User-centred design of bedside clinical guidelines for mobile devices

By

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Table of Content

Abstract

Local point of care clinical guidelines exist in numerous formats and cover a variety of clinical information, normally created on a national and local level. They are generally available as basic web pages, PDFs or documents. Despite widespread availability and use, accessing clinical guidelines and information can be highly inefficient and restrictive. The adoption of technology in health and care is increasing. Despite this increased uptake, some areas of clinical practice are still required to access and utilise clinical information that is inefficient or restrictive. Therefore, mobile device information delivery is becoming a key factor in providing health and care information at the bedside. However, recommendations on how to present clinical information on mobile devices (such as clinical guidelines with calculation/decision tools) are limited or not optimised for modern mobile design.

This study investigates the design, adaption and delivery of a clinical guidelines mobile application in the challenging area of co-design with clinicians with the aim of developing recommendations to assist in creating and delivering clinical guidelines on mobile devices. It also aims to answer if the selected methods of user-centred design are suitable when working with limited access to users and what design recommendations can be elicited/changed by utilising user-centred design (UCD) methods to gather feedback on features and functions. This study utilises a set of 'Bedside clinical guidelines' that have been utilised in numerous NHS Trusts in the UK for over twenty years.

Utilising results from user-centred design studies such as observations, surveys, focus groups and think-aloud, and analysing results from system usability scale (SUS), this thesis presents recommendations to assist in creating and delivering bedside clinical guidelines

on mobile devices. A set of 15 recommendations elicited from qualitative and quantitative user-centred design studies are presented along with insights into clinical technology use and the comparisons of user behaviour in terms of knowledge and clinical workflow. It also discusses clinical technology in terms of app use and device requirements. This work also presents novel methods of displaying decision algorithms and discusses the necessity of delivering clinical warnings with methods that do not contribute to alert fatigue. Other findings such as methods of reducing clinical guideline sentences for easier information assimilation and replacing manual methods of calculation are also discussed. Importantly, this work introduces novel methods of user-centred design that enable feedback elicitation from time-constrained and dominant subject groups, this was important in terms of working with clinicians to co-design a mobile application. It evidences the impact of working with a clinical expert and the outcomes such work can produce.

These studies found that clinicians use a mixture of technology to retrieve information, which is often inefficient or has poor usability. It also shows that smartphone application development for use in UK hospitals needs to consider the variety of users and their clinical knowledge and work pattern. This study highlights the need for applying user-centred design methods in the design of information presented to clinicians and the need for clinical information delivery that is efficient and easy to use at the bedside. It also highlights the need to adapt user-centred design methods to enable the elicitation of information from time-constrained groups and the importance of working with a clinical expert. The studies presented have culminated in the delivery of 154 clinical guidelines, co-designed with clinicians, and a framework for the delivery of over one thousand further guidelines. It is the first study to investigate the mobile delivery of bedside clinical guidelines utilising user-centred design methodologies.

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Authors Declaration

I declare that the work contained within this thesis is my own.

Publications related to this thesis:

- **Mitchell, J**., 2020. Utilising User-Centred Design to Develop a Clinical Guidelines Mobile Application. *Proceedings of the 33rd International BCS Human Computer Interaction Conference* Doctoral Consortium, eWic.

- **Mitchell, J**., de Quincey, E., Pantin, C. and Mustfa, N., 2020, July. The Development of a Point of Care Clinical Guidelines Mobile Application Following a User-Centred Design Approach. In *International Conference on Human-Computer Interaction* (pp. 294-313). Springer, Cham.

- **Mitchell, J**., de Quincey, E., Pantin, C. and Mustfa, N., 2021, July. 15 Usability Heuristics for Delivering Clinical Guidelines on Mobile Devices. In *Proceedings of the 33rd International BCS Human Computer Interaction Conference 34*.

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- Woolley, S.I., Collins, T., **Mitchell, J**. and Fredericks, D., 2019. Investigation of wearable health tracker version updates. *BMJ health & care informatics*, *26*(1).

- Barakati, S.S., Topaz, M., Peltonen, L.M., **Mitchell, J**., Alhuwail, D., Risling, T. and Ronquillo, C., 2020. Health Informatics Solutions in Response to COVID-19: Preliminary Insights from an International Survey. In *Integrated Citizen Centered Digital Health and Social Care* (pp. 222-223). IOS Press.

- Woolley, S., **Mitchell, J**., Collins, T., Rhodes, R., Rukasha, T., Gehlken, E., Ch'ng, E. and Cooke, A., 2021. Virtual Museum 'Takeouts' and DIY Exhibitions–Augmented Reality Apps for Scholarship, Citizen Science and Public Engagement. *(To be published in SPRINGER VERLAG in the Lecture Notes for Computer Science-LNCS,)*, pp.323-333.

- Topaz, M., Peltonen, L.M., **Mitchell, J**., Alhuwail, D., Barakati, S.S., Lewis, A., Moen, H., Veeranki, S.P.K., Block, L., Risling, T. and Ronquillo, C., 2021. How to Improve Information Technology to Support Healthcare to Address the COVID-19 Pandemic: an International Survey with Health Informatics

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List of Figures

List of Tables

List of abbreviations

A&E	Accident and Emergency
AF	Atrial Fibrillation
App	Application
BCG(s)	Bedside Clinical Guidelines
BNF	British National Formulary
CE	administrative marking with which the manufacturer or importer affirms its conformity with European health, safety, and environmental protection standards
CrCl	Creatinine Clearance
CSS	Cascading Style Sheets
ECG	Echocardiogram
EHR(s)	Electronic Health Records
FY1	Foundation Year 1
GL(s)	Guidelines
HCI	Human Computer Interaction
HTML	Hyper-Text Markup Language
IBW	Ideal Body Weight
MHRA	Medicines and Healthcare products Regulatory Agency
MI	Myocardial Infarction
NASA	National Aeronautics and Space Administration
NHS	National Health Service
NICE	National Institute of Clinical Excellence
PDF	Portable Document Format

PE	Pulmonary Embolism
PEF	Peak Expiratory Flow
QA	Quality Assurance
RCP	Royal College of Physicians
STEMI	ST-elevation myocardial infarction
SUS	System Usability Scale
UCD	User Centred Design
UHNM	University Hospital North Midlands
UI	User Interface
UID	User Interface Design
UK	United Kingdom
UKCA	UK Conformity Assessed marking is a certification

1. Introduction

1.1. Background and motivation

Throughout the UK, local point of care clinical guidelines are utilised to assist clinicians in delivering patient care (Pantin et al., 2006) and are generally available as basic web pages, PDFs or documents (NICE, 2020; Pantin et al., 2006). They exist to provide support and guidance on patient care pathways, clinical workflow, drug administration, and medical information (NICE, 2020; Pantin et al., 2006), aiming to 'bridge the gap' between specific clinical care at a trust level and national clinical guidance (NICE, 2020; Pantin et al., 2006). Despite their widespread availability and use, accessing clinical guidelines and information can be highly inefficient and restrictive (Littlejohns, Wyatt and Garvican, 2003; Burton and Edwards, 2019), whereas clinicians require agile access to clinical guidelines and an efficient delivery method(Pantin et al., 2006).

At present, there are no 'standards' (clear methods, designs, or recommendations) relating to clinical guidelines for use on mobile devices (Wyatt and Lewis, 2014; Wyatt et al., 2015). Previous studies have investigated the delivery of clinical guidelines on mobile devices (Payne, Weeks and Dunning, 2014; Cossu et al., 2014; Kwa et al., 2015), but rarely implement well-known heuristics for design (Nielsen and Molich, 1990; Nielsen, 1992b, 1994a, 1994b; Gerhardt-Powals, 1996) and often fail to involve users in each aspect of the design and development process, leading to poor usability (this is discussed in the literature review 2.5). Common issues include focussing on navigational design (likely due to the complexity of the information) while continuing to present the guidelines to users in the original format – not optimised for mobile devices (intended for books or larger screens)

or limited formats were the information is significantly reduced (Kwa et al., 2015; Payne, Weeks and Dunning, 2014; Cossu et al., 2014).

Research has suggested that there are potentially negative aspects to smartphone use in clinical settings, most notably relating to patient perception (Shenouda, Davies and Haq, 2018) and accuracy of information (Wyatt and Lewis, 2014). However, it is generally accepted that smartphone use to enhance clinical care and healthcare practice is mostly positive (Mosa, Yoo and Sheets, 2012; Payne, Wharrad and Watts, 2012; Mobasheri et al., 2015) with numerous studies providing evidence of the positive impact these devices and their applications have on reducing medical errors (Melton et al., 2015) improving learning (Shenouda, Davies and Haq, 2018) and creating a more efficient process for patients (Demiris et al., 2008; Archer et al., 2011).

In a clinical setting, relevant and accurate information is critical, it must be easy and convenient to access, benefiting both clinical practice, and clinical education (Mosa, Yoo and Sheets, 2012; Payne, Wharrad and Watts, 2012; Mobasheri et al., 2015). This is especially true for information such as clinical guidelines (NICE, 2020) which are used to support clinicians in making decisions on how to diagnose, treat and care for patients. There is, therefore, the clear potential for research combining methods for the design and development of medical applications and the delivery of medical guidelines.

There are examples of guidelines that focus on their use by practitioners. The 'Bedside Clinical Guidelines (BCGs)' are an example of local point of care clinical guidelines that are designed for use at the point of care. The BCGs have supported care at the bedside since 1996 and are currently utilised across 14 NHS Trusts throughout the UK, and aim to provide “consistent, evidence-based management of patients in acute hospital settings" (Pantin et al., 2006) for 'in the moment' bedside use. The 142 medical guidelines give information on issues faced daily on the ward with breadth from consent to cardiovascular

disease, from venous thrombolism to verification of death. Each guideline has a depth from drug dosage through contacting radiology to discharge policy. They are reviewed bi-annually, and each guideline has an individual author. During the editorial stage, the latest evidence, provided by the clinical librarian, is integrated into the guideline by the guideline author. The newly adapted guideline is then checked by the lead editor before being distributed for use across the NHS member trusts. The BCGs are currently available as an eBook (a pdf of the print edition) on each participating NHS Trust Intranet. Examples of BCG guidelines are provided in Appendix 1.

1.2. Development of research question(s)

The research described in this thesis, therefore, aims to investigate and develop efficient methods for presenting and authoring clinical guidelines for use on mobile devices. This has been achieved via following a user-centred design (UCD) approach (Abras, Maloney-Krichmar and Preece, 2004; usability.gov, 2019). UCD has been proven to provide positive outcomes when developing software (Kwa et al., 2014; Abras, Maloney-Krichmar and Preece, 2004). By producing clinical guidelines specifically developed for mobile devices, the aim was to address many of the issues related to efficiency and ease of access, creating a more usable app. To that end, several specific questions/objectives were developed to investigate the development of design recommendations, these are provided throughout this thesis. The overall objectives in relation to this study are as follows:

- How can utilising UCD elicit data from clinicians to inform the development of a clinical guidelines mobile application?

- What novel recommendations for the delivery of clinical guidelines on mobile devices can be established?
- What is the impact of recommendations on clinical guidelines (utilising a clinical expert)?

1.3. Structure of the thesis

This thesis is comprised of four studies, which are described within the thesis map (see overall study design) located at the beginning of each study chapter. Following this chapter, **Chapter two** (literature review) provides a scoping review and critique of the relevant research related to clinical guideline delivery on mobile devices. It also provides an overview of research related to designing for humans, mobile app design, and software design for hospital use. **Chapter three** introduces the observation and survey studies used to form initial recommendations for a prototype clinical guidelines application. **Chapter four** discusses the implementation of these recommendations on the development of a prototype application and reports on the results of evaluation methods (focus groups and a system usability study). It also provides an initial set of recommendations based on those discussed in Chapter 3 and further recommendations elicited from the data of the evaluation studies. **Chapter five** then discusses the implementation of these recommendations in terms of application development in the production of a second prototype. The developed application is then evaluated in **Chapter six**, with further recommendations being elicited from additional user studies. Chapter six then concludes with a final set of recommendations which are evaluated in Chapter seven. **Chapter seven** also discusses working with a clinical expert, information validation, and the impact of applying the final set of recommendations to clinical guidelines. **Chapter eight** provides a synthesis of the

overall study chapters including the implications and contributions to current practice. This also concludes the study, highlighting recommendations for future research.

