Workarounds in Accident and Emergency & Intensive Therapy Departments:

Resilience, Creation and Consequences

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Abstract

This research study investigated workarounds created when using arterial blood gas analysers in an accident and emergency department and an intensive therapy unit. It focussed on the creation and consequences, both positive and negative of these non-standard work processes. Observations were used to identify the real actions of the clinicians who used the machines and interviews investigated these actions in more detail. The key finding was that all five workarounds identified had both positive and negative downstream consequences depending on the circumstances of their use. The workarounds with predominantly positive effects also featured negative consequences that increased the likelihood of errors in the workflow. The workarounds with predominantly negative consequences were classed as violations of standard operating procedure, yet still included positive effects. One of these negative workarounds, entering a false hospital number, had the key quality of bypassing the patient identification workflow block, which made it vital in emergency cases. Adaptations to training and operational procedure could help to minimise the negative effects of workarounds while retaining their positive effects. Incorporating false hospital number entry as a formal policy in emergency 'code blue' situations with a special '999' number is one of the recommendations suggested. Another suggestion is to encourage A&E clinicians to liaise with the point of care team regarding workflow blocks on all A&E equipment. This would aid the future identification of workflow steps that are vulnerable to workarounds.

Table of Contents

1 Introduction

Computers are ubiquitous pieces of modern technology that can make our lives more productive. However, productivity can be lowered when we encounter a block in our workflow that impedes our ability to achieve our goal. Under these circumstances many of us rely on using alternative means of completing our goals, literally working around the block. It comes as no surprise then that the term 'workaround' was given to us by computer systems administrators who attempted to fix problems in their workflow (Pollock, 2005). These workarounds can be as simple as using a screwdriver to start your car and as dangerous as disabling a faulty alarm system. The effects of workarounds have recently become of interest in the field of healthcare due to its safety critical nature (for example, Halbesleben, Wakefield, & Wakefield 2008; and Kobayashi, Fussell, Xiao, & Seagull, 2005).

A key reason for the interest in workarounds is that these non-standard strategies have been shown to create opportunities for error within a workflow (Halbesleben et al., 2008). However, the same research also noted the possibility that workarounds can have positive effects on workflows. While the role of workflow blocks in creating workarounds seems stable, how they are spread is not as well understood (Halbesleben et al., 2008). Neither are the downstream effects of workarounds well known. This research study aimed to examine in detail the workarounds used in an accident and emergency department in a bid to further understand their proliferation and downstream effects. Data was also collected from an intensive therapy unit to better understand the workarounds identified. Two identical arterial blood gas (ABG) analysers were the focus of research. The ABG analyser is a vital piece of point of care equipment that aids in the diagnosis of respiratory problems. Data analysed in this report was gathered from 49 interactions with the machines and 8 interviews.

Healthcare is an industry that takes safety and error extremely seriously, so investigations into methods of decreasing errors is a continuous process. It has been proposed that increasing individual resilience within local departmental workflows can decrease errors and create safer environments (Cook & Nemeth, 2006). Individual resilient performance is increased with the type of expert knowledge that A&E clinicians possess, combined with the flexibility to respond to workflow threats. Due to resilience and workarounds both being closely tied to task workflows, this study also aimed to ascertain whether there was an identifiable link between workarounds and resilience.

Chapter 2 begins with a review of the background literature on error including James Reason's (1990) classic work. It will go on to discuss how error research has contributed to the development of the safety focussed fields of high reliability and organisational resilience. Recent examination of the organisational factors of hospitals has suggested that resilience may be better suited to healthcare than high reliability (Nemeth & Cook, 2007). Workarounds will then be scrutinised and the theories for how they are created and their consequences will be highlighted. Chapter 3 and 4 will present the methods and findings, respectively. Finally, a detailed discussion of the findings and the implications will be presented in chapter 5. This chapter will link the observed phenomena with the previously discussed literature and will make some recommendations for future change.

2 Literature review

2.1 Error and safety

Human error has been of theoretical interest since the time of ancient Greek philosophy when Socrates asserted that human error was caused merely by ignorance. The modern world uses error rate as a standard measurement in psychological experiments, which in turn provide insights into how human error affects safety critical organisations and causes major accidents. In his classic work on error, Reason (1990) listed some of the infamous disasters that have focussed modern error research. For example: the Bhopal tragedy 1984, the Challenger and Chernobyl disasters of 1986 and the King's Cross fire 1987 all added impetus to this field. The classic categorisation of errors into mistakes and slips, or lapses, highlights the fundamental difference in how these errors are cognitively formed. Mistakes can be described as faults in choosing a goal or in selecting the means of achieving a goal, whereas slips result from failures in the execution of a sequence of actions (Reason, 1990). The knowledge of how each is formed is crucial when attempting to reduce error and to create strategies of avoiding error.

Numerous techniques are used by both organisations and individuals in an attempt to reduce mistakes and slips. Standard operating procedures are used to help employees avoid mistakes and personal techniques can help individuals avoid slips. For example, a person leaves an important document under their car keys to help them remember it. Despite the best intentions, not all errors can be avoided and large organisations even see a certain percentage of error as unavoidable and therefore acceptable. It has been argued that large organisations can actually facilitate errors through latent organisational factors such as poorly thought out procedures or excessively unwieldy management structures (Reason, 1997). For susceptible organisations, such as nuclear power plants and hospitals, it is critically important to

comprehensively analyse errors and to attempt the removal of these pathogens from the system.

2.2 Medical error and safety

Healthcare is one of the fields in which a preoccupation with error is both necessary and encouraged. An indication of this necessity is the estimated 850,000 patient safety 'incidents' in the U.K. each year (Ash, Berg, & Coiera, 2004). The traditional approach to error prevention in healthcare is to assign blame to an individual or group of individuals and to introduce new policies and restrictions to ensure the error does not recur (Patel & Cohen, 2008). However, Reason (2000) suggested that such a person centred focus on the unsafe acts of those at the sharp end of the organisation removes the system context from the error. The traditional approach ignores the fact that errors are often consequences of factors further upstream, such as management policy and organisational tradition. Reason's assertion was that 'active failures' (errors performed by frontline staff) and 'latent conditions' (upstream factors which increase the risk of error) are in fact closely linked and cannot be separated. A means of focussing on both the individual and organisation, thereby working to isolate potential errors and improve safety, would be to treat hospitals as high reliability organisations (HROs).

2.3 High reliability

Reason (2000) maintained that healthcare would benefit greatly from applying the techniques used by HROs such as the nuclear and military industries. HROs recognise the human abilities to analyse situations and to compensate for unique circumstances as key factors in creating robust systems. These are exploited by HROs at an organisational level by incorporating them into two modes of operation. In normal routine mode operating procedures are standardised and hierarchical. During an emergency situation procedures change to allow experts on the spot to take control and thus negotiate a safe passage through

the danger. This has become known as high reliability because these organisations now suffer less than their fair share of accidents despite operating procedures being fraught with danger (Reason, 2000). High reliability can be achieved by expecting errors and emergencies to occur and by preparing for these through continuous training. Added to constant preparation are rigorous procedural standards which, when combined, reveal a pervasive preoccupation with failure throughout HROs.

Initial appearances indicate that high reliability is something that healthcare should strive to achieve. However, Nemeth and Cook (2007) argued that high reliability is not directly applicable to healthcare because the methods of achieving it do not transfer well to the dynamic and distributed nature of healthcare organisations. Among the reasons put forward, they remarked on the differences between the rigid military characteristics of an aircraft carrier, a typical HRO, and the loosely affiliated collection of almost cottage industries in healthcare. The standardisation and simplification required to achieve the rigid and reliable military structure have the potential to hinder the provision of healthcare rather than facilitate it. In addition, the lack of resources for extended training to deal with anticipated emergencies impedes progress and indeed suggests that healthcare is incompatible with the idea of reliability. Instead they propose that 'resilience' is a more suitable aim for healthcare.

2.4 Resilience of organisations

Despite Nemeth and Cook's (2007) contention that high reliability and resilience are fundamentally different, some of the defining characteristics of each are indeed very similar. For example, according to Hale and Heijer (2006) resilience is the ability of an organisation to manage risk by anticipating threats to its primary goals and implementing strategies to manage and circumvent those threats, which is essentially what HROs also aim to do. They wrote that it is "the ability to steer… the organisation so that it may sail close to the area

where accidents will happen but always stay out of that dangerous area" (2006, p. 36). The implication is that resilient organisations need to be aware of their place in relation to those dangers, which is a dynamic and ever changing task that ensures the organisation is never static.

The main difference between reliability and resilience at an organisational level is that reliability applies better to systems whose boundaries are well defined with few degrees of freedom, such as aircraft carriers, whereas resilience is more applicable to systems that have countless degrees of freedom and are not as well bounded, such as hospitals (Nemeth & Cook, 2007). An example provided by Reason (2000) illustrates this point, he commented that HROs allow workers to forget the fear of error because the organisation has tools and safeguards which will remind the worker at the right time. Resilient organisations on the other hand are not so tightly bounded and individuals must strive to remain aware of the risks to their goals at all times.

2.5 Cognitive resilience of individuals

Resilience can be applied to individuals in much the same way as to organisations, both aim to anticipate threats to their goals and create strategies to avoid these threats. At the individual level resilience is a person's ability to learn, adapt and create safety in settings that are naturally dangerous (Jeffcott, Ibrahim & Cameron, 2009). Healthcare professionals would appear to routinely adapt to situations in order to attain goals while avoiding errors. One example of this process is that of the busy operating theatre described by Cook and Nemeth (2006), in which workers adapted to the pressures of emergency cases and high work load by prioritising goals to ensure that high level goals were achieved prior to lower level goals. Procedural adaptations happened on-the-fly while the work continued around them. In making low level sacrifices it was accepted that certain loses would be tolerable in order to

achieve the more valuable high level goals. Balancing safety and getting the job done were instrumental to the successful resolution of difficult situations in this resilient organisation and once the emergency disappeared the workers resumed normal practice just as a HRO would.

