might just be the U+Es that have been done, or maybe the you know, the other blood results that we have, for example Hb or clotting. So its always been guided historically. Now whether that needs it by the doctors. Now whether we feel that that needs to change, I don't know, but I think its because of the nature of the patients, how critically ill they are, that its always been for bloods to be taken, and it's the same even with a surgical admission. You know, elective from theatre, we've always done blood straight away as you know, when they're been admitted to ITU. So um that's the standpoint, what I can say what we've done for years.

Kerry Yeah I think that's the same for me Lynne, yeah that's just what we've always done, that's how its always been. There is some guidance from ICNARC with regards for taking bloods all ITU patients should have had pre ICU bloods no less than 4 hours before their admission to ITU. So you know it sometimes we are repeating blood tests that have been done quite recently. But ICNARC requires that pre ICU bloods are done no less than 4 hours before ICU admission, and they need two sets of bloods, possibly within the first 24 hours if it, you know, obviously if that's possible.

Ffyon Does it? No I don't have that information

John Ffyon on the ward watcher database yeah there's a collection screen to calculate things like Apache scores and predicted mortality and there are a number of blood tests. So you put the highest and the lowest in the patients first 24 hours and it includes skittle as well as a panel of bloods, things like their best gcs and the

admitting diagnosis and whether they had CPR or not and it puts it all into a big algorithm try and give you a predicted mortality. So that's so if you wanted to know what it asked for next time you're in the unit, or you could probably Google it

Ffyon That's interesting to know guidance on it because I wasn't aware of that

Kerry Lisa Lloyd would be able to tell you that

Nathan They are very basic set. To my memory white cells and possibly CRP are the only ones that ICNARC asked for

John Does it not ask for things like the highest and lowest sodium and stuff Nathan?

Nathan There's a collection that come off the gas collection and a collection that come off the bloods

John Yeah I can't wait remember all of it

Nathan There's nothing there's nothing particularly fancy on there I think is the point it's the routine stuff that should have been done it shouldn't be missing from an admission

Ffyon So there is a strong historical precedent from what Lynne said as well in that this is what's always been done as a routine set that goes down for every patient admission every day and there's not been any sort of discretion or like pickiness about the blood tests in the past because there's that worry of missing something or getting delayed results and things like that. I just wonder, you know with the advent of being able to add on blood tests, you are probably going to end up taking one of each tube anyway but potentially could you…..is there scope to reduce what you're ordering and you've got the option later on to add on a test if you need it?

Kerry Yes, we're using add ons more frequently now I think

Ffyon So that would mean reducing what your basic set is already, or having a clinician decide what what's needed for that patient before. Before how is the how is the impact of that introducing the new checklist I know on the back of the daily ICU forms, has that changed what people are doing much?

Kerry I think so far just from my own experience not everybody has been using it but we are trying to use it. I think over the past few days especially we've seen you know certain blood tests not being done because the forms are being used.

John Certainly if I'm doing a ward round I'll try to make a decision at the end of it and tick the boxes and things. I think it's interesting when you are in a rush it's easier to not do it and you know the default then becomes a patient gets all the bloods done. I think you do need a bit of bandwidth at the end, you know when you're seeing the patient to actually think what they might need

Ffyon Yeah definitely requires a conscious decision rather than and sometimes it's time consuming as well. Okay I think we'll push on a little bit to Part 2 with this section which is just looking at the causes of it, so I think we've mentioned a couple already:

you know if you're in a rush, as a historical precedent, this habit is routine. Are there any other reasons that we sort of revert back to routine blood tests that you can think of? Safety? Does patient safety come into it?

Lynne Yeah that does come into it I think so with monitoring things like potassium and magnesium and things like that I think as we do pick up quite a lot of, you know the electrolyte imbalances and things don't we on them. Especially if patients have come back from theatre.

Ffyon Yeah definitely and anything else? Anything else to add on the causes of that one?

What feeds into…John you'll have worked elsewhere, does this happen elsewhere? does everyone else have a routine set?

John It's interesting, everywhere I've worked seems to have had a different approach to this. So for example when I worked in Australia they had just pre printed A5 pieces of paper with Microsoft Word document and the idea was at some point in the day you ticked whatever boxes you wanted for bloods and handed it to the nurse and then that was used as the patients ticket to get their blood checked the next day. So I suppose similar to what we've done it except there was a big stack of these A5 pieces of paper that had just been spat out of the printer and torn in half. I think other places I've worked there's a monday wednesday friday set of bloods which are done automatically and you don't actually get bloods on Tuesday and Thursday and if you want bloods at the weekend you have to ask for them, you know what I mean? So I've never got the impression that there's a definite way of doing it frankly.