1.4. Overall study design

Each stage of the study uses aspects from UCD methodology (Norman, 1986; Abras, Maloney-Krichmar and Preece, 2004; usability.gov, 2019), best practice design analysis and evaluation (Nielsen, 1995; Gerhardt-Powals, 1996; Norman, 1986; Abras, Maloney-Krichmar and Preece, 2004; usability.gov, 2019) and software development methodologies (Fowler and Highsmith, 2001).

This study utlises a set of clinical guidelines called the Bedside Clinical Guidelines.

An overview of the connectivity between each stage of the study is provided in Figure A and Table A provides an overview of the studies, participants and chapters.

Note that some of the planned stages shown in Table 1 were cancelled due to the SARS-CoV-2 pandemic and therefore an additional study that includes guideline adaption and working with a clinical expert was added to evaluate the impact of the final set of clinical guideline recommendations.

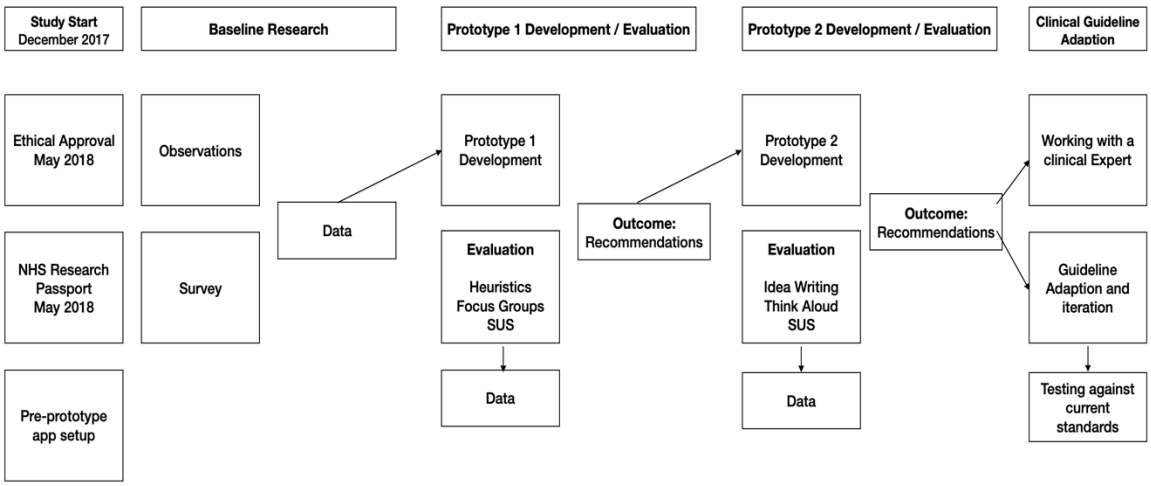


Figure A: Overview of thesis (Map)

Table A: Study stages of thesis

Study Stage	Methodology	Purpose	Participants	Stage in ref to Figure 1	Chapter in Thesis
Initial Ideation	Research Group Meetings and Observations	Develop initial ideas	4	Study Start	N/A
Requirements	Research Group Meetings, Observations, Survey	Identify functional requirements	4, 20, 146	Study Start	3
Development 1	App Development	Initial Prototype based on findings	4	Prototype 1 Development /Evaluation	4
Usability Testing	Heuristic Evaluation	Evaluation on basic usability	1	Prototype 1 Development /Evaluation	4
Development 2	App Development	Further development of the prototype to address heuristic evaluation	4	Prototype 1 Development /Evaluation	4
Focus Group 1	Focus Groups	User Feedback and further requirements elicitation	21	Prototype 1 Development /Evaluation	4
Development 3	App Development	Further development of the prototype to address Focus Group 1	4	Prototype 1 Development /Evaluation	4
SUS	Usability Study	To gather feedback from users	22	Prototype 1 Development /Evaluation	4
Focus Group 2	Focus Groups	User Feedback and further requirements elicitation	17	Prototype 1 Development /Evaluation	4
Development 4	App Development	Further development of the prototype to address Focus Group 2	4	Prototype 2 Development /Evaluation	5
SUS	Usability Study	To gather feedback from users	78 (2 sessions of 40 and 38 respectively)	Prototype 2 Development /Evaluation	6
Usability Testing	Think Aloud	User evaluation	38	Prototype 2 Development /Evaluation	6
Field Test	*On site field testing*	*To gather use data and user feedback*	*~ 10*	***Cancelled***	*N/A*
Pilot Test	*Live Pilot testing with Patients*	*To gather use data and user feedback*	*~30*	***Cancelled***	*N/A*
Guideline Adaption	With clinical expert	Evaluation	2	Clinical Guideline Adaption	7

2. Literature Review

The aim of this review is to form the basis of research in terms of the objectives outlined in Chapter 1. This review also aims to identify best practice (and limitations) regarding application design with users, mobile application design, and how those questions relate to designing a mobile application suitable for a hospital environment. Ultimately, this review will form the basis of practice to inform the development of a mobile device application to present the 'Bedside Clinical Guidelines' for use in a hospital setting.

2.1. Overview

This research study utilises a number of related fields. This includes, but is not limited to, broader subjects such as Software Engineering; User Centred Design; User Interface Design; Human Centred Design; Mobile Application Development and aspects of cognitive science, learning, and Human Computer Interaction (HCI). The study also requires more specific areas of research, these include Medical Decision Support and associated technology; Technology acceptance in a hospital setting; Point of Care tools for Clinicians and Clinical Guideline research. This review explores a number of these subjects.

2.2. Method

This study utilises aspects of a systematic literature review (Kitchenham and B., 2004). However, it should not be considered as one. The aim was to understand the 'state of the

art' in terms of clinical guidelines delivery and mobile health applications. The selection and exclusion criteria is outlined below.

Selection criteria

- Studies which include focus on developing applications for use in a hospital setting
- Studies which include the development of mobile device applications for use in a hospital setting
- Studies which follow a UCD methods to design an application for use in a hospital setting
- Studies which include focus on developing, evaluating and testing applications for clinical guidelines.
- Studies published post 2007 where they are specific to technology used in a hospital setting
- Peer reviewed journal and conferences articles

Exclusion criteria

- Studies not written in English
- Review articles and papers
- Studies where access to the papers is not possible
- Studies investigating mHealth as this is more consumer based. *mHealth* normally refers to consumer applications for tracking patient healthcare data and is therefore not relevant to this study.

Selection parameters

The following selection parameters were collected utilising a 'snowballing' method to produce a set keywords and clinical terms. These terms were then combined with UCD terms, as shown in the table below, to find related studied. Similar studies were also found utilising 'snowballing'. This review is considered a scoping review.

Search/Databases	IEEE, Google Scholar, JMIR, PubMed, ACM, Science Direct, Web Of Science, World Wide Web, Elsevier.			
Keywords	*One* Clinical Term *(see below)*	AND *One* Application development term (see below)	AND *One UCD* Terms (see below)	*One UCD* Terms (see below)
Clinical Terms	Health, Point of care, Clinical, Hospital, Clinicians, Doctors, Nurses, Patient, Patient Care, Clinic, Triage, Healthcare, Treatment.			
Application Development Terms	App, Application, App development, Application Development, Mobile application development, mobile device, mobile app, software development, software creation, app creation, application/app building, software, software framework, app framework, development, mobile development.			
UCD Terms	User centred design, user-centred design (spelling variant - Centered), human computer interaction, HCI, usability, user focused design, user design, participatory design, cooperative design, contextual design.			
Secondary method UCD Terms *(specific)*	Prototyping, rapid prototyping, card sorting, affinity diagram, use case, task analysis, user persona, user story, user stories, user flows, AB testing, AB Test			

Additional searches have also been conducted adding 'Clinical Guidelines' to some search terms.

For this review, studies in English were selected for convenience but with a wide range of papers from multiple high-quality journals, this is not expected to affect the quality or scope of the research. The research is also targeted at UK based hospitals meaning non-English written papers may not be relevant to this study. As the Bedside Clinical Guidelines are only available in the UK, and the NHS specifically, UK studies would be more relevant for information delivery. Some non-UK based studies are discussed in the literature review, these were located utilising 'snowballing'. In some cases, a small number of papers were not accessible, but on review, not directly relevant to this study.

For paper/article selection, it was important to select papers relevant to more modern technology, this is especially relevant when investigating how technology is applied in a medical setting. As this project focuses on the use of modern mobile devices, only papers post 2007 will be selected when studying how mobile devices have been applied. Papers prior to 2007 do not conduct research with modern mobile devices (smart phones and tablets) and as such, the technological limitations of these devices means the research is unlikely to be relevant to this study. A selection of these papers may prove relevant to other aspects of the project, such as user centred design elements, and in these cases the papers will be used.

For the scope of this review, a broad overview of the subjects mentioned in the introduction will be investigated. The review will also cover specific research related to representing clinical information presented on mobile devices, with particular interest in research conducted in UK hospitals using UK authored clinical guidelines.

2.3. HCI/UCD overview

Applications are generally developed to solve a complex problem or provide a solution to a task or service which would otherwise become prohibitively complex or repetitive (Garlan and Shaw, 1994; Northrop and Clements, 2012). Human Computer Interaction (HCI) is considered the main focus for developing software applications for users (Dix, 2009). HCI describes how people (users) interact with computer systems and takes into account the roles of language, human psychology, engineering, and design. HCI encourages designers to understand all of the factors that determine how people use

technology. At the heart of HCI is safe, efficient and effective interaction which employs techniques to build suitable systems that put the user first. Due to the popularity of HCI, ‘standards’ have been produced for developing software applications for users. These standards are produced by international bodies, government departments and major publications such as ‘ISO Standards’ (Bevan, 2001). Despite being produced by multiple organisations, all follow a similar structure and methodology.

A core concept of HCI is usability, which has become a more prominent aspect of system design and engineering, and has branched into more niche concepts such as User Experience Design, Interaction Design, User Centred Design etc. Although these are considered separate concepts, they follow an overarching theme that all involve users in the design of a computer system. The similarities can be seen in multiple methodologies. User Centred Design was originally developed by Donald Norman (Norman, 1986) and has now been developed into more specific frameworks via many iterations, though the core values are still relevant. Farrell (Farrell, 2017) of the NNGroup describes the ‘user experience design’ stages as ‘discover’, ‘explore’, ‘test’ and ‘listen’. Obvious similarities exist in the approach by Maguire, (Maguire, 2001)who, in earlier work describes ‘Human Centred Design’ as ‘planning’, ‘context of use’, ‘requirements’, ‘design’ and ‘evaluation’. Though semantically different, they both discuss very similar principles.