In this case the healthcare professionals made decisions to adopt strategies other than the standard operating procedures (SOPs) in order to achieve their main objective. Such deviations from recognised safe methods have been classified as straightforward violations, which come as a result of poor training, lack of supervision and lack of concern for the task (Reason, 1995; Taxis & barber, 2003). Performing a violation is deliberate and intended, yet consequences cannot be foreseen due to the departure from the SOP. With this in mind it would appear difficult to argue that departures from SOPs can increase individual cognitive resilience. This question shall be examined in more detail later; here it will suffice to mention the work of Back, Furniss, Hildebrandt and Blandford (2008), who observed strategies created by participants which increased resilience in a task that was continuously interrupted. One of the main conclusions was that resilience can be facilitated by strategies that incorporate reflection on performance and well designed systems can encourage this. An extreme example of this is the proposed forced delay in task resumption. This delay, or lockout, makes reflection mandatory while the user waits for the system to allow re-entry. However, as we shall see in the next section there will always be ways to bypass such technologically enforced procedures and these bypasses have their own consequences.

2.6 Workarounds

Workarounds have been described as; alternative methods of completing tasks (Ash et al., 2004) and purposefully using computing in ways for which it was not designed or intended (Gasser, as cited in Pollock, 2005). Morath and Turnbull defined workarounds as “work

patterns which an individual, or group of individuals, create to accomplish a crucial work goal within a system of dysfunctional work process that prohibits the accomplishment of that goal or makes it difficult", (2005, p.52, as cited in Halbesleben, Wakefield & Wakefield, 2008).

Halbesleben et al. (2008) likened workarounds to mistakes in that they are deficiencies in the selection of a method of achieving a goal. It was also suggested that these alternative methods of achieving the goal are not always of a lower quality than the original and can thus be a positive force. While the provision for workarounds to be constructive exists the research is overwhelmingly in support of the idea that they are a destructive influence on procedures, system resilience and safety. For example, Halbesleben, Savage, Wakefield and Wakefield (2010) investigated workarounds in intensive care units and suggested that workarounds violate the five 'rights of medication administration' which are: right patient, right drug, right dose, right route and right time. Engaging in procedural violations that can be created spontaneously seems to be an almost guaranteed tactic of increasing the risk of errors within the system. Yet according to Vestal (2008) nurses have transformed workarounds from a once in a while art into a way of life, indeed she went on to claim that nurses pride themselves on their abilities to get the job done by removing obstacles.

The question of why well trained, experienced and dedicated healthcare professionals engage in such risky practices is of considerable interest. Halbesleben et al. (2008), highlighted the effect of unnecessary, inefficient or problematic workflow blocks in pushing healthcare professionals to create workarounds, they went on to classify the sources of blocks that have been reported in the literature as:

Policies/laws/regulations:

When seen as arbitrary or not intended to apply to a person's situation they can be worked around. These workarounds can weaken regulation, which can lead to further policies meatn to restrict the workarounds.

Protocols:

These are the clinical protocols and guidelines that are intended to improve the quality of care given to patients. They can become blocks when they are perceived as wrong or not applicable to a particular patient. A clinician's perception of how his/her peers would react to violation is important when deciding whether the guideline will be violated or not.

Work process/design/flow:

These blocks are the result of poorly designed steps in a procedure or inefficiencies between steps. They include forcing functions and organic changes in process over time often in response to new regulations, individual preferences or new technology.

Technology:

These blocks include system limitations, restrictions on information that can be entered, complex or time consuming steps in otherwise simple tasks and also unintended consequences on other work process. They are predominately due to a lack of consideration for the work process that the technology will change.

People:

These include bureaucratic structures to restrict individual authorisation to complete tasks which involves gaining authorisation from a supervisor or colleague. They can be small scale but very restrictive (adapted from Helbesleben et al. 2008).

Some workflow blocks are intentional and aim to reduce errors by restricting the inappropriate possibilities at each stage of the work process; these are commonly referred to as forcing functions. In the terms used by Reason (1990), forcing functions have the effect of

reducing active failures of front line workers by improving latent conditions within the system. However good at reducing errors, blocks as forcing functions can frustrate users and are prime targets for workarounds. Other workflow blocks are unintentional, created by designers, management and other stakeholders with little knowledge of work processes. Both types of blocks are regularly bypassed. One common reason given for bypassing workflow blocks is that of time pressures faced by nurses (Patterson, Rogers, Chapman, & Render, 2006), this issue will resurface during the analysis of results as is it a common perception of the role of both doctors and nurses. A reason given for their spread throughout nursing is that after a while these processes become standard and many nurses do not even know that they are engaging in procedures that are not as designed (Vestal, 2008).

2.7 How workarounds affect resilience

One of the main consequences of workarounds is the increased vulnerability of the workflow process to errors. Reason (1997) created a 'Swiss cheese' model of error which claimed that systems contain layers of defences and have holes within each layer. These holes can allow errors to pass through; certain factors can align the holes in each layer and increase the risk of errors occurring. Halbesleben et al. (2008) used the Swiss cheese model to suggest that vulnerabilities are formed by workarounds creating more holes in the layers of system protection and then helping to align these holes. They went on to highlight the lack of a consistent workaround measurement technique as a difficulty in accurately assessing the consequences of workarounds.

The lack of a consistent measurement tool is partially due to the difficulty of studying workarounds, which are unique to each situation and partially due to the recent emergence of the interest in workarounds. The recent evolution of the field means that the real downstream effects are yet to be fully understood, particularly in the dynamic world of healthcare. As previously mentioned, there is a suggestion that workarounds can be constructive in that they

are not always of a lower quality when compared to the standard procedure. Creating new higher quality strategies can potentially increase system resilience by circumventing those work processes which are error prone. However, the process of creating workarounds is often so informal that the original inefficient processes can remain in situ, which means that no official work process redesign has taken place and stakeholders further upstream are none the wiser that a problem exists at all. This suggests that a detailed knowledge of a task is necessary to identify those non-standard actions which negatively affect the workflow. These workarounds must then be evaluated to identify any increase or decrease in resilience.

The central question that these ideas raise is: can workarounds increase resilience? Initially it appears difficult to answer due to the highly context specific nature of creating workarounds. It would however, seem to be entirely plausible that workarounds can enhance problem solving techniques by providing the worker with invaluable system knowledge with which to recover from potentially dangerous situations. They can certainly alert designers to workflow patterns that require changes to improve safety and increase resilience. The answer to the question of 'can workarounds create resilience at the sharp end of the system during their execution' is not currently known. The answer will surely be found by understanding the actions performed by operators at the sharp end of the system including the needs they have and the restrictions placed upon them by working guidelines and protocols.

Woods and Cook (2002) called for this deeper understanding of specific tasks and their difficulties in order redesign workflow and eliminate errors. Halbesleben et al. (2008) echoed the call when they stressed that only thorough consideration of the contexts in which workarounds are performed will lead to greater understanding of this phenomenon. Finally these researchers' recommendations also closely resemble the core principle of user centred design, that a focus on the end users is instrumental in designing useable and useful technology (Norman, 2002).

2.8 Summary

This chapter began by discussing how the classic views of error evolved into a variety of research threads. One of the most applicable threads to this research is that of high reliability, which is essentially understanding how large organisations deal with errors and move on from them. High reliability was identified as a characteristic of military organisations which have desirable qualities intended to manage the risk of errors and to recover quickly from these errors. Following on from this, the idea of a resilient organisation was compared and contrasted with high reliability. Individual resilience has become a focus for some researchers in healthcare although its characteristics can difficult to identify due to its highly context specific nature.

Also reviewed was the recent literature on workarounds; how these non-standard work processes are formed and also the consequences of them. It was suggested that workarounds may affect resilience in not just the anticipated negative way, but also positively by skipping workflow steps that are error prone. In this way the chapter revealed the areas of interest for this research study: the downstream consequences of workarounds, how they are created and whether these have any effect on resilience. The next chapter will detail the methods used during the research study which attempted to answer these questions.

3 Method

3.1 Introduction

This section outlines the techniques used during the research study. Data was collected in 35 hours over 12 days. The focus of the investigation was how clinicians interacted with an arterial blood gas (ABG) analyser in a London hospital. The ABG analyser aids in the diagnosis of respiratory problems by analysing blood samples taken from arteries. The analyser is accessed using individual barcodes and the analysis of the sample is automatic. Despite the ease of interaction workarounds were expected to exist. Three months prior to research a new analyser was purchased. The new analyser was thought to be an ideal case study for the creation of workarounds and their potential affect on resilience. The findings regarding the workarounds and resilience will be reported in the next chapter.

Observations and semi-structured interviews were used to collect data. Observations allowed the researcher to gain knowledge of what people did versus what they said they did. As the French philosopher Michel de Montaigne put it "Saying is one thing; doing is another" as cited by Robson (2002 p.310). Semi-structured interviews were used to follow up and expand upon topics of interest that had been identified during the observation phase. This combination of observations and interviews is particularly powerful when investigating behaviours that may be seen as deviant or against the rules as it allows a researcher to delve deeper into the causes and consequences of observed behaviour (Robson, 2002).

3.2 Participants

Participants were the nurses and doctors working in the accident and emergency (A&E) department and nurses in the intensive therapy unit (ITU) of the Royal Free hospital in London. Medical staff from other wards occasionally used the analyser in the A&E. The main cause of this was that the clinicians happened to be in the A&E checking on a patient or

performing another task when it became necessary to analyse a blood sample. However, it also occurred because not all wards have an ABG analyser and in some cases it was quicker and easier to walk to A&E rather than send the sample to the bio-chemistry laboratory. Thus, not all interactions observed in A&E were completed by A&E clinicians. ITU is a secure area with infection control measures in place, this meant that other hospital staff rarely visit and all interactions with the analyser were by ITU nurses.

Participants in the interviews were members of staff who used the machine regularly and had time available for interview. This included nurses and doctors in A&E and point of care technicians in ITU and the biochemistry department.

3.3 Materials

A small notebook and pencil were used to record observational notes, which were then transcribed in more detail into a different notebook. A mobile phone was used to audio record the formal interviews which were later transcribed using a word processor for ease of analysis.

3.4 Setting

One of the ABG analysers was situated in the resuscitation room of A&E. The analyser was located close to a computer linked to the hospitals central information system, CERNER, and one set of double doors, as can be seen in figure 1. The observer remained in close proximity to the analyser during his visits to the hospital. Although each of the three beds in the room had a curtain for privacy, the observer was at times required to move further away from the analyser to preserve patient privacy. Additional data was also collected in the ITU, where the analyser was located in an equipment room separated from the patients. This ward had the same model ABG analyser and the data collected provided a contrast to A&E data.

The resuscitation room is where critical trauma patients are received, treated and cared for. Patients who are not of a critical nature but require immediate attention are also brought to the resuscitation room. These patients can remain there until diagnosed and sent to a ward for further treatment. Within the room there is also a wide variety of medical equipment from patient monitoring devices to neo-natal emergency equipment.