Lynn One thing I will say is when a patient is due for discharge maybe, and if the consultant has said that only need bloods to order, or if they're a long term patient for example and they say right, sort of like every other day bloods or maybe on the monday and Thursday. We don't do them routinely then on every single patient we do it as instructed by the doctor. So I can't say that sometimes they are just done for the sake of it, because when it's been addressed that they don't need them done every day they're not done every day.

Ffyon So when there's specific direction otherwise, it doesn't happen so much does it, and it sounds like there's different baselines elsewhere still like whereas our baseline is like do them everyday and do the routine set everyday elsewhere it's it only happens Monday Wednesday Friday unless otherwise specified or you know the baseline is that the doctor tells what bloods what they want and that that's what gets done and nothing more than that so it's interesting to hear that it is different in other places as well. And then I know a big focus of what's been going on in ITU recently is that, well from talking to Joe anyway Joe why she was saying there's been a lot of like, you know, line infections and things like that and I'm not sure obviously it's very hard to directly link line infections to access for bloods and things like that, but are there any like noticeable consequences of doing routine blood tests in icu? Is there anything that patients say or examples that you can think of where there's been serious consequences or maybe not even so serious?

Nathan I think possibly has an impact on the length and quality of an arterial line sometimes they often clot off and things like that

Ffyon If they are accessed frequently or not?

Nathan Yeah and that but you know at the end of the day…..you have to sample don't you and the artline is getting taken off even more frequently because of the blood gases as well which are often multiple times in the day

Lynn One thing I will say is…as well as if a patient is deemed as not really needing the arterial line it will be taken out as well so you know if they've deemed that they're not needing regular blood sampling as such we won't just leave an arterial line for the sake of it which would cause infection.

Ffyon I think my experience in ITU as well the patients that are on HDU who are less likely to have lines in probably get less blood tests than the ones that are on ITU who do have lines in. Is that fair to say?

Lynn Yes but that's why they have got the lines in is because they need the more frequent blood sampling isn't it? And the more frequent monitoring so the idea behind with line bundles and everything I know we're going off track here but it's you know, it's the need of what the patient requires isn't it the level of sampling and monitoring they need

Ffyon Yeah, definitely. I think I guess what I mean is if they haven't already if you haven't got like easy access I suppose then it usually comes down to you know does this patient need bloods today, and asking one of the one of the clinicians who is around rather than the default being everybody gets bloods everyday. I think if they don't already have a line in, there tends to be a bit more prompting to be like oh do they really need bloods today or…?

John I've gotta put my hand up there and say, that you know if a patient has got an arterial line in for whatever reason, if they're on metaraminol or something, I'll be I'll be far more likely….shall we say if a patient doesn't have an arterial line I'll be far less likely to want bloods because I recognise that it means a venepuncture and probably have a bit of a think about do I really really really want that patient to get bloods today whereas when there is an arterial line it's much easier isn't it to say just whip off a set of bloods so I've got to put my hand up and say that there, that I probably have a different threshold depending how well if the patient's already plumbed in already as opposed to whether or not….. I don't know if that's just me or if other people are similar….

Kerry No, I think that's definitely true, it's a lot more of a conscious decision to take bloods from somebody when you actually have to take them as opposed to just take the bloods from a line that's already there. I definitely agree with you.

Ffyon There is a bit of literature backing that up as well. The likelihood of a patient having a higher volume of blood draw was directly relatable to whether or not they had a central line or an arterial line in situ at the time.

Nathan I think the conscious thought things a really important point here. Clearly we are thinking about it more. Just because it has been done for years in ITU's across the country does not mean it should be done and even just having that tick box on the back of the sheet I think just makes people think twice about it. And the fact of the matter is a lot of the time most of the most of the routine tests we are going to say yeah actually I do want to know what's going on the next day because they are critical care patients and things change but if every now and then it means we go, do you know what? the clotting has never been an issue this admission, there's nothing that we're doing to the patient to make us expect that there is going to be a problem with the clotting so let's not do the clotting. That's 1 less blood test everyday that you could potentially do. It's just making people consciously aware and thinking about it a little bit more. And can you because that question if you've not got the access to take the sample comes from you have to have a think about it and you think OK, could I, can you know 'getaway with' is the wrong phrase but ultimately that's I think possibly that's what you're doing is going to getaway with not doing the bloods on this occasion. Because I don't know that there's many things that would, if there's something that we really are tracking, then we're going to consciously want it.