The principles of user experience design involve initial research (for example: ethnographic studies; questionnaires or surveys; focus groups and interviews; or similar) which allow a developer or designer to determine the needs of the user. It has been widely reported that simply ‘asking’ what the requirements are, is not sufficient. This may be because the user is not approaching the problem as a developer might, or simply because they don’t know

what the problem is. This is highlighted by Holtzblatt who, in a 1995 study (Holtzblatt and Beyer, 1995), discusses interpersonal dynamics and idiosyncratic differences that can get in the way of developing a complete, accurate understanding of the customer problem and potential solutions. This also highlights the juxtaposition in that UCD is not design 'by' the user, but 'for' the user. The second stage is to explore methods that allow users a role in 'co-designing' the software application with methods such as card sorts and paper prototyping. Following the initial research, the software application is developed iteratively, gathering user feedback at various stages of the design and applying that feedback to improve the design at each stage. The final stage is a 'testing' or 'evaluation' stage, which involves both user feedback and more specific usability testing methods - of which there are many versions (discussed later in this review). This culminates in a software application that meets the needs (and usability factors) required by the user. This is also concluded by Abras, et al. (Abras, Maloney-Krichmar and Preece, 2004), Lieberman et al (Lieberman et al., 2006) and McGill (McGill, 2004) who suggest that these principles, including methods which involve the end user in the design of a software application, are considered more satisfying to use. These issues can often occur in applications that have utilised an 'end user design approach'. End user design is the opposite of user centred design. In effect, it is a design created by the end user or non-expert developer for personal use. This can be beneficial when creating an expert system, but it can also contribute to poor design and development, consistency, security and privacy (Lieberman et al., 2006). An efficient method to ensure user satisfaction is iterative designs (involving user feedback) that allow stages of design to be reverted (Lynch and Horton, 2016). Similar concepts exist in software development methodologies such as Agile (Fowler and Highsmith, 2001).

Despite the numerous advantages to user centred design, there are limitations that must be considered when designing for (or with) users in order to develop software. Various studies suggest that a UCD approach may not be practical in real world scenarios. This is largely due to the time and information intensive nature of a UCD approach (Vredenburg et al., 2002). Despite these being the only significant negative aspects of the UCD approach, they can be so limiting as to not be overcome. An example of this is the Kwa study (Kwa, et al., 2015) were information is presented in PDFs, some of which cannot be utilised on a mobile device. One method that adapts the approach to limit the impact of the issues, is to use an agile software development methodology when utilising UCD (Salah, Paige and Cairns, 2014; Chamberlain, Sharp and Maiden, 2006; Silva et al., 2011). Agile allows for iterative designs of an application and provides a framework which can (in itself) be limiting but improves the time versus cost ratio. Research, highlighted in a study by Da Silva (Silva et al., 2011) argues that both approaches aim to improve usability, and the integration of these approaches can yield positive results if correctly implemented.

User centred design becomes increasingly complex as more facets are considered. Knowledge is one of the main determining factors in how users feedback during the development process. If users have preconceptions or perceived knowledge of a subject, it can negatively affect the feedback they offer. The user may not be reporting the best method for that particular problem, instead reporting a preference (which is likely due to habit of the individual) (Nielsen, 1994a; Abras, Maloney-Krichmar and Preece, 2004). A solution to counter preconceptions, and perceived knowledge, is to educate users prior to asking for feedback, and using mock-ups and prototyping (Nielsen, 1994a). Nielsen suggests that users like familiarity in new software. Incorporating familiar features makes users comfortable, making for a more usable system. These findings are also repeated in further research which suggests that familiar concepts that a user can apply to a new situation or

application will always have positive outcomes (Dix, 2009; Whitenton, 2013). This familiarity can also be utilised when converting existing real-world systems into a software application, as suggested by Robbins (Robbins, 2014) and Gross (Gross, Bardzell and Bardzell, 2014) when discussing the use of skeuomorphic software design.

The opposite is also true. A lack of knowledge can also affect the outcome of the software application design (involving users) especially when specific information is required by the designer or developer (Wilson et al., 1996; Kujala, 2003). The effect of 'lack of knowledge', is specific to the needs to the designer, rather than the user, and cannot be corrected by educating users before gathering feedback. It can be avoided with careful experimental design.

Conflicting user needs can heavily affect the outcome of a design. An example of this is a user requiring a simple application, that has powerful complex features. Nielsen recommends using a method called 'progressive disclosure' which utilises secondary screens for more advanced features. This allows the main software design to remain 'simple', but the features can be powerful (Nielsen, 2006).

2.3.1. The availability of users

The availability of users also affects the UCD process. In a user-centred design case study conducted by Peicschl, Ferk and Holzinger in Iceland (Peischl, Ferk and Holzinger, 2013), it briefly mentions issues related to access and the cost of the UCD process. Peicschl also discusses further studies which discuss ineffective user participation and the difficulties in conducting studies with users (i.e. adequate numbers, access etc.). One solution is to develop 'personas' which describe user needs and goals. These are normally used in teams rather than for individual developers, but they can be useful in remembering users and for

describing and presenting information (Pruitt and Adlin, 2006; Lynch and Horton, 2016). Although this is briefly discussed, few studies mention failure to involve users or difficulty in recruiting and utilising users and this will need to be taken into account.

2.3.2. User Interface Design

A user centred design has many important outputs, but these are mainly achieved through the use of a User Interface Design (UID). How the UID is designed is an important factor in the usability of a software application. Once the user goals have been defined, the UID needs to offer a simple and usable method to achieve them (Nielsen, 1995; usability.gov, 2019). A user interface (UI) is defined by a number of elements. These can include objects such as buttons or titles, to images and layout boxes (usability.gov, 2019. These elements form part of a cohesive interface with which the user interacts to achieve their objective (usability.gov, 2019). For a UI to maintain usability, familiarity and a consistent approach, elements must form part of a 'design pattern' (Tidwell, 2010). When design patterns are used in the design of a software application they establish consistency, which is important for the usability of a system and the consistency allows the user to feel familiar with the UI (Nielsen, 1995; usability.gov, 2019). The design pattern can include the design of typefaces, colours, layout, and the visual hierarchy of information (Titles, sections, and links) (Tidwell, 2010). Visual hierarchy is an important aspect of IA as it enables to reader to understand the structure of the information (Djamasbi, Siegel and Tullis, 2011). A weak visual hierarchy for a UI can lead to a software application with poor usability (Tidwell, 2010). While the familiarity aspect applies across software platforms to aid the user, it is also an important consideration within a platform. Familiarity is important to users, it helps them to feel secure, and competent. It also allows a company to establish a brand identity.

Although there are a plethora of guidelines and best practices for UID (some with long lists), there are consistent approaches recommended by multiple leading authors which should be applied. In a similar theme to prominent methods for user centred design, user interface design methods offered by numerous researchers are semantically different, but ultimately aim to achieve a similar focus. Research by Nielsen and Molich (Nielsen and Molich, 1990; Nielsen, 1994a, 1994b) suggests a UI should focus on ten heuristics, all of which aim to deliver a consistent, usable experience for the user. The United States government usability guidelines (usability.gov, 2019) suggest a list of 'user interface design basics'.

The interface needs to be as simple as possible, allowing the user to easily navigate to or activate their required function. Simple does not always mean in its form, but more in how easy it is to navigate. Another UI approach is the ensure an interface remains consistent in order to keep confusion to a minimum. The layout also requires consideration in how each part of the content is related, spacial considerations for a "purposeful layout" should be adopted. This is especially true when considering cognitive ability and the 'Gestalt principles of grouping' (Brunswik and Kamiya, 1953) where human perception of objects close to each other form part of a group. For example, a title and text or image and description. It can also be affected by the 'serial position effect' where information positioned at the start or end of a sequence are most memorable. This has proven successful for large companies such as Apple and Nike (Lidwell et al., 2010). This effect can be utilised to promote features or messages for users (Lohse and Spiller, 1998), but the effect of 'banner blindness' should also be considered if utilising this technique. This is where users have learnt to ignore any content which resembles advertisements or ignore content in locations where advertisements are normally placed (Nielsen, 2007).

Essentially, considerations need to be made to the layout, standards, and efficiency, of any application in order to maintain usability (Nielsen, 1995; usability.gov, 2019). Displaying information that is cluttered or unnecessary confuses a user. This was discussed by Rosenholtz et al. where they investigated feature congestion and display clutter (Rosenholtz et al., 2005). Ensuring the user interface is clear, relevant, and informative, helps users to navigate any software application (usability.gov, 2019).

Considerations for how a user interacts with an application when it is loading or when errors occur should be high priority. Loading or response time is an important factor when building software for efficiency and high productivity. Research by Doherty (Doherty and Kelisky, 1979) suggests that a system response time of <400ms is key to high productivity, and response times greater than this have a disproportionately negative effect on productivity. Another key aspect of UI design is helping users to recognise and recover from errors. This could come in the form of a dialogue box or error message. If these prompts are missing, it can cause users to abandon use of the software or find the process of using the software frustrating (Nielsen, 1994a, 1994b).

2.3.3. Mobile application development

The software/web development industry has widely adopted a 'Mobile-first' approach (Wroblewski, 2012), especially when developing websites. In 2018 Google began adjusting their indexing algorithms to prioritise websites and web applications which utilise a mobile-first approach (Google, 2018). Another example of mobile development popularity is the increase in available smart phone applications, with smartphone application downloads surpassed 200 billion on all devices (Statista, 2021).

Mobile devices have many limiting factors when compared to developing for desktop computers (Chittaro, 2006). Mobile devices have a less powerful processor than a desktop computer, they have less memory, in terms of both storage memory and physical memory. This means that less tasks can be completed in comparison to a high-end desktop computer. The smaller screen size means that care must be taken around the display of information to ensure clarity and visibility and factors such as input types (touch input versus mouse input) must be considered. Battery life is a concern that must be addressed and mitigated for when designing mobile applications. These limiting factors may not constrain all aspects of a potential application but will certainly have implications in how a designer or developer approaches the software design (Budiu, 2013). How a designer will approach designing specifically for a mobile device is often directed by best practices, guidelines or mobile design patterns (Gong and Tarasewich, 2004; Wroblewski, 2012).

There are multiple approaches to mobile device application design, as mentioned by the patterns and practices above. These include websites designed for use on mobile devices (also known as dynamic websites), web-based applications, and native device applications (such as the Apple iPhone applications or Google Android applications available on their respective ‘app stores’). Each of these approaches can require separate software development strategies using a variety of languages, such as HTML, Objective-C or Java. Although the software development languages differ, the approaches and considerations for developing software to be used on mobile devices is consistent.

2.3.4. Mobile design

Due to the limiting factors of mobile devices, there are some common issues which need to be addressed in a mobile device application design. Mobile devices generally utilise a finger input 'touch' interface. Touch has many advantages, one being that it is more intuitive (Nichols, 2007) but there are aspects of interactivity which are lacking in a touch interface. Touch interfaces lack the standard computer mouse interactivity such as hover actions. This can limit the interaction feedback a user requires in order to maintain interaction feedback. A solution to this problem is to provide an alternative feedback method after the user has completed an action such as tapping a button in the UI. These methods offer feedback similar to the hover effects of a mouse and allow the user to maintain interaction with the UI (Clark, 2015).

Exactly how the user interacts (mechanically) is also a factor. 'Finger friendly' designs should be considered (Clark, 2015) These designs need to consider the average size of a finger (16-20mm or 45-57 pixels) when creating elements the user will interact with, such as buttons. This may not always be possible if the interface has a certain number of requirements, and the screen size cannot accommodate multiple elements of this size. In these cases, it is recommended to test the elements further in order to optimise the design and maintain usability (Clark, 2015; Pernice, 2017). Element placement can also affect the usability. In ~75% of cases, the thumb is used to interact with an application, often referred to as 'one handed operation'. This creates usability zones which are areas that the user can comfortably reach whilst operating the application in this way.