During observations, the resuscitation room could go from a state of quiet isolation to distributed and organised action in a matter of two or three minutes. This may happen when two patients enter in close succession and an emergency case follows shortly afterwards. At these busy times the medical team consisting of doctors, nurses and observers are added to the core team of nurses who are responsible for the ensuring the resuscitation room is always ready for patients. These additional staff would quickly fill the room and require space to work. At these times the researcher waited outside the room for a more opportune moment to resume observations. ITU was quiet and isolated, the only users of the analyser and visitors to the room were ITU nurses.

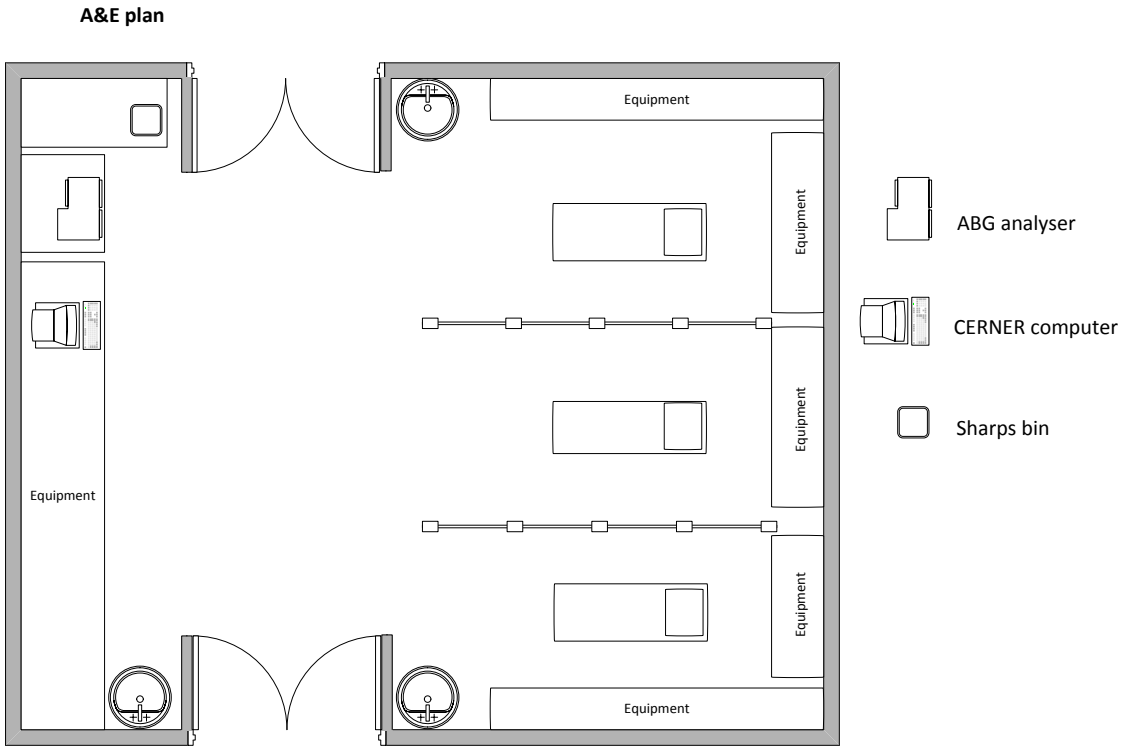

Figure 1. Plan of A&E. Shows the main area of interest surrounding the analyser.

3.5 Preparations

3.5.1 Ethical and research clearance

Hospitals are security and health sensitive environments which require clearance and authorisation prior to research being conducted. The application for authorisation was a long process which began far in advance of research starting. It involved receiving ethical clearance from the university, a background check by the National Health Service (NHS), immunisations against infectious diseases and also clearance by the management team in A&E at Royal Free.

3.5.2 Observation preparations

Jorgenson (1989) claimed that research begins the moment an investigator comes in contact with the research environment. For this reason pilot studies are often used to ease a researcher into a complex environment. Practising in a similar environment is recommended as excellent

preparation for both observations and interviews (Robson, 2002). However, they are sometimes impractical due to the specific characteristics of some environments being difficult to recreate or emulate. The case of investigating a precise interactive diagnostic machine in a particular location was specific enough to remove the possibility of running pilot observations for this study.

Instead the researcher prepared himself for the tasks ahead by seeking to understand the techniques and best practices of observations and interviews. For example Jorgenson (1989), described observational methodology as a flexible, open-ended and opportunistic process that requires logical processes of inquiry on the part of the researcher. This meant that in addition to understanding the processes of interaction being observed, the researcher had to remain open minded and strive not to unnecessarily discount data. To achieve this, the researcher attempted to eliminate preconceived ideas of the environment, people, machines and interactions that were to be encountered.

Validity of data in observational studies is often based on how accurately the data describe the phenomenon of interest. According to Jorgenson (1989), observational data is by definition of high validity due to its concern with understanding and describing concepts in terms of how they apply to everyday life. There are however, some potential risks to validity in small observational studies. The close proximity between participant and observer during an interaction that is usually solitary has the potential to alter the behaviour of participants (Robson, 2002). These observer effects include demand characteristics, where cues from the researcher may lead a participant to perform the way they think the researcher wants them to perform, and also observer bias, in which an observer's own expectations about what may happen alters the way that they interpret the data. The method used to alleviate these negative effects was for the observer to use his judgement whether to engage with the participant or to prioritise minimal interaction between observer and participant.

3.5.3 Interview preparations

Interviews as research methods can be time-consuming, costly and difficult to run, thus preparation in the form of understanding techniques and pitfalls is essential. The skills required of an interviewer would seem to be quite ubiquitous; using straightforward questions, listening more than speaking and removing the cues from questions that indicate the 'desired' response (Robson, 2002). However, as Gillham (2000) pointed out these skills do not come naturally and conversations can often be more of a battle than a fluid transition between speakers. To support the researcher in developing the ability to facilitate a successful interview two pilot interviews were run with colleagues. The audio recordings of the pilots were analysed for inconsistencies and areas to be improved upon. These also gave the interviewer an opportunity to practice the common techniques of probes and prompts, which can help to steer interviews in the desired direction.

3.6 Observational strategy

3.6.1 Procedure

In consultation with the A&E matron, clinical lead and secretary, a schedule of days available for observations was agreed upon. During these available days the researcher was allowed to enter at any time of his choosing. The main proviso imposed was that during the particularly busy periods in the resuscitation room the researcher was required to leave and return at a quieter time. This happened on three occasions. Leaving during these times allowed the professionals perform their duties without the observer getting in the way and provided additional privacy to patients and their families. These enforced breaks enabled the researcher to reflect on the recently observed interactions and to consider the aspects of interest to be investigated on resumption of observations.

The entire observational stage was exploratory and descriptive, meaning that it sought to examine and understand workarounds and their effects. Observations passed through diverse

stages during which different aspects of Spradley's (as cited and adapted by Robson, 2002) observation scheme were emphasised.

1. Space – the layout of the physical setting: location of important instruments, locations of workers and also of the researcher.
2. Actors – relevant details of those involved: profession (doctor or nurse) and experience.
3. Activities – activities performed by the actors.
4. Objects – those objects within the environment that have a direct impact on the tasks; furniture and equipment.
5. Acts – specific individual actions used to complete tasks.
6. Events – particular occasions of interest: chats between colleagues and training.
7. Time – the sequence of events.
8. Goals – the aims of actors when engaged in actions and activities whether they were successfully accomplished or not.
9. Feelings – emotions in context, did they have an effect on interactions.

Initially, all nine aspects were attended to with an emphasis on understanding the physical environments and how it related to the work. After two hours the space had been explored and fully recorded. The observer then concentrated on aspects 2 – Actors, 3 – Activities, 4 – Objects, 5 – Acts, 6 – Events and 8 – Goals. Spradley's list was of great benefit to the observer to focus his mind at key moments of interaction.

Research was conducted at a variety of times from early in the morning to late in the evening and also at weekends. This was primarily to obtain a representative sample of interactions with staff who are often extremely busy. In addition, due to the nature of the A&E department it can be impossible to predict at what times the ABG analyser will be in demand.

Many of the A&E and ITU clinicians that commonly interacted with the ABG analyser had been alerted to the presence of the observer prior to beginning. Even so, it was felt appropriate that the researcher politely ask for permission to observe the interaction. As expected there were a variety of reactions, while all staff obliged the request some then ignored the researcher to continue with their task, while others described in detail the actions that they were carrying out and how they related to their goals, others still wanted to converse about unrelated topics such as the current sporting events or the news of the day. It was common for the participants to ask what the researcher was doing; in these cases a standard answer of "I'm researching strategies of interaction with the ABG analyser" was provided. This style of short and unspecific description was suggested by Jorgenson (1989) to alleviate concerns of participants and to allow them to relax.

When a staff member was interested in describing the process the observer listened and asked questions based on their comments or actions, and in this manner conducted a number of informal interviews. These interviews were initially vital to gaining a detailed understanding of the task and the extraneous factors involved in the interaction. Later these informal interviews served to gather more specific data regarding the strategies of interaction used, as discussed below in the interview section.

The process of interacting with the ABG analyser was fast, even for novice users, which meant that note taking during interaction was impractical as the researcher may have missed something important while jotting notes. Luckily, as the process typically lasted less than 5 minutes it was possible for the researcher to record his notes as soon as the interaction had finished.

3.6.2 Notes

These notes took the form of keywords which recorded the procedure and comments on the specifics of interaction such as: profession (nurse or doctor), time and any other points of interest, such as colleagues present. The use of keywords was an incremental development to find the best, most descriptive ones. Emerson, Fretz and Shaw (1995) highlighted the benefits of using a personally developed style of recording comments and keywords suggesting that each word is then loaded with meaning for the researcher that will aid him in later analysis. For example, the following entry "m, doc, 26, 2nd 2day, chatting with col, 'back again, you must know this machine better than I do', scan, enter false, bin & wait" meant that a male doctor, on the 26th of the month used the machine for the second time that day, he was chatting with his colleague throughout, while making a comment to the observer, scanned his own ID, entered a false hospital number and left the sample on the sharps bin until the results had printed.

Later in the day these jotted notes were transcribed into a historical account of interaction. These accounts were recorded as simply and factually as possible as suggested by Emerson, Fretz and Shaw (1995). This gave the researcher an exact account of what had happened and was then used as a basis for coding and analysis.