Ffyon Yeah definitely rather than the rest of them are just sort of as a byproduct or just routine monitoring sort of thing whereas if you're really interested in it you will definitely remember to get it. Um so I suppose what do you….this is moving on a little bit but what do you think is the best way to get people in that in that frame of mind? Where they are consciously thinking about what blood test is needed you know? Is it a checklist or is there another way that you can get people to switch on that decision?

Lynne Can I just bring in something else? We do have a high turnover of nurses as well new staff so to be honest if it was somebody at the bottom of the bed that is not, you know, has only just come out of supervision or something like that I'd be really worried about then making informed decisions to be honest. What's do you think about that Kerry?

Kerry I think with regards to with how new staff are, you can definitely tell with things like there's probably more blood gases taken by staff who were recently you know working on their own in ITU…it's a way that they can kind of keep an eye on what they're doing because they are often quite, you know, afraid that they're going to miss something or that the gases are going to be poor if they leave doing gases for quite a long time so I think with regards to blood gases they are making those decisions to do those themselves but with daily bloods I think that it would be unfair on a lot of the nursing staff especially the junior ones for them to, you know, make any kind of decisions about what bloods were taken. But I think that the whole point is that at the end of the ward round it will be like a consultant or a senior decision as to when bloods are taken so I don't think it would….I can't see that it would be put onto the nursing staff because I think that would be quite an unfair decision for them to make especially new staff.

Nathan Yeah definitely totally agree I don't think that that is something that that we would expect nursing staff to have to decide - should I be taking them or shouldn't I - you kind of always have to have a fall back that if you don't know the answer whether I should or shouldn't, then just do what you have always done sort of thing….but I you know, that first step is that tick box on the back of the daily review chart. I quite like that thing that John was mentioning about having a ticket for getting blood tests taken. It's as with so many things it's about culture change and we've got to. I mean still on our unit some of the daily review sheets are updated and have that tick box on and some of them don't. I don't want paper coming out your ears but it's just about changing the culture that becomes that and I think most of the staff do that. They're looking at that back page every time and everyday I'm looking at them saying have they requested these bloods or not. I don't think you need to take it much further than that because that box in itself makes the the clinician think about what they're doing - do I actually want all these blood tests or not? It's almost always checked by a consultant and if we're not certain, you know, I can't answer for everybody but if we're not certain we should be asking somebody senior saying, 'do we need to do this blood test tomorrow?' And I mean the culture just becomes instead of 'I'm automatically going to take all these blood tests every morning' it becomes 'I'll have a look at the blue sheet say which ones need to be done for this patient'

John I think I agree with everyone and also in terms of culture change, its interesting it just becomes a multipronged approach so you know obviously Ffyon we're having this meeting today which, probably that - what do you call it, is it transformation research? where everyone who is at this meeting is going to be completely a sold on the concept? and we all work in the unit as well where you know we've got that change in the unit paperwork that people can hopefully see. We're going to be presenting that change at our clinical governance which means that people can start to see the difference there. As well, you know we're revamping the blood book so I don't know…. can I present here?

you can give it a go let me see if I can if I stop are you able to present. there we go I've stopped and

So what if I don't let me usually maybe it's cause I'm outside the organisation or something…ah there it is

just just as you setting up john the other thing is quite useful instead is is educating the masses just in terms of as you said ffy on you aware how much all these work test cost kind of detail everyone that it costs £25 to do it a clotting screen everyday people are going to start thinking twice about it

John Can you see my screen now? Yes so this is this is this thing that obviously Ffyon and Callum came up with we've got our critical care bedside booklet, but I think that were changing the name to quick reference guide or something like that. anyway this is going to have various things on it like the COVID guidance and Glasgow coma scale, the confusion assessment method and it's so it's a revamp of the booklet that we've got already that the nurses and doctors find very useful but but

crucially were sticking a few extra things in and one of those extra things as the guidance for routine blood testing so hopefully this will be in everyone's drawer and…. every patient drawer and that way, you know people can see at a glance what the options are