Mobile devices are available in a huge range of types and styles. This offers user choice, but also creates user design problems due to varying screen sizes. This creates a problem

for a mobile UI designer and considerations for multiple resolutions need to be made. One solution is to utilise what is called a ‘responsive’ approach to the design of the software, especially web-based applications (Clark, 2015; Lynch and Horton, 2016). Responsive applications are designed to adjust to the size and resolution of the device they are displayed. This allows applications to work optimally on multiple devices without the loss of any of the design aspects. This reduction in screen space also produces further issues with how complex a UI can be. As suggested by multiple authors (Nielsen, 1995; usability.gov, 2019), a UI should remain as simple as possible. This is also true for Mobile Device UI’s, but the limited screen size may require further UI simplification. An example is that menus may not fit the width of the screen, unlike on a desktop computer. This can often lead to solutions becoming overly simplified, which is not always optimal for usability (Hoober, 2015; Pernice and Budiu, 2016). Screen size can affect the UI, and the content of the application can be affected by screen size since text must be legible, images must be viewable, and both may require more space (McGrane, 2012). It is necessary to minimise scrolling, since this requires multiple user interactions which can be cumbersome for the user (Loranger, 2014). This may lead to a reduction in how much content is displayed or a reduction in the actual content itself. A solution could be multiple content levels; for example, sub menu systems or links to read more, although this may reduce reading speed (Loranger, 2014). Loranger suggests loading content on scroll, but not if the design for the user is goal orientated. These issues also encompass other aspects of a mobile device application. Images and tables can be complex to display on mobile devices (Schade, 2017). Forms are also a factor and may need to be re-designed to provide one section at a time to the user (Bidui and Nielsen, 2011). Limiting the requirements of the keyboard or typing for a user is beneficial to the usability of a mobile device application as typing can be more difficult than a standard keyboard (Bidui and Nielsen, 2011).

The popularity and ubiquitous nature of mobile devices mitigates all of the negative issues when comparing mobile application development to its desktop counterparts. The portability and popularity of such devices makes mobile application development crucial. It is exactly that portability and ubiquity that makes the development of mobile applications for use by clinicians in hospital settings so necessary.

2.4. User centred design methods

2.4.1. Active vs. Passive UCD

Throughout the literature search, it became apparent that studies involving UCD methods either engaged users passively or actively. It is therefore necessary to provide an overview of passive and active participation in terms of UCD, and examples of where they have been utilised in the literature.

2.4.2. Passive participation

User centred design does not necessarily require a user to be actively involved in the actual design. Using passive methods such as observing user behaviour when using a product or engaging with a service and drawing conclusions from these observations, users are involved passively but have no active input to the design process. Ideally, where observations are employed, they should be utilised for identifying user behaviour/engagement with an existing system, or a system that has been created with input from users (O'Reilly, 2004; Emerson, Fretz and Shaw, 1995). Observations can also be utilised more broadly to develop an understanding of user behaviour towards specific tools,

i.e. technology and medical information. A large number of studies utilise observations for mHealth applications. A recent example of a study utilising observations was provided in a study by Stevenson and Oscarsson (Stevenson and Oscarsson, 2021) where users were observed to understand their behaviour and use of an evidenced-based application for maternity care. However, few studies were identified that mention/utilised observation of clinicians. No studies could be identified that utilised observations for the delivery of clinical guidelines on mobile devices. This could be due to a number of factors such, as previously mentioned. Aspects such as access issues, end user systems or cost could have contributed to the lack of studies.

2.4.3. Active participation

In contrast to passive participants, users who are engaged in the design process by, for example, prototyping a user interface or iterating on ideas formed in a workshop environment could be considered to be actively engaged in the UCD process. From the literature, active participation in UCD for health and care systems research may involve asking users to co-design an interface using elements of iterative design and prototype methods, with users involved throughout for the purpose of delivering a satisfactory system (Nielsen, 1992c; Bidui and Nielsen, 2011). Active UCD allows users to influence the design through participation in focus groups or usability studies resulting in highly engaged users actively shaping the outcome of the project.

Both practices (active and passive) have benefits on the end result of a project designed with UCD methods, however actively engaging users may have a more significant impact long-term, especially where the users who co-design a product/system are the same users

who eventually use the system. Additionally, such active engagement can lead to radically different design compared to traditional products/services that already exist.

2.4.4. User preference / behaviour

Determining user preferences is a standard goal that UCD approaches can facilitate. Some of the most common UCD methods used for this purpose include structured and semi-structured interviews, surveys and questionnaires. As these methods are targeted at the individual rather than group level (such as workshops and focus groups), they are very useful for identifying differing user preferences without the drawbacks of peer-pressure or overly dominant voices associated with group-level activities. Several studies that have investigated user preference are discussed in the 'Clinical Guidelines on Mobile devices' section further in the review.

Behaviour identification is another theme similar to understanding user preferences but is broader in scope. Identifying user preferences often operates on a predetermined set of options, whereas behaviour identification makes no assumptions on what these options might be. The options themselves might be determined from observing user behaviour. Behaviour identification is most often observed in a passive way (for example watching a user performing actions on an interface), reducing the chance of biases inherent in other data collection methods. The think-aloud method (Nielsen, 1992a), where users are asked to continually talk whilst performing an activity, is a common addition to such observations.

2.5. Software design/development in a hospital setting

2.5.1. Software Applications for use in a hospital setting – previous studies

Recent research indicates that clinicians also have a high proportion of mobile device ownership. The research reports that clinicians use mobile devices to support their clinical practice and education (Payne, Wharrad and Watts, 2012). Similar studies have concurring findings (Ventola, 2014a; Boruff, 2014; Gagnon et al., 2016). Research has established that both medical students and Junior Doctors have a high level of mobile device ownership and both groups understand the need for applications to support their education and clinical practice (Payne, Wharrad and Watts, 2012).

Clinicians have reported 'googling' the NICE guidelines on their personal mobile devices because the clinical guidelines are so hard to find, search and navigate. A study as early as 2006 found that frequently use Google to search for medical information (Tang and Ng, 2006). There is a great deal of support for mobile applications for use as tools to support clinicians in their practice. These include dosage calculators, improved search functions, and interactive flow charts. Most of which are available in some form but are often designed with little research or testing (Buijink, Visser and Marshall, 2012; Stoyanov et al., 2015).

Health related applications available for use in a hospital setting are increasing at an exponential rate (Stoyanov et al., 2015). These applications range from various dose calculators to heart rate monitors, to Diabetes applications (in which it is possible to log and monitor blood sugar/diet etc.) The ubiquitous nature of health applications on mobile devices is making it a popular choice for researchers and developers. The impact of mobile software applications for clinical practice is largely positive (Ammenwerth et al., 2000; Payne, Wharrad and Watts, 2012; Wyatt et al., 2015). These applications are predominantly

‘eHealth’ applications designed for patients to use for self-diagnosis, recording, and sharing health information, either with clinicians or to educate themselves. Applications designed to support clinicians in their daily roles are also being developed, and research suggests these will eventually play a significant role in clinical practice (Aungst et al., 2014)**.** In most cases, the software methodologies discussed in this review have been utilised to an extent in one form or another. More recently, research (Boulos et al., 2014) that reviewed a number of applications designed for hospital or clinical use, stated that the applications lacked evidenced based content (in medical content, claims regarding their likely benefit, and available features). It was also noted, that utilising concepts of user centred design should be a necessity. There was not enough emphasis placed upon usability and readability, for applications used in these settings.

In contrast to the commercial applications discussed, research-based application development is popular in fields such as e-health and for medical devices. Non-commercial research-based application design is more focussed on UCD, this may be due to the non-commercial nature of the field (less time constraints). Many of these studies have developed applications using a user centred design approach (Holzinger et al., 2011a; Ghazali, Ariffin and Omar, 2014). These studies have found UCD successful and noted that the UCD methodology contributed towards a more usable system. Other studies investigating design, such as the 2009 study by Peleg and Tu (Peleg and Tu, 2009) or a 2010 study by Grando (Grando, Peleg and Glasspool, 2010), have developed specific recommendations for clinical guidelines. However, these studies investigate computer interpretable guidelines as opposed to guidelines aimed to assist the clinician utilising mobile systems.

2.5.2. Software Application design for use in a hospital setting – considerations

The main issues when developing software applications for use in a hospital setting are the geographical and market differences between the research areas. High profile research projects in the US, differ greatly from high profile projects in the UK or Sweden, for example. Security risks are a factor (data protection) (Ayubi et al., 2016) but the main barriers are social, ethical, and legal. These barriers are not confined to application development (Anderson, Cavicchi and Vagnoni, 2007).

A study by Elrher (Ehrler et al., 2013) suggests that the initial challenges of implementing mobile device applications in clinical practice are mainly cost related, though in some circumstances, related to changes in workflow. Another study by Tang and Carpendale (Tang and Carpendale, 2008) found these issues also occurred and that educating clinicians and adjusting the software based on feedback provided positive results. There may be an opportunity in how UCD is implemented to ensure it fits with the current workflow in order to minimise disruption in the implementation.

Various methods for evaluating applications designed for use in a hospital setting have also been developed (Wyatt, 2003; Tang and Carpendale, 2008). These methods often allow for a successful evaluation on the usability, trustworthiness and usefulness, but lack the necessary standards that some papers recommend need to be implemented at a government policy or international standards level. The Royal College of Physicians highlighted this need in a recent publication on mobile devices (Wyatt et al., 2015). In the paper Wyatt et al. states the vast majority of medical apps remain without any form of regulation or safety check, and some of these may present a patient safety or other risk.

There are other impact factors which can also affect the implementation, this includes personal preferences with one study (Holzinger et al., 2011b) suggesting clinicians prefer reading from paper versus screens. This has been discussed more widely in other fields, and it has been suggested elsewhere that students learn better from 'hardcopies' of texts (Mangen, Walgermo and Brønnick, 2013). Another is the impact of negative perception or personal prejudice towards the use of mobile devices in a clinical setting, as this can be seen by both patients and other clinicians as unprofessional (Payne, Wharrad and Watts, 2012). Although, this study does suggest that the use of mobile devices for learning and development amongst junior doctors is considered appropriate practice amongst this group (Payne, Wharrad and Watts, 2012). Mobile device application creation and use has grown at such a rate in recent years, that it could be argued that the suggestion that people prefer 'hard copy' texts was simply prejudice from a population that had been raised without access to those technologies, this is normally referred to as 'baby duck syndrome' (Seebach, 2005).

2.6. Themes in health and care systems research using UCD methods

Various aspects of user-centred software development, especially in heath and care, have recurring themes that need to be considered. An emerging aspect is the use of mobile devices and in particular, software that enables clinicians to access information at the bedside.

2.6.1. Clinical Guidelines on mobile devices

Studies to measure the impact and usability of 'computerised' clinical guidelines implemented on mobile devices are limited. This is especially true for UK based studies that utilise a user centred design approach. UK based studies are necessary to compare and contrast how these methods have worked within the UK healthcare system, which is largely unique in its structure. The search method for this review yielded few papers when searching specifically for studies that had created applications to present clinical guidelines on mobile devices following a user centred design methodology. This is limited further when restricting papers to post 2007, which saw the release of the iPhone and later, an increase in smartphone usage worldwide. This had a huge impact on how user interfaces were developed (Laugesen and Yuan, 2010; Wroblewski, 2012).

A study in 2014 titled 'Supporting Doctors through Mobile Multimodal Interaction and Process- aware Execution of Clinical Guidelines' (Cossu et al., 2014) provides evidence that a UCD approach to an application used in a clinical setting can be successful. This study demonstrated that an approach which reduces cognitive workload and provides efficient access to clinical guidelines is desirable amongst clinicians. It also describes how multi-modal input, such as voice recognition technology for accessing information, can be successfully utilised. How this will work in a hospital setting in the UK remains to be established, especially when considering data protection issues and patient confidentiality. Other relevant research, such as the production of the NASA GuideView system (Iyengar, Florez-Arango and Garcia, 2009) or research by Van der Velde on mobile access to Clinical guidelines (Velde et al., 2003), highlights how clinical guidelines can be simplified and adapted in order to be more efficient, reduce cognitive load and be integrated into a usable system. Although this research highlights these factors, they were developed in a pre-

smartphone era, which limits the transferability of some factors (such as the interface design and testing methods) into current research.