3.6.3 Effects of observation on participants

As previously mentioned, clinicians had various reactions to being observed. At no point did any staff member refuse to allow observation or voice a problem with it. While many were curious and wanted to show the observer the workings of the machine others were preoccupied with their jobs and other duties. No participants showed any overt indications of negative effects of their performance. However, on three occasions participants inserted the blood sample and then left the analyser to retrieve the patient's hospital ID number, it cannot be ruled out that they did this once they realised that their actions were being recorded.

Indeed at one point a participant used her operator ID for a colleague who did not have a barcode for the machine; she then commented jokingly "I'm going to get struck off for that one!" This comment indicates that the staff were constantly aware of the observer's presence and may have at quieter times altered their behaviour to appear in a more favourable light.

3.6.4 Advantages and disadvantages of observations

Observations come with some distinct advantages and disadvantages. The main advantage in this study was that it allowed the researcher to see the actions performed by professionals in reality rather than relying on notoriously inaccurate self reports. For example, Auge and Auge (as cited in Robson, 2002) highlighted the effectiveness of observations at penetrating the closed society of drug mis-users in professional bodybuilding. Jorgenson (1989), argued that observations are also particularly appropriate for the type of exploratory and descriptive studies that aim to generate theoretical interpretations of events. This is due to their flexibility to incorporate casual conversations and to allow a researcher direct access to the phenomenon.

Of course, observations require a great deal of preparation on the part of the researcher, to avoid negative observer effects and also to ensure techniques are being applied as rigorously as possible. In this study the main disadvantage was the unpredictability of the busy times in A&E. Some days were exceptionally busy, providing many opportunities to observe realistic interactions. Occasionally it was very quiet, during these days however conducting interviews allowed continuous data collection to take place.

3.7 Interview strategy

According to Jorgenson (1989), participant observation studies should use observation as a basic strategy and include other methods to develop and further investigate topics of interest. Interviews added this ability to further investigate and in doing so attempted to validate data

from observations. Two interviewing styles were used; informal on-the-spot discussions regarding the actions being taken by the participant while they interacted with the system and formal arranged interviews with specific members of staff. These methods helped to expand the researcher's knowledge of the procedure and the surrounding work environment and allowed deeper investigation into the formation and distribution of workarounds.

3.7.1 Informal interviews

Conversations, both casual and in-depth, play important roles in participant observation studies. As Jorgenson (1989) pointed out, participants often have a wealth of knowledge in the subject domain which can be useful to the researcher. As previously noted, some A&E professionals were valuable sources of insight into the thoughts and attitudes of A&E clinicians. Participants who were engaged in these conversational interviews were those who initiated conversation with the researcher. Occasionally, participants were too busy to engage in conversation. At these times, the observer relied on non-verbal cues and knowledge of the current situation in the resuscitation room and ITU to avoid interrupting the clinicians.

Initially these informal interviews provided the observer with a detailed illustration of the process, highlighting standard operating procedures and explaining the necessity for alternative strategies to be used. For example, early on it was noticed that staff routinely delayed disposal of the blood sample until the results were printed. This was performed in a variety of ways but always with the intent of waiting for the printed results. Delving a little deeper the observer questioned a doctor about the practice, who revealed that the old analyser would occasionally "suffer from the jitters" and "refuse to give results". Thus, to avoid having to draw more blood from the patient the old sample was held or left on the table until the results had been printed. Memories of past experiences was a common reason given by participants for using the technique of delaying blood sample disposal, however none could remember where they had learned it. For the answer to this question a more detailed

investigation had to be conducted. Since the typical interaction with the ABG analyser was under 5 minutes and it was vital that healthcare staff were not interrupted during their shift, it was necessary to schedule formal interviews at break times or at the end of shifts.

3.7.2 Formal interviews

While casual conversations were valuable in the context of actions performed during interaction, discovering how strategies were created and spread required a more thorough and systematic analysis. Robson (2002) highlighted the power of the research interview as its flexibility to be shaped according to the responses given by participants; intriguing answers can followed up and significant information can be accessed by the interviewer. In this study formal interviews allowed the researcher to investigate specific areas of interest which lay outside normal staff interactions with the analyser. Eight formal interviews were conducted in total: three with point of care (POC) technicians responsible for analyser maintenance, three with nurses from A&E and two with doctors from A&E.

Interview questions were developed during observations. As suggested by Gillham (2000), a list of questions was maintained and analysed throughout data gathering. This list was pruned and edited over time in response to continued data analysis. This process resulted in a list of available questions on certain topics that were tailored toward the skills and experience of the participant. Participants were provided with information explaining the nature of the study, the option to withdraw at any time and the researcher's contact details. Consent forms were also provided and signed by each participant. Sample information sheets and consent forms can be seen in appendix A.

Two different interviews were developed; one for the clinical staff of doctors and nurses and the other for the POC technicians. The basic format of these interviews can be seen in appendix B. The first interviews conducted were with the POC team in the biochemistry

department due to their intimate knowledge of the workflow and of regulatory considerations. These interviews were only held after about 6 hours of observation, when the researcher had gained an understanding of the workflow and had identified areas of interest. In addition to valuable information regarding the interaction process the POC team gave the researcher a deeper understanding of the wider aspects such as manufacturer support and management concerns.

Throughout research clinicians from A&E were recruited to examine topics in more detail. Interviews were scheduled for times when the clinicians were available. The topics of interest were predominantly workarounds identified, the reasons for their use, attitudes among the doctors and nurses towards the workflow blocks that caused them and the real and perceived consequences of using the workarounds.

3.7.5 Advantages and disadvantages of interviews

Interviews proved to be a particularly effective method of gathering data due to their flexibility and adaptive nature. Answers provided often exposed areas of interest which could be immediately followed up, and much of the data gathered was rich and insightful when it came to analysis. However, interviews required considerable investment of time on the part of the researcher both conducting them and analysing the data. Flexibility was required to arrange the interviews as the participants were busy hospital employees. Finally transcribing interviews was a particularly time consuming activity.

3.8 Data analysis

3.8.1 Observational data

Iterative processes of analysis were used in which data were progressively linked to form an overall view of interactions with the analyser. The first stage was to observe the participant and record the interaction using keywords. Immediately after each interaction there followed

a period of reflection during which the researcher considered how the observed interactions linked with previous participants' interactions. The next stage took place at the end of each day and involved a more detailed analysis of all events that occurred during that observation period. It was a simple re-writing process which expanded upon the facts contained in the keywords. The final step was to examine data in a variety of sets, for example interactions with specific workarounds, and also in combination with data gathered from interviews. Common themes were tentatively explained using interview data and notes were made in areas that required further analysis. These final two steps were performed throughout the data gathering process, to ensure a continual refinement of focus in observations and interviews.

3.8.2 Interview data

It was undoubtedly more difficult to analyse interview data than observational data. Where the observations were short bursts of activity after which a time of reflection, jotting notes and consideration helped to sort the data and to make it understandable. Interviews were between 5 and 15 minutes of constant information exchange and so gathered much more data than observations. After the data was transcribed they were analysed in isolation to highlight the most important information. Interviews scripts were also examined in sets according to the interviewees for example nurses, doctors and biochemistry technicians to attempt to highlight patterns of use or opinions regarding workarounds. Findings of interest that came out of data analysis are reported in the next chapter.

4 Findings

4.1 Overview

There were a total of 49 interactions with the arterial blood gas (ABG) analyser observed over a 12 day period. 46 of these events were successful, meaning that the operators completed their goals and received the results of analysis; of these 25 were in the accident and emergency (A&E) and 21 were in the intensive therapy unit (ITU). 3 interactions were unsuccessful, meaning a situation arose which prevented the analyser from providing the results; all of these were in the A&E. Unsuccessful interactions were caused by 2 events: an operator having an insufficient sample size, the minimum being 2ml and the analyser being locked due to a failed quality control. Events referred to in this chapter can be seen in appendix C, participant comments in appendix D.

For the purposes of identifying and classifying workarounds only successful interactions were considered. The five workarounds identified were: using a colleague's barcode to access the system, entering a false hospital number to identify the patient, writing patient details on an external memory aid such as a glove or cardboard tray, delaying disposal of the blood sample and cancelling calibration. These workarounds will be examined in more detail later in this chapter.

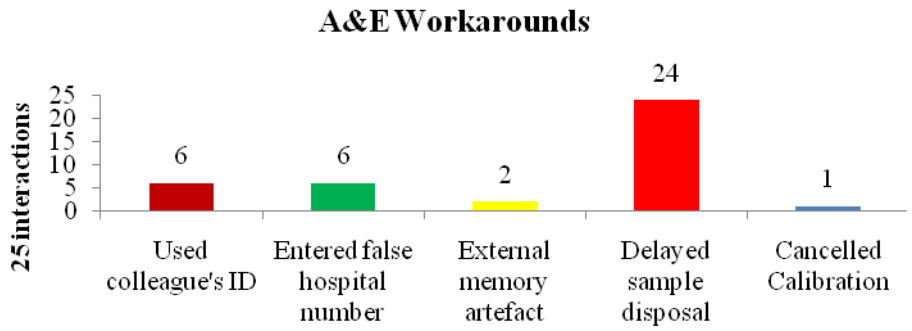

Figure 2. A&E workarounds. Shows the occurrence of workarounds in A&E

Figure 2 shows that all five workarounds occurred in A&E at some point. Sample disposal was delayed in all but one of the 25 successful A&E interactions, making it the most widespread workaround identified. Next most frequent were using colleagues' barcodes and entering false hospital numbers happening 6 times each, then using an external memory artefact which happened twice and finally cancelling calibration which took place only once.

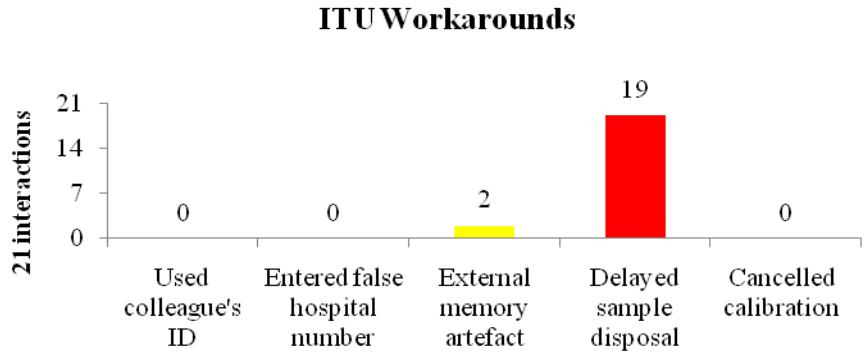

Figure 3. ITU workarounds. Shows the occurrence of workarounds in the ITU.