Ffyon that's great and that i know it's not strictly speaking a guideline but it's like a reference guide isn't it if you're not sure you can refer back to that. And just touching on what you said about transformational research like transformation research and like what we're doing is like that's one way to try and generate buying into a into a change into a unit but that's one of the things that's really difficult I think with projects like this is like trying to get everybody to buy into it and like believe that it's a good thing and that we should be changing practise a lot of people well not the attitudes that have come across anywhere a bit like well why do we need to change what we're doing it works why you know why we changing it sort of thing so I don't know if anyone any thoughts on how you can sort of overcome that

Kerry I think maybe from a nursing side, I don't know what Lynn thinks but when the new nurses are starting on the unit now we are having education weeks for them and we're covering topics like blood transfusion practise…they have to get their competences to be able to do the transfusions and so um actually things like this could be included as part of a presentation on, you know, the transfusion practise or blood gas practise, whatever, for the new nurses that are starting so that's one way to kind of, embed it into them from the beginning of their practise that, you know, these are things that we should be looking at being guided by the blue forms as to what bloods are taken you know just being a bit more aware really. It's something that I've discussed with Joe already with regards to blood transfusion so it's something that we could possibly add into those sessions on the education weeks when the new stuff start.

Ffyon That's great, that's a great idea okay. So you've got your booklet for the new doctors and then you've got your education weeks for new nurses as well and then I think within the new doctors induction is there any inclusion of this?

John Um, so not yet….but that's just reminded me there will be by August.

Ffyon Great stuff. I think there's two things that we were talking about….so there's one which is the routine blood tests and then the other which is the blood gases. So blood gases I think it's I think it's fair to say, and do correct me, but it is mainly decided by the nurses about how often they they want to do them, how often they feel like they should be doing them…like you were saying you know with more junior nurses it probably is, you know, fair to expect them to do more blood gases and not fair to expect them to try and make more decisions about it but then with the blood gases (error: meaning tests) I think that tends to be more doctor led from my experience or clinician led I should say and so I think for the purposes of this first step anyway, the first focus will probably be on the blood tests and then i mean maybe later down the line you look into the blood gases but i think that's a bit trickier.

Okay so I shall go back to presenting….right so Task 2 is a sort of discussion on what what do you think we've actually gathered in terms of information. I think we've touched on quite a lot um so ICNARC guidance on bloods before admission it's an issue sometimes that patients have already had blood tests a few hours before but they get them duplicated anyway, there's a strong historical precedent sometimes there's other time factors if you're in a rush or if you don't feel competent to make decision you're more likely to order more than less, or if there's patient safety factors you know like potassium or magnesium that Lynn was mentioning. What are the places are doing? Whether the presence of an arterial line or central line makes any difference and where the staff is new, the stuff turnover as well as the culture, replacing the actual physical things you can do to change things like changing the forms or the actual education or induction package that you introduce and how you generate a bit of buy in through that education package. Are there any other points that you think should be raised within this discussion or other important points should be thought about?

So in terms of safety and this was an issue that was raised by one of the other consultants actually that if you start trying to make individual decisions about every patient there's a risk that things are missed or that an important test isn't ordered. Ss that a consideration or concern or do you think that that's not quite as important as tailoring the blood tests the patient? Or you know is it a risk benefit situation? Any thoughts on that?

Lynn I personally do worry….I do worry about the risk especially as sometimes depending upon which consultant we've got on the round sometimes it might be the end of the day, if it's really really busy, where they've not been reviewed by the consultant so if it's all sort of, you know, nurse led I would really sort of like worry you know with if blood work hadn't been done all day for example. But I haven't heard the discussion and documentation that came before this so i could be sort of talking rubbish really

John Sorry Lynn that's my fault really, I didn't pass on the invite until too late because I completely forgot

Lynn Don't worry I was in another meeting anyway from 11:00 o'clock so don't worry

John I think what the what we've put in place to hopefully avoid the situation you describe is that if the doctor doesn't make a decision the default is to do the whole lot so if there if the doctor the day before says you know just do use U+E's that's fine but if the doctor hasn't ticked anything the default is to just do what we've always done and that we do never be a patient who misses out if that makes sense

Lynn Ohh yeah that's fine then yeah totally understand now yep great

Ffyon Yeah yeah that's a good safety fallback isn't it. With regard to the COVID situation, I don't know what the situation is on ITU but imagine that it's a difficult and stretched situation but are you finding that as you've got more patients, it's more difficult to keep up with daily blood tests for every patient from a nursing perspective?

Kerry No I don't think so.