The first study was completed in 2014 by Kwa (Kwa et al., 2015). This study utilised a UCD approach to develop a 'mobile app to hold 600+ clinical guidelines'. Kwa used methods such as focus groups and interviews to establish current issues with guideline access; and card sorts to categorise guidelines. From these, the study developed a prototype application which was then made available for testing. The application was eventually made commercially available. The main focus of the study was to develop a menu system capable of making access to the clinical guidelines more efficient, something which the study achieved by utilising what was described as a '3 click - multiple point entry system' were a user can access any required information in 3 clicks or less. The produced application was also measured on a System Usability Scale and yielded positive results for usability. This proves that a UCD approach works efficiently in a hospital setting.

The study does produce a perceived usable system to access the hospital approved guidelines, but this is limited to the menu system of the application. The user is presented with the original guidelines in a Portable Document Format (PDF) and this creates numerous usability issues. These issues relate to a number of design aspects (discussed previously in this review). Mobile devices have limited screen sizes and PDF format documents created for reading on desktop computers mean that users have to interact more with the application to read a specific section. As discussed, an application needs to be consistent throughout to maintain a high standard of usability.

The second study was completed in 2014 by Payne, Weeks and Dunning (Payne, Weeks and Dunning, 2014). This study also used a user centred design approach and produced a mobile device application called 'iTreat' to allow clinicians to access clinical guidelines and procedures. The authors state the study had a number of limitations, these included

limited testing and small sample sizes. The authors show evidence that even in a pilot study, an application which follows a UCD approach can lead to clinicians saving time and allowing clinicians to access clinical guidelines more frequently and in a 'user friendly' way. The study also utilises a very small amount of information in terms of the guideline presented to the users.

Unfortunately, the study had other limitations. Not only does the study have a small sample size, but focused on a junior doctor cohort (n=39). Therefore, it limits feedback from experiences clinicians and fails to consider tacit and semi-tacit knowledge capture. Although this offers valid data for the implementation of a UCD mobile device application, it does lead to the requirement of further study to establish how these applications could be used by all clinicians, across multiple disciplines. The authors conclude by stating the cost and perception of mobile device use in a hospital setting are barriers to adoption. These are facts that align closely with research discussed in this review.

Further studies investigate more specific guideline delivery to clinicians. A recent study by Müller (Müller et al., 2021) is an example of a study that delivers an individual guideline via mobile. However, this limits the scope of the study as clinical guidelines are often heterogenous in nature making it difficult to deliver multiple guidelines in the same system. Another relevant study by Ehrler (Ehrler, Lovis and Blondon, 2019), conducted in Switzerland, investigates the design and development of a bedside nursing care app. The study concludes that the involvement of end users early in the process to help address the heterogeneity of the nursing workflow processes in the different wards is a necessity. The study is an example of successful outcomes utilising UCD, providing more efficient access to clinical information. However, the study is limited in terms of recommendations for developing mobile applications for clinical guidelines.

These studies offer an insight into how a UCD approach to developing mobile device applications for use in a hospital setting can be successful. This is especially true when considering the results, which show that these applications have made access to guidelines more efficient and user friendly. Attention must be given to displaying information in such a way as to specifically relate to clinicians. These studies also lead to further questions, such as how can a UCD approach make access to the guidelines more efficient, or even improve the efficiency of the guidelines themselves? How can a UCD approach work with all roles in a clinical environment? How can clinical guidelines information be structured and stored for efficient access and portability? There are further questions which are should also be considered, and the fact that this is an emerging area of research allows for numerous approaches to solving the questions considered in this review.

2.7. Conclusions

This review has provided an outline of best practices within the fields of HCI, user centred design, mobile application development and more specifically, how they can be applied in a clinical setting. There is consensus within the fields discussed on the benefits of user centred design for health and care software. There are minor differences that are largely semantic in nature. There is no question that a UCD approach has many benefits from the perspective of the user, and that by utilising a UCD approach it is possible to improve efficiency, usability, and overall satisfaction with an application.

This literature review has highlighted the importance of using evidence-based literature in the application information, specifically both the content and the implementation. The content is to be supplied by the Bedside Clinical Guidelines Partnership. They employ a

robust procedure that is rigorously checked to ensure that the clinical information is correct and absolutely current. A challenge will be in displaying the information that they provide in an intuitive and interactive format that is based heavily in research and approved by users. This review has highlighted some of the processes other studies have followed to achieve this. The implementation will be heavily focussed on user centred design methodologies. However, there are several limiting issues that relate to this research specifically which have been described in this review: availability of the users (in this case clinicians) and how this will impact such a project; the perception of patients and other medical practitioners, especially towards the use of mobile devices in a hospital setting; workflow adjustments required to implement applications into a clinical setting; and how a user centred design approach for each clinical guideline can be utilised. These, along with the development of the BCG application will be discussed in the following chapters.

2.8. Exclusions and limitations

For this review, requirements gathering (Maiden and Rugg, 1996) was omitted. Requirements gathering can easily be confused with gathering user preferences. Understanding user preferences can help to design a system where user needs have already been identified but need to be refined, whereas requirement gathering seeks to identify the needs themselves. As this study centred around a system where the user needs have been identified, it was un-necessary to understand the needs of the users in terms of what the product should be. The primary goal of this study is to identify how the existing BCG information can be adapted for delivery at the bedside, not what the information the BCG should contain. The contents of the BCGs has already been determined by medical professionals over twenty years of product adaption and delivery. However, the

requirements of a technology system in terms of clinical workflow and information delivery will need to be established.

2.9. Considerations from other industries beyond academic literature

Other than the literature discussed in this review, it is also worthwhile to discuss design considerations from alternative sources. Practice in numerous industries contributes widely to design and development recommendations. Key contributions include design guidelines from Apple (https://developer.apple.com/design/human-interface-guidelines/) and Google (https://material.io/design/guidelines-overview). The aviation industry also contributes widely, for example, the Federal Aviation Administration (FAA) develop numerous handbooks and manuals (https://www.faa.gov/regulations_policies/handbooks_manuals). The National Aeronautics and Space Administration also produce space mission design tools for numerous technologies (https://www.nasa.gov/smallsat-institute/space-mission-design-tools). There are other examples in engineering and education which also offer design recommendations for learning and knowledge management that could also be worth consideration i.e. the engineering council standards and guidance (https://www.engc.org.uk/standards-guidance/).

2.10. Literature Summary/Overview

An overview of key papers, methods, and key findings is provided below:

Study	Method	Key Findings
Payne, Weeks and Dunning (Payne, Weeks and Dunning, 2014)	User-Centered design	• Successful implementation of a mobile guidelines application.
Kwa (Kwa et al., 2015)	User-Centered design	• Successful implementation of a mobile guidelines application. • High SUS scores using UCD
Cossu (Cossu et al., 2014)	User-Centered Design	• Successful Process- aware Execution of Clinical Guidelines' • Demonstrated that a UCD approach contributes to reduction in cognitive workload

An overview of the key UX Guidelines/principles from the literature that will inform this work:

Study/Guidelines
1. Responsive Design (Clark, 2015; Lynch and Horton, 2016)
2. UI Guidelines (Nielsen, 1995; usability.gov, 2019)
3. Observations (O'Reilly, 2004; Emerson, Fretz and Shaw, 1995)
4. User-Centered Design (Nielsen, 1992c; Bidui and Nielsen, 2011)

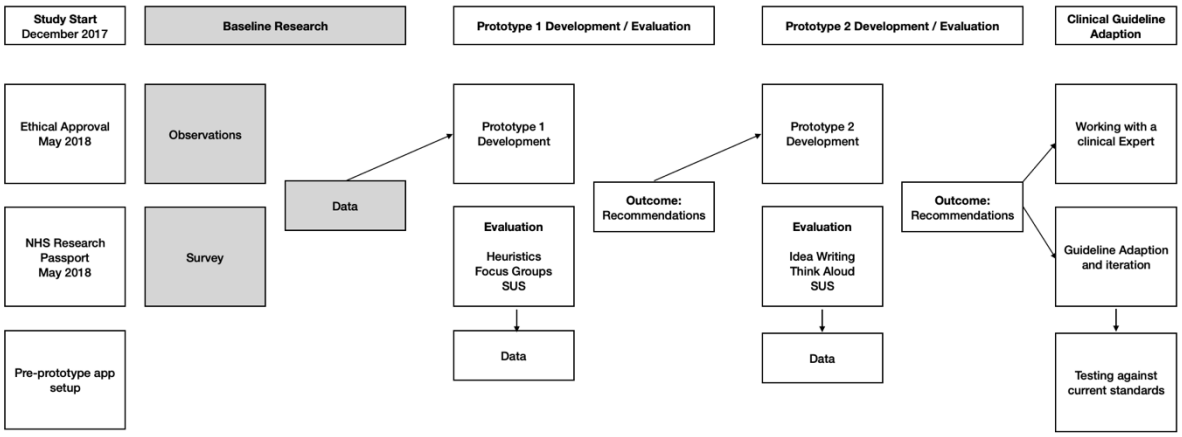
3. Observing and surveying clinical technology use in an acute hospital environment

Aim:

- *To observe and survey clinicians to better understand current technology utilisation*

Objectives*:*

- *understanding of the need and context of use for clinical guidelines*
- *understand the requirements of clinicians in terms of workflow and their environment*
- *establish any current technology utilisation within the hospital*
- *establish any current app utilisation within the hospital*
- *understand clinician's interactions with technology in the field*
- *to assess if user centered methods are suitable for gathering the required information*



The placement of this Chapter within the PhD study is highlighted (Grey)

The research/results presented in this chapter were published in 'Springer Lecture Notes in Computer Science (volume 12202) - Design, User Experience, and Usability. Case Studies in Public and Personal Interactive Systems'. 9th International Conference, DUXU 2020, Held as Part of the 22nd HCI International Conference, HCII 2020, Copenhagen, Denmark, July 19–24, 2020, Proceedings, Part III.

3.1. Observations

3.1.1. Introduction

A key aim of this research is to establish a set of recommendations to inform the delivery of clinical guidelines on mobile devices. It is imperative therefore to establish an understanding of the need and context of use for clinical guidelines (Norman, 1986; usability.gov, 2019) and to understand the requirements of clinicians in terms of workflow and their environment. In order to identify if (and how) clinical guidelines were being used,

it was necessary to observe clinicians in practice. The aim of the study described in this Chapter is to establish the need and context of use for clinical guidelines and not to establish an understanding of participant long term behaviour in a clinical environment. These observations also aimed to establish any current technology utilisation within the hospital, and the clinician's interactions with this technology.

3.1.1.1. Choice of method

An established evaluation method of understanding these factors is observational studies, sometimes referred to as ethnographic studies. Observational studies can be an expensive method in terms of time, but often offer an insight that cannot be established utilised methods such as questionnaires or interviews. Methods of observation, such as those described by Potts (Potts, 1993) and O'Reilly (O'Reilly, 2004), can be used for shorter and less time intensive observational studies that allow researchers to establish an understanding of the user environment, as well as the needs and context of use for any software applications. This is evidenced in studies by Koppel (Koppel et al., 2005) and Khairat (Khairat et al., 2018a) were shorter observational studies were utilised.

In terms of clinical guidelines and the delivery of clinical guidelines on mobile devices, few of the studies mentioned in the literature review conducted observations. There could be several contributing factors as to why observations were not performed, e.g. time limitations, access to clinicians or access to clinical environments. One dominant factor may be that clinicians undertook most of the research discussed. Another aim is to assess if these methods are suitable for gathering the required information and if observations combined with questionnaires can produce results that inform the recommendations this study seeks to establish.