As can be seen in figure 3, the ITU data contrast starkly with those from A&E. Out of the five identified in A&E only two occurred in ITU: writing patient details, which occurred twice and delaying sample disposal, which occurred 19 times out of 21 interactions and was ITU's most prevalent workaround. The most notable aspect of this data is the complete lack of three workarounds, which indicates that clinicians in ITU usually followed the standard operating procedure (SOP).

4.2 Arterial Blood Gas analyser

The interactive medical device under investigation was the Siemens Rapidlab arterial blood gas analyser 1200 series, as seen in figure 4. Its function in healthcare is to diagnose a variety of pulmonary problems, especially those related to the lungs and respiratory system. The 1200 series can analyse blood gases (pH, pCO2, pO2) related to the respiratory system, measure the levels of electrolytes (Na+, K+, Ca++, Cl-) which are important for muscle functions, analyse metabolites (Glucose, Lactate, Neonatal Total Bilirubin) which are vital to

metabolism and also analyse CO-oximetry (tHb, HHb, O2Hb, sO2, COHb, MetHb) which are related to blood oxygen levels (Siemens, 2010). This comprehensive set of tests makes the machine a critical piece of point of care (POC) equipment. Both A&E and ITU have identical analysers; ITU have had theirs for 2 years and A&E received theirs just 3 months prior to this research project.

Figure 4: Siemens Rapidlab 1200 series, © Siemens Healthcare Diagnostics Inc. 2007-2010. All rights reserved.

In the Royal Free hospital both analysers are maintained by the POC team, who are part of the biochemistry department. They are responsible for maintenance on a daily and weekly basis as well as fixing problems as and when they occur. The POC team can only help with problems during normal working hours of 9-5 Monday to Friday. During these hours they also provide training for A&E staff on the formal procedure of interaction. Completing training is a requirement for obtaining a barcode which allows access to the system. ITU has a permanent POC technician who is responsible for all their POC equipment and also delivers training on these machines, but is not responsible for maintenance. This technician is also only available during normal working hours; however she has a much closer relationship with the ITU team as she is permanently based in the ITU. She knows the names of the nurses and if a new agency nurse starts the technician ensures that the nurse receives training as soon as

possible. This contrasts with A&E staff who must contact the biochemistry department to schedule training or find time to attend the arranged sessions, meaning it sometimes does not happen as with the doctor in A&E event 16 who had "not found time to attend training" but nonetheless had used the analyser 10-12 times.

The analyser is designed for a high working load and low maintenance. To achieve this it performs a short automated calibration every 30 minutes and a full automated calibration every 8 hours; in addition it washes internal equipment and performs regular automatic quality controls (AQCs) (Siemens, 2010). These actions increase reliability of the results, but as shall be seen they can be worked around and subsequently lock the machine for long periods.

Increased reliability and throughput are two of the main reasons that the hospital upgraded from the 800 series ABG analyser to the 1200 series. Another reason was the ability of the 1200 series analyser to link directly to the hospital's main information system. This will allow patient results to be automatically added to their digital file and permit authorised staff to access the records. This has not yet been implemented but is in the planning stages. The POC team hope that the direct link between analyser and information system will provide a final regulatory incentive to eliminate a large percentage of the negative workarounds such as entering false hospital numbers and sharing barcodes. Currently each patient's blood gas results are stored in each analyser's memory and can be retrieved at a later date, but only if the original analysis results were correctly identified using a patient's hospital number.

4.3 Workflow

When an operator has authorisation to access the system and the patient details available the SOP is linear and onscreen instructions are easy to follow. There are five high level steps to complete in order to obtain the results: scanning the operator's barcode, inserting the blood

sample to begin analysis, removing the blood sample, identifying the patient and retrieving the results. These can be in see figure 5 below; a task analysis of the procedure.

In order to gain access to the system an operator must scan their barcode or enter the barcode number. The blood sample must then be inserted for analysis, however it is critical that the sample is mixed to ensure no clots or air bubbles are contained within the syringe. This is aided by the sample being taken in heparinised syringes, which are specially designed to reduce clotting. Once the sample is inserted the operator must then touch 'analyze' on the touchscreen display, after which a message is displayed 'system is temporarily busy please wait' and a countdown timer indicates the estimated length of the wait. This initial wait is for the preliminary analysis and is short; the system then prompts the user to remove the sample. After removing the sample the user touches 'continue' and is prompted to enter the patient's details beginning with the hospital number and including last name and temperature. The operator touches 'continue' after entering the details and the results begin to appear onscreen, the first results are displayed quickly but the final few can take up to 50 seconds. The results are printed after all have been displayed onscreen. Depending on how quickly the operator enters the patient details, results can be printed as quickly as 90 seconds after the user is prompted to remove the sample.

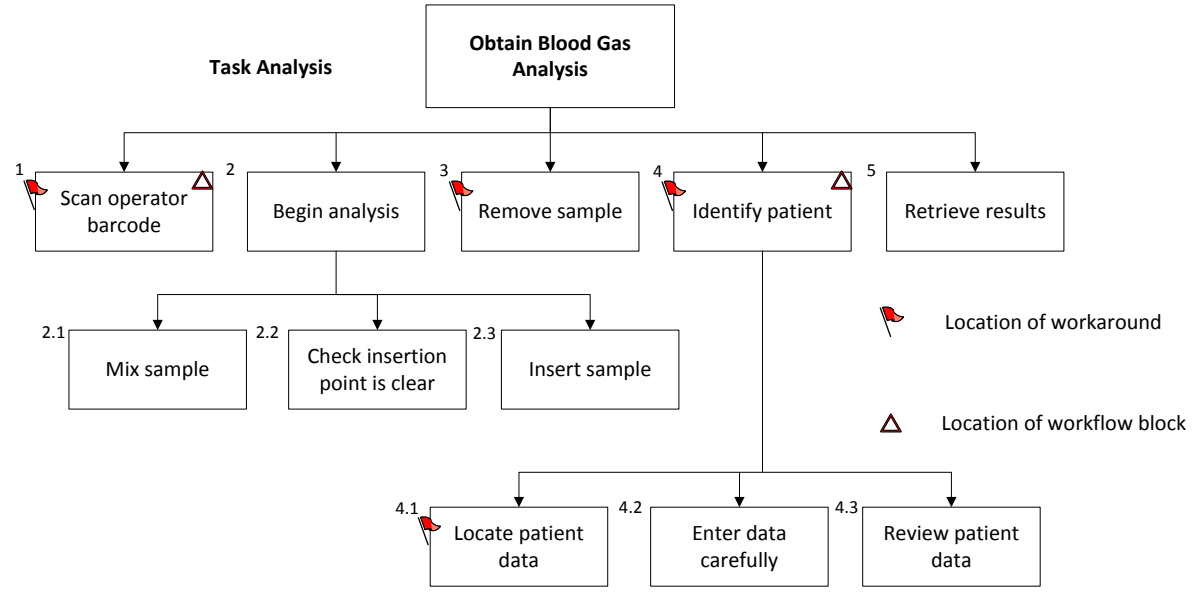

Figure 5. Task analysis. A breakdown of the workflow.

4.4 Workflow blocks

There are two high level tasks that can cause blocks in the workflow, these are 'scan operator barcode' and 'identify patient', in figure 5 they are steps 1 and 4. These are both regulatory procedures. Step 1 is partially a case of enforcing the rules by making operator identification mandatory and is also a method of ensuring only trained hospital staff access the machine. Step 4 is necessary to record the data of a particular patient and to allow retrieval of the data at a later date. These blocks are regularly bypassed in the A&E for a variety of reasons, which are examined later in this section.

Workflow blocks also exist in the system that are not part of the typical operator interaction and so are not in the task analysis, these are;

A. The machine is calibrating or washing.
B. The machine is locked due to an AQC showing a drift in the values and a risk of inaccurate results.
C. The sample size is insufficient to perform analysis (minimum 2ml).

These blocks are due directly to hardware issues and are implemented to ensure accurate results and an efficient and reliable analyser. Block B is impossible to workaround, as the machine will be out of service when it locks itself. Block C is also impossible to workaround; with an insufficient sample the machine cannot complete a full analysis. There is a special option to obtain a small number of results from micro samples; this option was never used during observations and will be discounted from the discussion. Block A, however, is possible to work around; it is feasible to cancel both calibration and washing.

The next sections focus on examining each workaround in more detail. In order to gain a deeper understanding of the workarounds, factors attributed to their creation and proliferation throughout departmental staff will be reported, as well as the downstream consequences.. Opinions held by the operators will also be described in order to shed some light on how those at the sharp end of the organisation view workarounds. Events involving interaction with the analyser that are referred to in the next section can be seen in appendix C and the comments of participants in appendix D.

4.5 Sharing barcodes

Scanning a barcode or typing the barcode number is required to gain entry to the system. Since this step is mandatory, if a user does not have a barcode, it constitutes a workflow block and they must work around it. This is typically done by asking a colleague to scan their barcode to allow entry for the operator.

4.5.1 Creation and proliferation

There are three main reasons for adopting this technique:

1. The operator is new or temporary and has not received a barcode.

All A&E professionals receive their barcodes after attending training. New doctors and nurses do not typically do this on their first day and can often wait much longer, yet they still need to analyse blood samples. It is not always feasible or appropriate to ask a colleague to perform the analysis for them; scanning a barcode to allow a colleague use the analyser themselves takes a matter of seconds.

2. The operator is from a different ward and so does not have, and cannot get a barcode.

Only clinicians based in A&E and ITU can be issued with a barcode to use the ABG analyser; clinicians from other wards should send samples to the biochemistry lab. This does not stop doctors and nurses from other wards that do not have an analyser from coming down to the A&E. Interviewee 2 commented that this will happen "if they have a particularly sick patient and they need immediate access to an ABG analyser". Many A&E clinicians cited memories of the old 800 series analyser as an example of why clinicians use A&E's analyser. There was a generic password of '7777' which was common knowledge throughout the hospital and was even written on the analyser. The nurse in interview 6 hypothesised that because of this "older staff still tell new nurses to 'go to A&E for the analysis', because it can be quicker than joining the queue in biochemistry". As ITU is a more secure environment visiting clinicians are rare and there is no problem with staff from other wards using the analyser.