Ffyon Not been an issue

Kerry No I wouldn't say so anyway just I think so we've been - touch wood -very lucky where we've not been completely overwhelmed and you know we have been able to just carry on as normal you know with regards to many things

Ffyon So with regard to blood tests, theres been no, sort of, changes or considerations with covid it's pretty much been able to carry on as normal?

Kerry I think so john would you agree? Lynn

John Yeah other than we are just generally busier I don't think there's a particular covid angle to this

Ffyon Not loads of procalcitonins or ferritins or anything like that?

John Well its interesting the COVID era has helped us to usher in the use of procalcitonin which i think has been something that we've been looking to do for quite some time and so now i think all patients seem to be getting their procalcitonin done three times a week now and not just the covid ones which I move it once but I think we're quite happy about and the ferritin is a special request on admission so yes I don't feel that there's a covid angle….yeah I don't think necessarily your project is…

Ffyon Well that's good in a way I won't have to worry about that one. OK excellent I think that that about covers it for me and if anybody else has any thoughts or if you've taken any notes or anything but I think it would be useful please feel free to drop me an email, to my nhs email and yeah if you have any other revelations I would love to know. It's all going to help inform so second part of my thesis which is looking at making some recommendations and looking at some strategies on how we can sort of change the way that things had done not specifically to us in Glan Clwyd but more generally as well across the board in critical care so thank you all for your time. I'll sure to be providing you with some goodies to say thank you and so come and find you at some point appreciate how busy will also thank you very much taking the time to do this for me.

Appendix 6 Bedside Guide

GIG CYMRU NHS WALES
Bwrdd Iechyd Prifysgol Betsi Cadwaladr University Health Board

YGC Critical Care
Routine Blood Testing
Junior Doctor Guidance

Introduction
• Routine tests specified in 'Tomorrow's Bloods', specialist tests MUST be specified under 'Management plan and targets'. • Deviation where you feel appropriate is encouraged, subject to consultant review. • Consider reducing testing frequency further in stable, long-term patients.

Summary of testing

	Level 1 or 2 Patients	Level 3 Patients
FBC, U+E, CRP	• Daily if acute derangement. • Reduce frequency if repeated normal results. • Reduce frequency if chronic derangement.	Daily monitoring
Coag, INR	• Daily: ◊ Deranged PT or APTT ◊ Unstable / septic ◊ Evidence of bleeding ◊ Platelets <50 ◊ Anticoagulated (excl. prophylaxis) ◊ Receiving RRT	
	Otherwise, do not routinely order	Otherwise, every 3 days
Bone Profile, Mg^{2+}	• Daily: ◊ Previous derangement ◊ Receiving electrolyte replacement ◊ Receiving RRT • Reduce frequency if repeated normal results, • Reduce frequency if clinically stable with derangement not for replacement.	
LFTs	• Daily if acute derangement. • At least 48 hourly if unstable or septic. • Reduce frequency if repeated normal results, or if • Reduce frequency if clinically stable with chronic derangement.	
Glucose	BM more appropriate if the is a monitoring requirement—do not routinely order.	
PCT	On admission, then on Mondays, Wednesdays, and Fridays	

Appendix 6 Study Aims and Outcomes Mapping

Aims and Outcomes Mapping

Study Aim	Chapter 2: Scoping Review	Chapter 3: Case Study Workshop	Chapter 4: Discussion
The reasons for routine daily blood tests in critically ill patients?	Theme 3: Problems identified	Theme 2: Factors that influence the decision to do routine bloods	Automation Time 'Just in Case'
What behaviours drive routine daily blood tests in critically ill patients?	Theme 3: Problems Identified	Theme 1: Habits and Routine Theme 4: ICU Culture	Culture, Habit and Routine Knowledge
What possible changes to the process could be made?	Theme 4: Strategies to reduce unnecessary blood tests	Theme 4: ICU Culture Theme 5: Barriers to change	Guidelines/Standardisation Consistency Equipment Processes
What are the potential barriers to change?	Theme 3: Problems Identified	Theme 5: Barriers to change	Education Culture Time
To produce a set of core outcome measures for future research in this area	Chapter 5		

To produce local and national recommendations for reducing routine blood tests in ICU	Chapter 5		
To use this case study to explore the interaction between culture and positioning within this specific case study context	N/A	Positioning and Culture	N/A
To explore co-production methodology to generate 'buy in' to changing practice and culture	'Buy in' discussed as important in ICU culture and change	Co-production as method of producing 'buy in' explored in case study	N/A

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