3.1.2. Design

3.1.2.1. Methodology

In this study, observations were conducted following the methods described by Potts (Potts, 1993) and O'Reilly (O'Reilly, 2004), with the 'jotting note' method (Emerson, Fretz and Shaw, 1995) adopted for recording. The benefit of the 'jotting method' approach is that less time is spent on writing notes during observation sessions (Emerson, Fretz and Shaw, 1995) allowing more time to actively observe clinicians (as time was limited due to the restrictions of research in a hospital environment). Potential other methods included longitudinal ethnographic studies (O'Reilly, 2004), diary studies (Emerson, Fretz and Shaw, 1995) and interviews (O'Reilly, 2004). However, these methods require time intensive observations/participation. Standard ethnographic studies often take a number of years and simultaneous observations across multiple locations to confirm observation outcomes. The purpose of this study is to understand the environment and behaviour through observation and a full ethnographic study is not required.

3.1.2.2. Participants

Clinicians across multiple departments at the Royal Stoke University Hospital were observed over three months between May and July 2018. Observations were conducted over several sessions in five wards: Respiratory; General Medicine, Accident and Emergency, Paediatric Accident and Emergency, and Resuscitation. Clinicians were selected using a convenience sample method. 8 sessions of up to 4 hours were conducted

with participants of up to 10 clinicians (junior and senior). In total seventy-three (n=73) clinicians were observed in groups. Observations were conducted by following clinical ward rounds and observing at nursing stations. Ethical approval was granted by Keele University Research Governance in the Faculty of Natural Sciences (ERP2370) and from Research and Development at the University Hospitals of North Midlands NHS Trust.

3.1.3. Observation Results

3.1.3.1. Observation findings

Observation notes were analysed for key themes using the processing analysis discussed by Emerson (Emerson, Fretz and Shaw, 1995), these are discussed in the following sections. For this study, workflow refers to specific patterns of working (e.g. Patient information retrieval) and not how the clinicians practice medicine.

3.1.3.1.1. Key Findings

Table 1 provides the consistent findings derived from the notes/observations made during the observational study.

Table 1: Key observations

Observation finding 1	Clinicians are interrupted regularly, even when using technology.
Observation finding 2	Junior clinicians use technology more often than senior clinicians
Observation finding 3	Junior clinicians appear to use technology to establish knowledge. Senior clinicians utilise technology for knowledge affirmation.
Observation finding 4	A mixture of personal and hospital technology was used during observations. Personal devices were

	often used for clinical knowledge retrieval, whereas hospital technology was used to retrieve patient data.
Observation finding 5	Nearly all clinicians who utilised technology on their personal devices during observations used dedicated apps rather than an internet browser.

3.1.3.2. Discussion of Observation Results

Observation finding 1

Clinicians were often interrupted during their interaction with technology, generally by colleagues requiring information or patient-specific questions. Recent research evidences the impact of this (Westbrook et al., 2018; Bellandi et al., 2017). In many cases, Clinicians repeated steps within software applications due to time-outs or losing their train of thought. While it was visibly frustrating for the clinicians that they had to re-engage with the technology, e.g. login or restart the application, it was accepted that this is how the technology behaves. However, there are detrimental effects, e.g., loss of time or frustration associated with such less optimal solutions. Time loss and its effects were discussed by Scott (Scott, 2008) during a study of technology acceptance and the usability of Electronic Patient Records (ERPs). Scott found that clinical users with high computer self-efficacy are less easily frustrated by systems considered to have poor usability. For users without high computer self-efficacy, ease of use or perceived ease of use are essential factors for technology acceptance (Scott, 2008).

Observation findings 2, 3

It was evident during observations that technology plays a crucial role in ensuring that clinicians have access to a wide range of up-to-date knowledge. All clinicians utilise the same technology for patient information retrieval, an apparent restriction due to hospital

and privacy rules. Hospital devices are used for patient information, but personal devices are often used for knowledge retrieval. Clinicians preferred using smartphone apps over web-based services (via an internet browser) when accessing the information on their own devices. This preference is likely due to the native features of the application in comparison to the web-based versions. An example of this is the British National Formulary (BNF) application, which utilises core-data storage to allow offline access. This is supported in studies by Payne, et al. (Payne, Wharrad and Watts, 2012), Mobasheri, et al. (Mobasheri et al., 2015) and O'Connor and Andrews (O'Connor and Andrews, 2016), all finding an inconsistent and mixed-use of technology within clinical environments.

Additionally, it was also observed that junior clinicians use technology to establish and increase their knowledge base. Conversely, senior clinicians use it to affirm their knowledge. Junior clinicians use of smartphone applications and web-based services such as the National Institute for Clinical Excellence (NICE) was higher during observations. A study investigating smartphone use amongst surgeons by Patel et al. (Patel et al., 2015) supports that fact that junior clinicians utilise technology more than their senior counterparts.

Observation findings 4, 5

One key finding from observing clinicians was that some departments embrace technology in all aspects of clinical practice, and some only for information retrieval. Multi-modal technology use was evident, perhaps due to the lack of availability of some systems on mobile devices. Nearly all clinicians who utilised technology on their personal devices during observations and used dedicated apps rather than an internet browser.

3.1.4. Summary

The observations highlighted the factors (e.g. reasoning for utilising guidelines) which any design must consider, including how clinicians utilise technology. The findings highlight that there is an inconsistent delivery of health information that leads to a mixed or multi-modal use of technology, despite most applications not being available on multiple devices. It also shows the importance of ease of use and perceived usability in introducing systems to clinicians. The optimal solution may be to deliver information and patient data across multiple systems, allowing clinicians to choose how they access the information necessary for their daily practice. Obviously, due to security and privacy rules, especially within the UK National Health Service (NHS), this is not currently possible. As a solution, any system design should consider integrating as much of the information a clinician requires as possible, in line with the current security and privacy rules. An example of this would be the integration of calculation tools with the delivery of clinical information, enabling the clinician to avoid using multiple systems or applications. Clinical scenarios should also be utilised during testing and evaluation to ensure they fit into the workflows (thought/processes) clinicians have established.

As mentioned, it was evident that technology use plays a crucial role in clinical care. During observations it was clear that clinicians utilise apps daily and therefore it was decided to survey clinicians to gain an understanding of the types of apps they use.

3.2. Survey

3.2.1. Introduction

A survey was developed with the aim of understanding current smartphone and application usage amongst clinicians and medical students. The results of the survey would later inform requirements for the smartphone application. The survey was developed to answer the following key research questions:

- Is smartphone ownership consistent across all groups surveyed (Consultants, Mid-Level, Junior and Students)?
- Is there a significant difference in the use of iPhone, Android and Other devices by Clinicians/Students?
- Has smartphone use changed significantly since prior research was conducted; do more or fewer clinicians/students now use smartphones regularly to support their practice?
- Is there any consistency regarding which smartphone applications clinicians and students use?
- Is there a relationship between the clinical role and smartphone app use?
- Does age affect the use of smartphone applications for clinical use?

3.2.1.1. Background

As mentioned, several previous studies have investigated mobile device and app usage among medical students and clinicians. Table 2 shows a breakdown of the results from these studies, categorised by 'year published' and where necessary, study limitations. The 2012 paper by Payne et al. (Payne, Wharrad and Watts, 2012) investigated smartphone use among students and Junior clinicians. They found that ~74% of Junior clinicians owned a smartphone, and over 68% of those were Apple iPhones. The paper also sought to establish the 'type' of applications clinicians use, and how they utilise their devices.

A similar survey by Mobasheri et al. (Mobasheri et al., 2015) found that 98.9% of doctors owned a smartphone, representing growth of over 20% in two years. The research established that 78% of clinicians use apps. As this research was conducted several years ago, the relevance of the results may be questioned when considering growth in smartphone and app usage over the past seven years.

Table 2: A summary of the results from past research discussed within this report

Study	Year	Smartphone Use or Ownership	Device use	App Use for practice	Discusses specific apps	Limitations
(Payne, Wharrad and Watts, 2012)	2012	76.50%	iPhone - 65.7% Android - 18.7%	39.90%	Discuses App 'Type' but not specific apps	*Only Students and Junior Clinicians*
(Mobasheri et al., 2015)	2015	98.90%	iPhone - 75.6% Android - 21.5%	89%	Discuses App 'Type' but not specific apps	-
(O'Connor and Andrews, 2016)	2015	98%	iPhone - 48% Android - 52%	47%	Discuses App 'Type' but not specific apps	*Only Nursing Students*

A study by O'Connor and Andrews (O'Connor and Andrews, 2016) established that Smartphone use was high among students, but less than half reported using Smartphone apps for clinical practice and learning.

As smartphone, particularly medical apps, become more prevalent, it is essential to establish whether their use changes over time and the specific technologies and apps on which clinicians and medical students currently rely. Although recent research ((Mosa, Yoo and Sheets, 2012; Payne, Wharrad and Watts, 2012; Mobasheri et al., 2015; O'Connor and Andrews, 2016) has investigated the 'type' of apps clinicians access (e.g. calculation tools) the focus of this study is specific applications, so that comparisons can be drawn. These survey were conducted during a period of exponential growth in the smartphone market and as such, could be out of date.

3.2.2. Design

The survey was designed considering the research questions mentioned in section 3.2.1. The survey questions were developed utilising methods created by Moser and Kalton (Moser and Kalton, 1985). The survey was then piloted with colleagues at Keele University.

3.2.2.1. Participants

A survey was developed and distributed to students and clinicians. The survey collected data relating to the respondent's device ownership their role within the hospital (i.e. Consultant/FY1); website use relevant to their role; app use relevant to their role; time in role and local guideline use and respondents age. Specific App use (e.g. App Name) was

collected via open-ended response. No honorarium was offered in exchange for completing the survey.

3.2.2.2. Ethical Approval

Ethical approval was granted by Keele University Research Governance in the Faculty of Natural Sciences (ERP2370) and from Research and Development, the University Hospital North-Midlands NHS Trust.

3.2.2.3. Survey Distribution

The online survey was distributed electronically to a selection of NHS Trust Hospitals in North West England via emails sent by Lead Clinicians in 3 Trust hospitals. The survey was also distributed to students *(3rd, 4th and 5th years*) at Keele University School of Medicine (n=~300), the University Hospital North Midlands NHS Trust.

3.2.2.4. Question analysis and justification

The following highlights the questions distributed in the survey and the justification/purpose of each question.

- ***Question 1:*** *Please describe the mobile device you currently use on a regular basis. (Example: iPhone X, running iOS 11)*

The purpose of this question was to determine if any changes have occurred in the types of devices clinicians use. Previous studies (Payne, Wharrad and Watts, 2012, Mobasheri et al., 2015, O'Connor and Andrews, 2016) highlight a higher than the market average for iPhone use (Statista, 2019). The smartphone market is highly competitive (Statista, 2019), and it is critical to determine two factors. The first is that the types of devices utilised for determining testing and evaluation methods. The second is the development platform the project would utilise to maximise use in a clinical environment.

- ***Question 2:*** *Please list any websites you use on a regular basis to support you in your role. (Example: UHNM Intranet for specific calculation tool)*

This question was designed to understand what tools clinicians currently utilise. Nielsen (Nielsen, 2012) describes the importance of providing a system that has learnability and memorability in the 'five quality components' of usability work. Understanding other systems clinicians use can contribute to the design of any new system, as emulating some of the design aspects of existing systems can contribute to the usability (Nielsen, 2012).

- ***Question 3:*** *Please list any mobile device applications you use on a regular basis to support you in your role. (Example: Medscape)*

As with question 2, this question was designed to understand what tools clinicians currently utilise.

- **Question 4:** Please describe your current role and grade. (Example: Consultant, Respiratory)

This question was designed to understand how the clinician's answers were affected by their role and experience.

- **Question 5:** What is your specialty?

As with Question 4, this question was designed to understand how the clinician's answers were affected by their role and experience.