3. The operator has forgotten their barcode.

Although there were no observations of A&E professionals not having their barcode, it was mentioned during interviews. However, it is a rare occurrence because the barcode is attached to their employee identification which is necessary for many tasks, not least entering some of the restricted areas in the hospital.

4.5.2 Effects of sharing barcodes

If the operator using this workaround is doing so because they have forgotten their ID the ramifications are not serious. However, if the operator has not been fully trained there is the possibility that they may damage the analyser. The widely held belief that untrained operators are a cause of system failures was voiced by interviewee 2, "new [doctors and nurses] have the potential to use it incorrectly and cause damage to the machine which may be out of action for some time". This is a very real fear as the analyser can be 'out of action' for long periods over the weekend when no technician can service it. For example, one Saturday the observer arrived to find the analyser had locked itself due to calibrations being repeatedly cancelled; it had been locked since 03.03 that morning and was not unlocked until 12.13 on Monday afternoon.

Experienced clinicians reported that they understood the risks of cancelling calibrations too well to do so. The next example to show the effects of untrained operators using the analyser was again A&E event 20 in which a doctor without a barcode scanned a colleague's barcode. He then proceeded to cancel calibration which caused the analyser to lock for a short time, until a technician arrived to fix the problem. The technician's following actions highlighted the danger of sharing barcodes. The technician searched for the operator to no avail as the barcode identified another person who could not remember who the doctor was. In this way training and retraining becomes particularly difficult as individual operators cannot be easily identified.

4.5.3 Perceptions

A&E clinicians recognise the advantages of only trained staff using the analyser with interviewee 7 saying "ideally other ward staff would go to the biochemistry lab". However, A&E clinicians can be the facilitators of this workaround as interviewee 5 highlighted with the comment:

> We can be seen as a bit soft down here, not silly or anything, but we put the patient first and might let them use it. But afterwards we might give out and tell them not to do it again, I would anyway.

POC technicians see the introduction of unique barcodes as a critical step in eliminating negative workarounds. They hope that once analysis results are automatically sent to the central information system operators will recognise the full audit trail and will comply fully with the SOP. Since each operator will be responsible for the information entered with their ID, sharing barcodes and entering false hospital numbers should decrease.

4.6 False hospital numbers

Each patient has a hospital number which identifies them. This number should be entered into the system to attribute data produced during an analysis to that particular patient. This step also allows the operator to enter the patient's name and recorded temperature. Of the three tasks available only entering the patient number is mandatory which presents a workflow block when a patient's notes are not readily available and is then circumvented by entering any random number

4.6.1 Creation and proliferation

The common occurrence of false hospital numbers in the A&E is widespread knowledge. It was commonly referred to as a result of the busy life of an A&E clinician. Interviewee 2 defended the technique saying that it is "a time saving measure when people haven't got the number to hand", which was a stance echoed by the clinician in event 9. Another way to complete the step without bringing the patient's chart was observed when the doctor in event 14 commented "I always forget the notes" as she went to the nearby computer to find the information on the CERNER hospital database.

One biochemistry technician in interview 3 put the reasons behind the technique succinctly "because the step is mandatory, something has to be entered, so in order to get the results staff will just put in any number. It's a means to an end." This means is acceptable in one particular type of case, a 'blue code' which is an emergency trauma event where the patient is rushed straight to the resuscitation room without being registered. However no such 'blue code' occurred during observations and was not a reason for the use of this workaround during research.

The interesting aspect about the use of this technique is that it was not observed in ITU. Further examination of the environment highlights the reason for this. In ITU the patients are long term and it is always known what patients are in the ward at any given time. As such ITU patients' hospital numbers have been printed on a page along with the barcode, and left beside the analyser making it almost as easy to scan as to work around.

4.6.2 Effects of false hospital number

The most immediate effect is that the results, both printed and onscreen, cannot be reliably attributed to a particular patient. The printed results contain no other identifying data so if mixed up with other results they become unidentifiable and useless. However, for most interactions with the analyser, clinicians take the results to the patient immediately and subsequently write the information in the chart. Another effect, and one that ITU nurses are very careful to avoid, is that it makes retrieving a particular patient's previous analysis results impossible.

As mentioned above, entering a false number during a 'blue call' can speed up the process of interaction. This ensures that the global workflow remains unaffected and the clinicians can continue diagnosing the emergency trauma patient.

4.6.3 Perceptions

Staff perceptions of this workaround varied greatly within the A&E, from interviewee 4 claiming that entering a false hospital number "caused no problems at all, anyway it [the analyser] is not connected to the information system", to the doctor in event 21 saying "the number is important because without it you don't know whose ABG it is." Interviewee 4 knew that the lack of an integrated network reduced the functionality but also believed that it became useless to enter the correct details because of this. However this belief was not pervasive; the doctor from event 21 also claimed that "it would be bad [not entering the hospital number] because the information doesn't go onto the hospital system." The beliefs that clinicians had regarding the consequences of a workaround were identified as important in whether they decided to engage in that workaround. This idea is elaborated upon in the next chapter, in the section discussing why clinicians choose workarounds.

ITU nurses were unanimous in their view of the hospital number as being very important. They were clear that it is essential to be able to reproduce the exact results for a doctor if asked. Again, this was primarily due to the long term nature of ITU patients and the necessity to measure how they have been performing over a period of time.

4.7 Delayed sample disposal

The most pervasive workaround identified involves the operator delaying disposal of the blood sample until the results have been printed. The system prompts the operator to remove the sample prior to the results appearing on screen and being printed. The delay between removal and results being printed is typically 90 seconds or more so it is easy to dispose of the sample in the sharps bin which is beside the analyser in A&E and behind the operator in ITU.

This strategy was observed in all but three successful staff interactions. Two of the interactions which failed to include this workaround occurred in the ITU and were both made by the same nurse in events 4 and 17, who commented that she didn't need to wait "because she didn't need the whole analysis". By this she meant that the first few results that were sent to the screen told her all she needed to know and so she disposed of the sample. The other interaction was with a new A&E doctor in her first attempt at using the analyser, she had not yet learned the technique.

4.7.1 Creation and proliferation

Delayed sample disposal is a strategy created in response to the adverse event of the analyser breaking down mid-analysis and not printing any results. This would necessitate the analysis to be run again and if the sample had been disposed of a new blood sample would be required. The previous 800 series model was notorious among staff for failing mid-analysis; however this did not happened to any of the clinicians observed using the 1200 series.

There were two main methods of learning this technique. In A&E a common answer was that the strategy was developed in response to a past experience. For example, the response of the doctor in event 19 to the question of creation was "I guess that I once analysed the sample, disposed of it and it [the analyser] didn't work so I thought damn I need to go and bleed the patient and put them through a very painful procedure."

The second method of learning this technique is for a colleague to instruct the operator in its importance. This is best seen in ITU where the POC technician has adopted the strategy as a formal step and includes it in standard training. So although it is not in the user guide posted above the ITU analyser it is part of each operator's formal training.

4.7.2 Effects of delayed sample disposal

The effect of using this technique is to improve workflow, by minimising the negative consequences of a system failure. In the event of system failure the clinician can reuse the sample to run another analysis. This also means that the patient does not have to provide another arterial blood sample, which can be a difficult and uncomfortable procedure.

4.7.3 Perceptions

The ITU POC technician commented that this technique is "logical, common sense. You are a professional in a professional environment; you make sure that the full results are printed." Yet this technique is not in the SOP for either the 800 series or the 1200 series. The positive effects of this workaround are the reasons for the ITU technician adopting it as standard practice.

While for ITU nurses it is part of their training, A&E clinicians learn this technique from experience and each other. The participants who commented on this strategy also mentioned how painful it is to have blood drawn from an artery and they will avoid doing this twice if at all possible.

4.8 Memory aids

Although not a common technique, using an external artefact as a memory aid for the patient details including hospital number, temperature and name is a positive one. The memory aids identified were disposable latex gloves and small cardboard trays which are sometimes used to transport samples to and from the analyser.

4.8.1 Creation and proliferation

This is another organically created technique in which staff attempt to compensate for their forgetfulness or desire not to carry the patient notes each time. It was only observed 4 times and it was not possible to interview the clinicians involved in depth. However, the ITU nurse

in event 1 commented that he did this because the patient was new and his hospital number was not on the list yet. The other ITU nurse who used this strategy in event 5 said that in her experience the list is not always updated on time and there can even be problems during transfers from other wards which means the number can be incorrect. Since entering a false hospital number is viewed very badly in ITU, a nurse encountering an incorrect printed barcode would have to return to the patient to find the right one. This nurse said she had been caught out and did not like having to go back.

4.8.2 Effects of memory aids

This technique can help a clinician to fulfil their duties of entering the patient details correctly without the need to bring the patient's notes. It is also a faster strategy than using the computer located in the vicinity, which was observed in A&E event 14, as the operator must log in the computer system and then search for the patient.

4.8.3 Perceptions

As it was an uncommonly observed strategy it could not be followed up in much detail. However, two nurses had stronger opinions than most. The A&E nurse in interview 5 was against the idea of using the cardboard trays as they "cost too much money to be just used to write on." The same nurse was more accepting of writing on gloves. The other A&E nurse in interview 6 was much more positive; she saw the benefits of the strategy and even commented that "it may stop people entering wrong hospital numbers."

4.9 Cancelling calibration

There exists an option for the user to cancel the short, 2 minute, automated calibration that is completed every 30 minutes. It is a simple matter of pressing one button on the touchscreen. The SOP as written in the user guide above each analyser states clearly that this action should be avoided if at all possible.

4.9.1 Creation and proliferation

Calibration is cancelled when an operator requires an immediate analysis or when the operator does not understand the consequences of doing so. If, for example, the calibration begins at the exact moment that a clinician wishes to analyse a sample of a 'code blue' emergency trauma patient, it is possible that the clinicians may have to wait over 2 minutes for the analyser to complete calibration. In this situation the operator may decide that the patient's needs are greater and cancel the calibration. However, as previously mentioned it was also observed in A&E event 20 that an untrained doctor cancelled calibration for no reason at all. During an informal interview after unsuccessful A&E event 2, two nurses indicated that they understood the negative effects of cancelling calibration to actually engage in this workaround.

4.9.2 Effects of cancelling calibration

When calibration is cancelled the analyser cannot realign the elements which measure blood gases, electrolytes, Metabolites and CO-oximetry. Because of the high working load of the analysers there is always a danger that the values of these elements may drift too far away from the safe minimum for an accurate analysis. When this happens, the next automatic quality control could determine that automated calibration cannot realign the values and a technician's assistance is necessary and thus lock access to the analyser until the technician has performed calibration. This of course means that the analyser is unavailable for any clinicians to use.