- **Question 6:** What is your Gender?

Understanding the demographics of respondents would allow for comparisons between gender for app use or device ownership preference. This was not analysed for the purposes of the study as in hindsight seemed irrelevant to the studies aims.

- **Question 7:** What is your age?

Age can be a contributing factor to technology acceptance (Chen and Chan, 2011). It is widely understood that older individuals are less likely to be accepting of new technology and systems (Arning and Ziefle, 2007; Chen and Chan, 2011). It was important to understand the effects of age on app use and device ownership preference.

- **Question 8:** How long have you worked in your current role?

This question was designed to allow for the analysis of role experience on technology use. Understanding how junior and senior clinicians interact with technology/systems for their clinical roles may have an impact on how a system is designed.

- **Question 9:** Do you currently use the Bedside Clinical Guidelines? If so, how do you normally access them?

Although this research aims to develop methods of delivering clinical information, it focusses specifically on the Bedside Clinical Guidelines (BCGs). This question informed the knowledge and awareness of the BCGs within the test environment.

3.2.3. Results

3.2.3.1. Data Analysis

Coding, Frequency analysis, and cross-tabulation were completed in IBM SPSS Statistics version 24 for Mac. Where necessary, the Chi-squared (X^2) test was used to compare data with results from alternative sources or when comparing between clinical groups, age groups, and devices. P-value <0.05 was considered statistically significant (Box, Hunter and Hunter, 1979).

3.2.3.2. Responses and demographics

The survey received one hundred and forty-six responses (n=146). Survey respondents were separated into age ranges. Respondents were further categorised as Student Clinicians

with 45% (n=65) of the responses, Junior/Mid-Level clinicians with 23% (n=34) of the responses, and Consultants with 32% (n=47) of the responses (see Table 3 and Figure 3).

3.2.3.3. Age range of respondents

Figure 1 shows the total number of respondents separated by age.

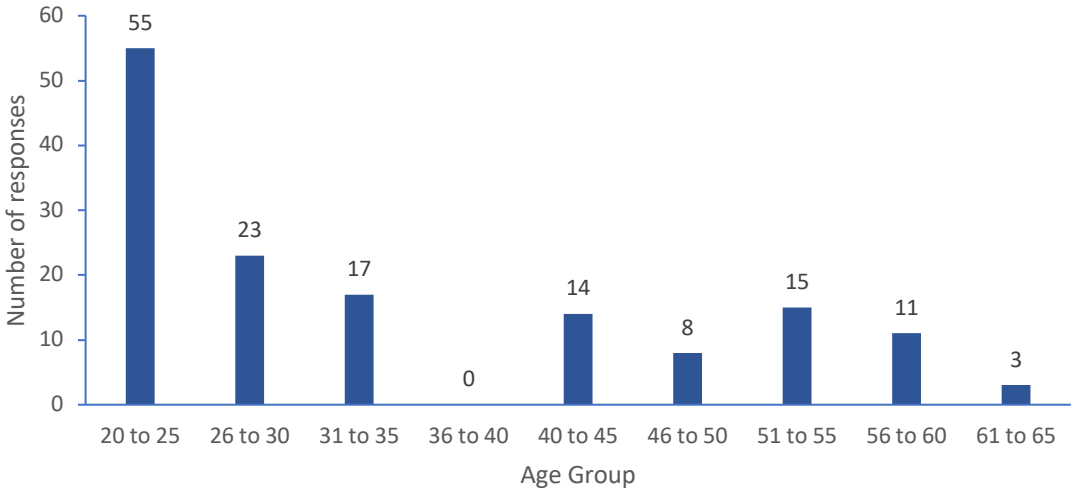


Figure 1 - Age ranges for Clinical Survey Respondents. Age ranges 21 to 25 and 26 to 30 largely represented the Student respondents, and some Junior level clinicians

3.2.3.4. Device ownership and manufacturer

Table 3 shows the actual number of clinicians; their role; and their preferred smartphone. 98.6% (n=144) of clinicians reported using an iPhone or Android Smartphone for clinical practice (Table 3). Clinician and medical student iPhone ownership was ~72% (n=106), while Android device ownership was 26% (n=38) (Table 3). All roles demonstrate ownership preference for iPhone over android (Consultants, Mid-Level, Junior and Students) ($p =<0.05$). This result is significantly different ($p = <0.0001$) to research, which shows general ownership of Android and iPhones to be ~49% for each device (Statista, 2019). This result verifies findings of previous research (Mobasheri et al., 2015), which found that 75.6% of doctors own iPhones. The survey conducted for this paper discovered <1% (n=1) of clinicians do not own a smartphone and <1% (n=1) do not own a mobile device, both were Consultants between age 56 and 65.

Table 3 - Mobile device breakdown for each clinical role and device type. iPhone use is significantly higher than Android use across all groups.

		Device			
		Android	iPhone	None	Other
Role	Consultant	13	32	1	1
	Mid-Level	4	12	0	0
	Junior	5	13	0	0
	Student	16	49	0	0
	Total	**38** (26.4%)	**106** (73.6%)	**1** (0.7%)	**1** (0.7%)

3.2.3.5. Mobile App Usage

Survey participants were asked to identify '*any apps you use on a regular basis to support you in your role*'. Of the respondents, 9% (n=13) stated that they do not use smartphone applications to support their role; of these clinicians, the majority (n=10) were Consultant clinicians, representing 15% of the total number of Consultant respondents. The majority of these (n=11) reported accessing the web-based tools provided by their NHS Trust on a regular basis.

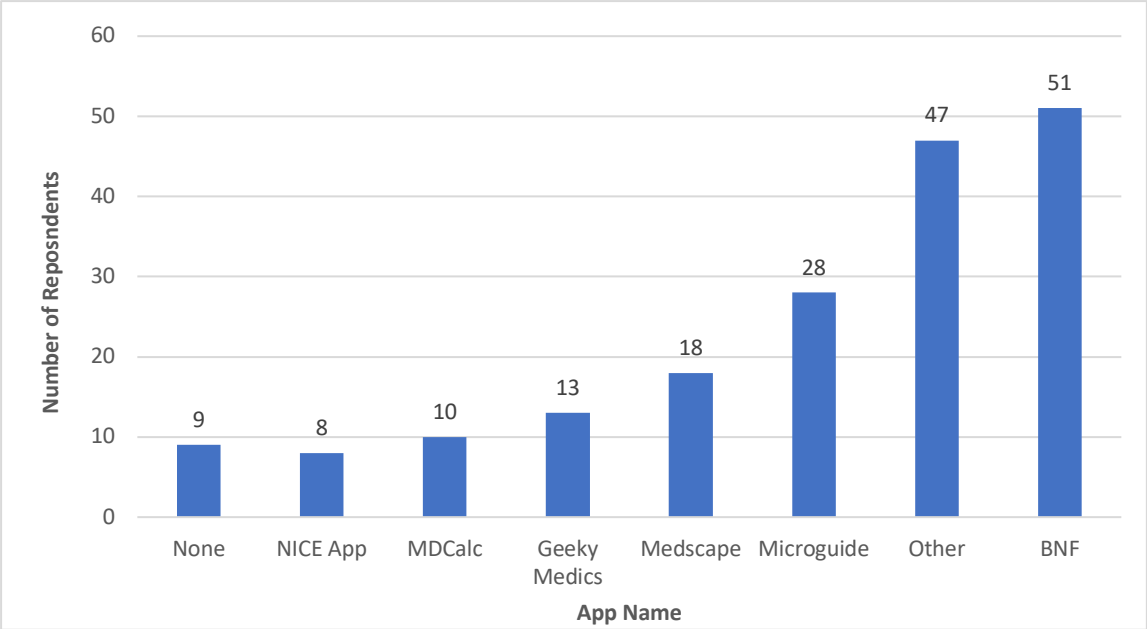


Figure 2 - Percentage of respondents using Applications 'per app'

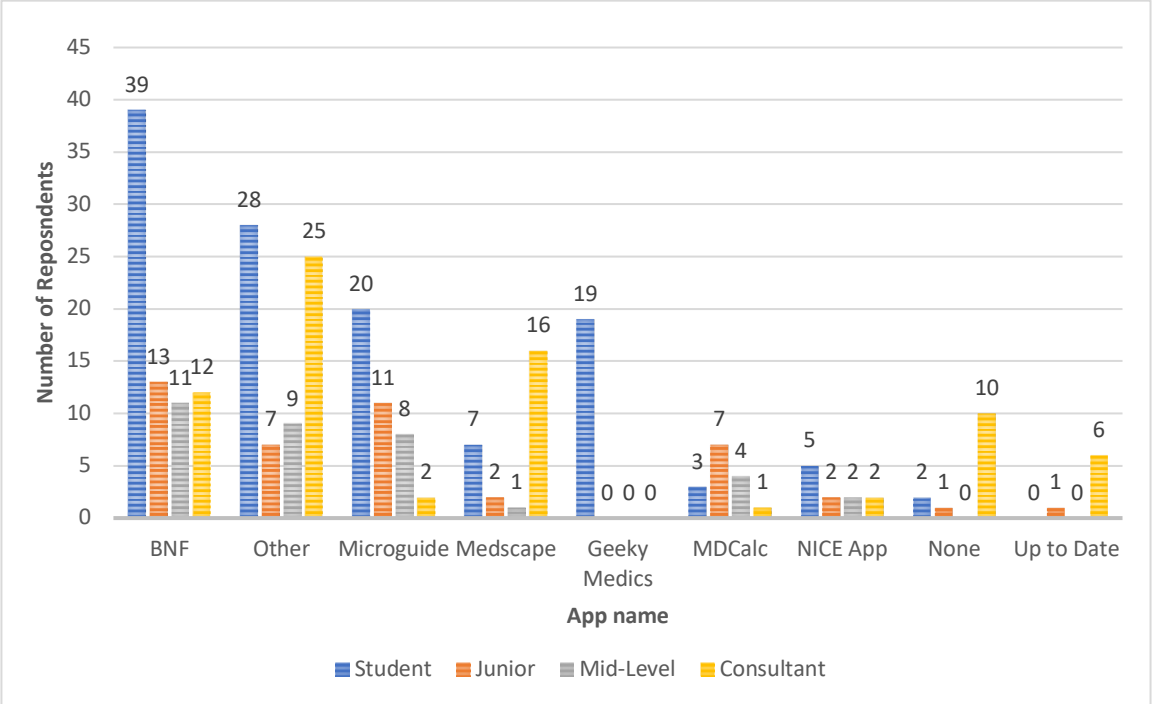


Figure 3 - Application use across clinical roles 'per app'.

Survey participants named a variety of apps (Figure 2). The most 'popular' was the British National Formulary (BNF) app, with 51% (n=75) of respondents. Microguide was named by 28% (n=41) of respondents, students (n=20) and Junior/Mid-Level clinicians (n=19). Fewer Consultants, 3% (n=2) report using the Microguide App. The survey also found that Medscape was used by 18% (n=26) of respondents, and MDCalc was used by 10% (n=15)

of respondents. Interestingly, Medscape is predominantly used by Consultants (n=16) while MDCalc is used more by Junior Clinicians (n=11) compared to Consultants (n=1). There was a reported 8% use (n=11) of the National Institute for Clinical Excellence (NICE) App. However, NICE no longer support or update this application. Several respondents - 5% (n=7), reported using the 'UptoDate' app, these were predominantly Consultants (n=6). Another application which has high reported use amongst Students was 'Geeky Medics'. 60% of Students (n=28) reported using 'Geeky Medics' to support their study and clinical practice. Notable was the mixed-use of 'Other' apps. Almost half, 47% (n=69) reported using Apps which was not used by others who were surveyed. These applications include calculation tools; clinical tools based on a specific clinical discipline; learning tools, and applications for general administration - Figure 3 shows 'use' and 'breakdown by role' of apps. Survey responses were analysed, and 'named' apps recorded.