4.9.3 Perceptions

The nurse in A&E event 11 pointed out that the new 1200 series analyser calibrated more often than the old analyser and so was unusable during these times; however she indicated that she understood this was the price to pay for accurate and reliable results.

A pervasive attitude in the A&E identified from formal and informal interviews was that new, inexperienced or untrained operators are responsible for most of the cancelled calibrations. This was true of the one observed cancellation, performed by a doctor without training. However, the remaining workarounds were not committed any more frequently by new doctors than by more experienced doctors. Indeed, the doctors that completed the procedure perfectly were just as likely to be new as experienced.

4.10 Summary

Workarounds are, by their very nature, created to help the operator achieve their goal. In addition to bypassing workflow blocks, clinicians reported using them to speed up time spent with the machine. Both ITU and A&E clinicians also held a wide variety of opinions regarding workarounds and their consequences ranging from workarounds being acceptable to completely unacceptable. However, the most surprising finding was that each of the five workarounds had both positive and negative effects depending on the circumstances of their use. How these relate to the literature discussed in chapter 2 and how it might be possible to eliminate the negative effects is discussed in the next chapter.

5 Discussion

5.1 Introduction

By systematically analysing the creation and consequences of workarounds and attitudes towards them it has been determined that there are possibilities when individual resilience can be increased by using workarounds. However, the link was not as strong as hypothesised and so this section also examines the positive and negative downstream effects of each workaround in more detail. In order to discuss these ideas, examples from the hospital are reported in combination with relevant theories highlighted in the literature review in chapter 2. Finally, some potential design implications for the system and the work process will be presented.

5.2 Resilience

At the outset of this research project a question of importance was how workarounds could affect system resilience. It was hypothesised that some workarounds created by operators circumvented error prone workflow processes and subsequently increased the ability of the operator to guard against errors. As data analysis progressed it became clear that on this occasion the link was not strong. In particular it was difficult to identify whether system resilience was affected on a wider scale. What can be said is that the possibility for workarounds to affect local system resilience does exist.

For an example of how a workaround can increase local resilience we will look at the technique of delaying sample disposal. Operators make the decision to use this technique when they anticipate the occurrence of negative consequences, specifically that the analyser will fail mid analysis. By inserting the additional step of delaying disposal into the workflow an operator ensures that system failures cause the minimum amount of damage to their primary goal. This strategy aims to manage the negative consequences of a potential failure in the workflow and so corresponds to Hale and Heijer's (2006) definition of individual

resilience. This is a clear example of the local workflow becoming more resilient to errors after a workaround is used.

One example of increased wider departmental resilience is that of cancelling calibration during a 'code blue' emergency. A&E clinicians may cancel calibration during an emergency situation to receive the results of analysis faster. Thus, they sacrifice the lower level goal of calibrating the analyser to ensure the higher level goal of patient care is not adversely affected. Cook and Nemeth (2006), claimed the techniques of reorganising goal priority and sacrificing lower level goals were instrumental in creating a resilient A&E workflow. This suggests that there is a possibility for wider departmental workflows to experience increased resilience as a result of a workaround.

Unfortunately it was not possible to follow up on this example of wider resilience during research due to the fact that no blue codes occurred when the researcher was present. Another difficulty of attributing cases of increased or decreased departmental resilience to a particular workaround was the fact that most workarounds had both positive and negative consequences.

5.3 Positive workarounds, negative consequences

Workarounds were deemed positive when the identified downstream effects were predominately advantageous to the operator and the workflow. These include; delaying disposal of blood samples and using external memory aids.

As previously mentioned the technique of delaying disposal of blood samples ensured that any negative consequences encountered due to the analyser failing would be minimised. However, this hospital wide workaround can also create negative downstream effects. For example, it increases the risk that a blood sample will fall and break. This is because operators leave the syringes in places that are not designed to hold them: on tables, on the lid

of the bin or held in their hands. Blood spills in hospitals are not uncommon occurrences, yet are always treated seriously due to the potential ramifications of contamination.

Another consequence is to increase the chance of a mistaken identity. If an operator leaves a sample in a common location for delaying disposal, it could be mixed up with another sample. This would, in effect, remove the positive effects of the workaround; in the event of the analyser failing samples could not be identified and thus could not be reanalysed.

5.4 Negative workarounds, positive consequences

Bypassing a step in the standard operating procedure (SOP) is a straightforward system violation as discussed by Reason (1995) and Taxis and Barber (2003). The deliberate violations identified were sharing barcodes, entering false hospital numbers and cancelling calibrations. These three can create holes in the layers of system defences, just as in the Swiss cheese model explained by Reason (1997), in which each layer of defence contains some holes where errors can slip through and certain actions can align the holes making errors more common or can even create more holes. Some of the negative effects of these workarounds are: results being lost or mixed up, results becoming less accurate and training, re-training and imposing sanctions becoming more difficult as operators cannot be identified.

However, as these violations circumvent workflow blocks they also speed up the entire interaction process, which is itself a positive effect. For example, sharing a barcode allows an operator to use the system without looking for their own ID, entering a false hospital number instantly skips a step and cancelling calibration allows immediate access to the analyser.

Entering a false hospital has an effect that is more important than merely speeding up interaction; it is a critical workaround during an emergency trauma event. It is essential because code blue patients are rushed directly to the resuscitation room, bypassing reception, without receiving a hospital number. Not having a hospital number makes receiving the

results of analysis impossible without working around the patient identification step. During research there was an opportunity to briefly examine the event log for a particular weekend; it showed that during some emergency interactions '999' was entered as a hospital number rather than the more common '123'. Following this topic in interview 8, it became apparent that '999' was not an official hospital number for code blue situations, but was a variation of the false hospital number workaround. Some clinicians used '999' for themselves, so they could find out which system logs were performed during emergency situations and which were not. A recommendation discussed below is to retain this emergency workaround.

In order to eliminate the negative effects of entering false hospital numbers it is vital to understand the importance of the workaround during an emergency case. It might be difficult for a systems designer or manager to know the importance of this workaround because they are so far removed from operations. However, a good example from ITU, discussed below, shows how procedures were changed based on understanding the needs of those operating at the sharp end.

5.5 From informal to formal

The analyser in ITU is 2 years older than in A&E. This time has been used to eliminate one negative workaround and to formalise one predominately positive workaround. A laminated memo stuck to the wall behind the ITU analyser dated 2008 reads:

> Barcodes are not to be shared under any circumstances with any other users, even if they have received training. I have observed this and if it continues I shall remove the barcode access of that person.

This note created by the ITU POC technician is an explicit and constant reminder of the consequences attached to violating this procedural step. Another innovation in ITU is the previously mentioned augmentation of the training procedure. It now formally incorporates

the additional resilient step of delayed sample disposal. These targeted actions demonstrate how the technician's knowledge of both procedural necessities and the demands of working at the sharp end of the system helped to remove a negative workaround and standardise a positive workaround.

Woods and Cook (2002) argued that a detailed knowledge of a work process from the view of those at the sharp end of the system is essential to identifying and fixing problems. It appears that such knowledge is also required to identify positive workarounds and to understand how to incorporate these into the standard operating procedure.

5.6 Why work around?

The question of why well trained healthcare professionals engage in risky workarounds was raised in chapter 2. Some participants' responses indicated the busy life of an A&E clinician as the cause. Yet this fails to explain the lack of negative workarounds in the ITU in which nurses are also very busy.

When interviewee 4 was asked why some A&E clinicians enter a false hospital number, she didn't give the standard response of 'time saving measure', she straightforwardly stated that "they are lazy or just couldn't be bothered." It is this researcher's opinion that the perceived laziness is due to clinicians who are not fully aware of the negative consequences of violations, particularly the consequences for patients. This lack of understanding results in workarounds being regularly used.

Reason (1995) argued that violations can be caused by, among other things, poor supervisory examples, lack of concern, the failure to reward compliance and the failure to punish non-compliance. By incorporating some procedural changes it may be possible to alter the attitudes of clinicians and lower the incidences of negative workarounds while retaining positive workarounds.

5.7 Design implications

Entering a false hospital number is the negative workaround that has the most positive outcome and is widely practised. In order to retain the positive effect the '999' emergency resuscitation workaround should be adopted into formal procedure. To ensure it is used only in the specific emergency situations, the policy should be made clear and well defined during training. In addition, the impossibility of retrieving previous results after entering a false hospital number and the negative consequences for patients should be made obvious to all clinicians and a memo this effect should be posted in close proximity to the analysers. These steps should greatly decrease the negative incidences of this most helpful workaround.

Delayed sample disposal should also be incorporated as a formal policy and should be instructed during training. To ensure that the potential negative effects are bypassed, the lid of the sharps bin should be the standard location to place the sample during this step. There is a lip surrounding the lid which prevents the syringe falling off. Since the sharps bin is where samples are disposed of it should provide a reminder for clinicians to complete disposal by pushing the sample into the bin. Taking this even further would involve redesigning the lid of the sharps bin for the purpose of holding the syringe, although the author notes that this is likely to be expensive.

Personal sanctions as result of sharing barcodes should be made more explicit to all staff. A memo or notice should make clear the potential negative consequences for the workflow and also for the staff members who use this workaround.

Finally, a wider interdepartmental change involving communications between the POC team and both A&E and ITU clinicians would help to identify any workarounds developed in the future. All senior clinicians in A&E should be encouraged to approach the POC team regarding workflow difficulties and problems encountered due to workarounds by other staff.

This would be in addition to the normal motivations for communication and could be applied to all POC equipment throughout the department. This more explicit step of reporting workflow concerns could help the POC team to identify workarounds and to classify them as positive or negative before taking any further steps.

6 Conclusion

Workarounds seem to exist in all human interactions with technology; from disabling alarms to skipping steps in standardised procedures. Previous research in this area has shown that healthcare professionals are particularly adept at creating workarounds to bypass workflow blocks. While this field is still developing, much of the research has focussed on the fact that workarounds often produce negative downstream consequences (Halbesleben et al., 2010). Interestingly, the main finding of the present study was that workarounds can have both positive and negative consequences, depending on the circumstances of their use.

Further research should consider how workflows are altered by both the good and bad effects of workarounds. In addition, future researchers should note how the effects can be hidden in the work processes of other seemingly unrelated tasks. For example, entering a false hospital number showed positive effects in the workflow of providing emergency care to 'code blue' patients. This study's main limitation was its inability to further investigate the workflows of these emergency situations, which could have led to a greater understanding of wider departmental effects and resilience.

A particular difficulty associated with researching workarounds is their specificity to each situation. Each workaround is created for a special purpose within a unique workflow. The same 1200 series ABG analyser in a different environment may exhibit none of the identified workarounds from this study. Understanding each unique workflow as suggested by Woods and Cook (2002) requires time and energy. Tighter integration between the operators at the sharp end and the other stakeholders may prove a useful technique in identifying workarounds to be examined. Specifically, a channel of communication for reporting identified workarounds or workflow blocks would alert stakeholders to areas of concern.

What strikes this researcher is that the classification of workarounds as either negative violations or positive workflow improvements may prove too simplistic. Future work should expect one workaround to be both a violation and a workflow improvement. The challenge for researchers and practitioners is how to weed out the negative consequences while keeping the positive effects.

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Appendix A: Consent Form and Information

Informed Consent Form for Participants

(This form is to be completed independently by the participant after reading the Information Sheet and/or having listened to an explanation about the research.)

Title of Project: *Work-Arounds Developed to Make Interactive Medical Equipment More Resilient*

This study has been approved by the UCL Research Ethics Committee Project ID: MSc/0910/004

Participant's Statement

I …….....

agree that I have

- *read the information sheet and/or the project has been explained to me orally;*
- *had the opportunity to ask questions and discuss the study;*
- *received satisfactory answers to all my questions or have been advised of an individual to contact for answers to pertinent questions about the research and my rights as a participant and whom to contact in the event of a research-related injury.*

I understand that my participation will be audio recorded and I am aware of and consent to, any use you intend to make of the recordings after the end of the project.

I understand that I am free to withdraw from the study without penalty if I so wish and I consent to the processing of my personal information for the purposes of this study only and that it will not be used for any other purpose. I understand that such information will be treated as strictly confidential and handled in accordance with the provisions of the Data Protection Act 1998.

Signed: Date:

Investigator's Statement

I ……..

confirm that I have carefully explained the purpose of the study to the participant and outlined any reasonably foreseeable risks or benefits (where applicable).

Signed: Date:

Information Sheet for Participants

You will be given a copy of this information sheet.

Title of Project: *Work-Arounds Developed to Make Interactive Medical Equipment More Resilient*

This study has been approved by the UCL Research Ethics Committee Project ID: MSc/0910/004

Name, Address and Contact Details of Investigators:

Liam O' Connor, 161 Harringay rd, N15 3 HP, liam.oconnor.09@ucl.ac.uk

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We would like to invite you to participate in this research project. You should only participate if you want to; choosing not to take part will not disadvantage you in any way. Before you decide whether you want to take part, it is important for you to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or you would like more information.

This study is aimed at understanding how professionals use technology in environments where resilience is essential. You will be observed using this machine and interviewed afterwards. The interview will depend on the free time you have available and can be cancelled at any time.

It is up to you to decide whether or not to take part. If you choose not to participate it will involve no penalty or loss of benefits to which you are otherwise entitled. If you decide to take part you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time and without giving a reason.

All data will be collected and stored in accordance with the Data Protection Act 1998.

Appendix B: Interview questions

A&E/ITU biochemistry questions

1. What is your position in the hospital?
2. How long have you worked here?
3. How often is the machine in A&E/ITU maintained?
4. Is it usable during these times?
5. In what ways is the new 1200 series analyser different from the old 800 series model?
    - Follow up on answers to gain insight on operations
6. Who provides training for staff on the analyser?
7. What does the training you provide consist of?
8. Are staff advised to hold the blood sample until results have printed?
    - Why/why not?
    - If not in training, how did it arise?
9. What are the effects of cancelling calibration
10. How did this strategy develop?
11. What are the effects of entering a false hospital number?
12. How did this strategy develop?
13. Did the previous 800 series analyser have these problems?
14. In what ways does the new analyser improve the work procedure?
15. In what ways is it negatively affecting the work procedure?

Medical staff questions

1. What is your position in the hospital?
2. How long have you worked here?
3. Try to think of a time when you entered a false hospital number. Why did you do this?

4. Why do other members of staff do it?
5. What do you think the effects of this technique are?
6. How do you think this strategy was created?
7. What happens when there is an emergency case and the patient has no hospital number?
8. Try to think of a time when you held the blood sample until the results had printed and then disposed of it. Why did you do this?
9. How did you learn this technique?
10. Can you think of any downstream effects of this technique?
11. Try to think of a time when you scanned a colleague's operator ID. Why did you do this?
12. What other reasons cause members of staff to do this?
13. What do you think the consequences of this technique

Appendix C: Event summaries

Successful A&E interactions

Event	Operator	Colleague's ID	False patient ID	Held sample	Memory aid	Cancelled calibration
1st	Nurse	no	no	yes	yes	no
2nd	Doctor	no	yes	yes	no	no
3rd	Nurse	no	no	yes	no	no
4th	Nurse	no	no	yes	no	no
5th	Nurse	no	no	yes	no	no
6th	Doctor	no	no	yes	no	no
7th	Doctor	no	yes	yes	no	no
8th	Doctor	no	no	yes	no	no
9th	Doctor	no	no	yes	no	no
10th	Doctor	yes	yes	yes	no	no
11th	Nurse	no	no	yes	yes	no
12th	Nurse	no	no	yes	no	no
13th	Doctor	no	no	yes	no	no
14th	Doctor	no	no	yes	no	no
15th	Doctor	no	yes	yes	no	no
16th	Doctor	yes	yes	yes	no	no
17th	Doctor	yes	no	yes	no	no
18th	Doctor	yes	no	yes	no	no
19th	Doctor	no	no	yes	no	no
20th	Doctor	yes	no	yes	no	yes
21st	Doctor	yes	no	yes	no	no
22nd	Doctor	no	yes	yes	no	no
23rd	Doctor	no	no	yes	no	no
24th	Doctor	no	no	yes	no	no
25th	Doctor	no	no	no	no	no

Successful ITU interactions

Event	Operator	Colleague's ID	False patient ID	Held sample	Memory aid	Cancelled calibration
1st	Nurse	no	no	yes	yes	no
2nd	Nurse	no	no	yes	no	no
3rd	Nurse	no	no	yes	no	no
4th	Nurse	no	no	no	no	no
5th	Nurse	no	no	yes	yes	no
6th	Nurse	no	no	yes	no	no
7th	Nurse	no	no	yes	no	no
8th	Nurse	no	no	yes	no	no
9th	Nurse	no	no	yes	no	no
10th	Nurse	no	no	yes	no	no
11th	Nurse	no	no	yes	no	no
12th	Nurse	no	no	yes	no	no
13th	Nurse	no	no	yes	no	no
14th	Nurse	no	no	yes	no	no
15th	Nurse	no	no	yes	no	no
16th	Nurse	no	no	yes	no	no
17th	Nurse	no	no	no	no	no
18th	Nurse	no	no	yes	no	no
19th	Nurse	no	no	yes	no	no
20th	Nurse	no	no	yes	no	no
21st	Nurse	no	no	yes	no	no

Appendix D: Event Comments

A&E event comments

Event number	Comments - Successful A&E
1	*wrote patient id on glove*
2	*No op Id check* "usually does that weird"
3	*left the machine during analysis to retrieve the patient ID*
4	*Had student with him, was instructing on the procedure and use*
5	*Commented that the previous ABG analyser sometimes rejected the sample before results were printed, its therefore better to keep the sample*. It hadn't happened yet that the new one rejected the sample, but it was an old habit.
6	*went back to patient in resus to get patient ID*
7	*Q :why use a false patient ID "*patient is just over there I know who it is*", but patient in the same room, same patient as previous doctor*
8	"new machine is better than the old one, its more reliable"
9	-
10	*Said that false patient ID does not cause any problems at all*
11	*Written on cardboard. Commented that never cancelled calibration as it would take much longer after that. Colleague said that the new one calibrates more often but recognised this as good because its more accurate*
12	-
13	-
14	*Searched for notes on CERNER*, "I always forget to bring the notes" "did I pass?"
15	*was with trainee*
16	"I haven't had time to go to training", but had used the machine 10-12 times
17	Q: why do you hold the sample "Picked it [that strategy] up from making mistakes"
18	-
19	"sometimes it doesn't work so I need to put through the sample again" "I guess that I once analysed a sample, disposed of it and it didn't work so I thought 'damn I need to go bleed the patient and put them through a very painful procedure again'"
20	*Cancelled calibration, caused the machine to block. His id didn't work* "the machine can skip some information, like potassium, then you need to do it again, it's very painful" *Biochem technician went looking for him later to tell him off*
21	"it would be best if you could enter either the number or the last name" "the number is important because without it you don't know whose ABG it is" "It can be bad [not using the patient ID] because the information doesn't go onto the system"
22	-
23	Consequences of workarounds "you can be banned from using the machine", " I've got so many patients, I can't remember all their numbers"
24	"Did I pas?"
25	*Nurse only worked in A&E for one week*

ITU event comments

Event Number	Comments – Successful ITU
1	"the patient was on the list the last times he was new, oh, he's there now though"
2	"I'm in a rush this patient must go to CT"
3	"Sometimes the patient ID doesn't scan" Q:is it normal to H&W? "Yes, in training we are told to wait with the sample". "I use this machine countless times a day"
4	-
5	Q: why did you write on glove? "Sometimes there is no number, a mistake in transfer or there are two numbers."
6	"in some busy cases the nurse may enter 1 to go faster"
7	Q: is a record important? "if a person questions the results then you can show them the previous results"
8	Q: is a record important? "its very important to keep a record, if something serious happens then they may need to look at the data and get a printout"
9	-
10	A&E staff don't have time to do all that - entering all the information
11	Q: are the records important "they're very important because you need to be able to see the previous results if the printouts are lost or if the clinician requests them" " sometimes if a gas sample is analysed upstairs [ITU4] because this machine is broken then we don't know the number, there's no list up there"
12	-
13	I've used lots of these machines, you just want them to be fast and this one's pretty fast
14	this machine is faster than the old one but it blocks itself more often especially on the weekends, it needs more attention than the other one
15	
16	
17	Same nurse as before, Q why didn't you hold the sample? "I didn't particularly need (?), I only needed (?)"
18	Q how important is it to enter the patient number? "its not vital but its good practice"
19	-
20	-
21	-