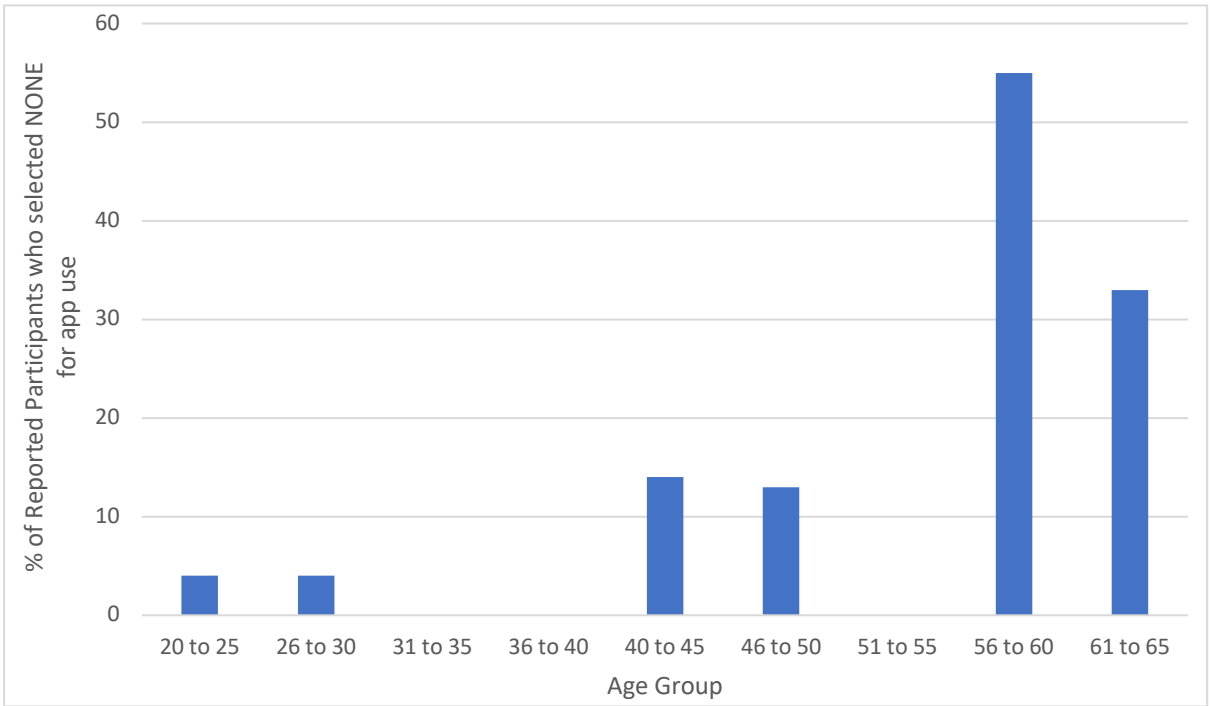


Figure 4 - Respondents who reported not using apps for clinical practice on a regular basis

Figure 4 shows the results where respondents reported 'None' for using apps regularly to support their practice. The data shows that significantly higher percentages (p=<0.0001) of

older clinicians (*56 to 60 and 61 to 65*) do not use applications on their devices. In comparison, relatively few clinicians below the age of 56 reported 'None' for using apps regularly to support their practice.

3.2.3.6. App Analysis

It is essential to establish design patterns to inform the framework of the prototype; this will allow for consistent usability when clinicians adopt new apps for their practice (Nielsen, 1992c).

The most popular apps reported by clinicians in Figures 2 and 3 were analysed for consistent design features. The analysis investigated the type of menu, information access type for accessing sections, i.e. lists, and if a search function was available all standard features which form the framework of the majority of apps. This analysis then informed the design of the prototype app described in Chapter 4.

Table 4 - Popular App Analysis (Basic)

App	Menu	Information Access	Search
BNF	Tabbed	ListView A to Z	Yes, Filter based
MicroGuide	Slide Out	ListView by Category	Yes, Full search
Medscape	Tabbed	ListView A to Z	Yes, Filter based
MDCalc	Tabbed	ListView A to Z	Yes, Filter based
NICE app*	Tabbed	ListView A to Z	Yes, Filter based
GeekyMedics ▵	Main Menu	ListView by Category	Yes, Filter based

**No longer available, ▵ Student Learning Tool only*

As Table 4 shows, the most popular apps all utilise a 'List View', either by category or in an alphabetical format. The apps also utilise a filter-based search function, rather than a full search. Finally, these Apps predominantly adopt a tabbed menu system as opposed to allowing users to quickly access other system features, e.g. Settings or alternative views.

3.2.4. Discussion

The discussion addresses the research questions the survey was designed to answer (discussed in the introduction to this section).

'***Is smartphone ownership consistent across all groups surveyed (Consultants, Mid-Level, Junior and Students)?***'

The early adoption of iPhone app development for web-based clinical service tools such as Medscape, Microguide, and the BNF which were launched in 2009 (MobiHealthNews, 2009), 2012 (Microguide, 2020), and 2013 (NICE, 2020), respectively may have influenced the device bias. Medscape (as an example) was not launched on Android devices until four years after it was made available on iPhone. This is a relatively long period in which brand loyalty and user adoption can grow. Fellow clinicians owning a particular device or manufacturer can also be influential on others, an example of 'peer pressure' (Rahim et al., 2016), which may lead to a growth in the adoption rate of that particular manufacturer. A critical factor in app development is identifying the device that the app is being developed for. According to the survey results, 100% (n=99) of Students, Junior and Mid-level clinicians 'use' their Smartphones to support their clinical practice. This includes utilising either web-based resources such as the NICE Guidelines (NICE, 2020) or on-device apps such as the BNF App (BNF, 2019). These results are significantly higher than those of previous studies, which have looked at other student groups, such as Nursing Students (O'Connor and Andrews, 2016), which highlights the changes in terms of the question research question '*Has smartphone use changed significantly since prior research was conducted; do more or less clinicians/students now use smartphones on a regular basis to support their practice?'*

The survey revealed that 95.7% (n=45) of consultants reported utilising their Smartphone for clinical practice. In addition, 13% (n=10) of consultant respondents stated that they do not use Smartphone apps regularly. This supports the argument that smartphone ownership is consistent across all groups.

'Has smartphone use changed significantly since prior research was conducted; do more or fewer clinicians/students now use smartphones regularly to support their practice?'

The results indicate that clinicians predominantly use the iPhone over Android devices. This result echoes the findings of similar studies (Payne, Wharrad and Watts, 2012; Mobasheri et al., 2015). Potential reasons for iOS domination in this profession are multifactorial, and device preference falls outside the scope of this study. However, previous work indicates that common factors relating to device preference and/or selection include: Trust, with research indicating that users trust Apple manufactured devices more than similar manufacturers (Reuver, Nikou and Bouwman, 2015; Zhou et al., 2017); security, with Android devices perceived as less secure than iOS (Zhou et al., 2017; Benenson, Gassmann and Reinfelder, 2013); prestige and cost may contribute to higher adoption rates amongst Doctors. Conversely, similar studies have found that Nurses and Nursing students have a much lower iPhone adoption (O'Connor and Andrews, 2016). There is potential for further work in this area. There is little difference in iPhone, android or device use by clinicians or students; almost all (98.6%, n=144) of the respondents reported using an iPhone or Android Smartphone for clinical practice. The rate of device use has grown significantly in comparison to similar (earlier) surveys (Payne, Wharrad and Watts, 2012; Mobasheri et al., 2015) and supports the results of more recent studies (O'Connor and Andrews, 2016). The growth described here is consistent with the growth

of smartphone use in general (Statista, 2019). Disregarding 'general' smartphone use, there are several factors which may be contributing to this growth.

Is there any consistency regarding which smartphone applications clinicians and students use?

As is the case for the general population, app use has grown amongst students and clinicians. Previous research (O'Connor and Andrews, 2018) identified that less than half of students surveyed used apps to support their clinical practice, while this study indicates that over half use the BNF app alone. Geeky Medics is popular among Students, but since this is a study tool aimed at Student Clinicians, its use may not be required after they have completed their studies and become qualified clinicians.

The survey also identified a large number of clinicians using Apps which have not seen widespread adoption by other clinicians. Some applications may be specific to a particular field or discipline, and further work in-app use and adoption, defined further to specific 'fields' is required.

It has been suggested that the calculation tools are more popular with junior clinicians simply because they are more likely to be carrying out calculations (Payne, Weeks and Dunning, 2014). A senior clinician/consultant might recommend a particular drug but prescribing may be left to a junior clinician. This may explain the significant difference in-app use amongst younger clinicians (e.g. MDCalc use). It may be that junior clinicians are yet to find an app which 'suits' them, they may not be sure what they need, or which app best fits them. Again, further study would be required to establish this.

The NHS does not officially authorise the majority of the applications reported by clinicians. Apart from the 'BNF' app and the NICE app (which is no longer available), all other apps are developed by third-party development companies. The Royal College of

Physicians' Health Informatics Unit has 'developed and piloted an 18-item checklist to help clinicians assess the structure, functions and impact of medical apps' (Wyatt et al., 2015). These support mechanisms for assessing applications for use in UK NHS Hospitals are growing, and the regulation of these apps may have future impact.

The 'App Store' rankings for the 'most mentioned' apps identified in the survey, also reinforce the findings of the survey. The most mentioned app from the survey (BNF) has an Apple '*App Store*' ranking of 10th in the UK and a Google '*Play Store*' ranking of 15th. Removing apps for consumer use (such as MyGP or NHS A&E Wait Times), the BNF would rank first. Microguide is the next 'non-consumer' app in both stores, ranked in the top 50 of both the Google and Apple App store. Whilst the 'App Store' ranking is not significant to the design or usability; it does corroborate the results of the survey, since the 'App Store' rankings and reported 'use' by clinicians/students correlate. There are some aspects of app use which may have influence that cannot be taken into account in the NHS Trusts surveyed. Apps such as 'UptoDate' require a subscription, which is included by some trusts as part of their service (Esht.nhs.uk, 2019). It is likely that these services will have a higher adoption rate in those trusts, and further investigation is required to establish this.

Both of the app store 'ranking' and any 'official' app lists may contribute to smaller growth in apps developed for clinicians. These ranks or lists may lead to clinicians and students being reluctant to use newer or less prominent apps, especially if they are not recommended.

In short, the behaviour of students for learning has obvious differences to that of clinical practice and therefore apps deidicated to learning are utlised. However the clinical practice apps remain similar in function even though they do differ in terms of developer.

Is there a relationship between clinical role and smartphone app use?

Survey results suggest that junior clinicians are more inclined to use Smartphones in their daily practice in comparison to senior clinicians, especially for smartphone-based applications. Clinical disciplines will be a contributing factor to Apps use, though this was not within the scope of this study. A more specific role analysis might mean that some applications in the 'other' group may see higher use amongst clinicians with similar disciplines. Having a significant number of respondents from each clinical area would allow for a more thorough analysis of application use per discipline.

Does age affect the use of smartphone applications for clinical use?

The survey results do indicate that age has an impact on app usage. Older clinicians were less likely to utilise apps in their clinical practice (Figure 4). This could be due to their experience, or potentially due to other factors such as personal preference, confidence in using third-party apps, or the use of services which do not provide apps. This would need further investigation.

3.2.5. Limitations

The use of more general applications such as 'Facebook' or 'Mail' may be widespread amongst clinicians. Clinicians were not asked to provide this information in the survey, but these would undoubtedly contribute to the design expectations and considerations of usable Apps. Collecting this data could enable an understanding of generic design aspects other applications use, this would allow for the mirroring of functions from apps users utilise on a more regular basis i.e. layout of menu bar.

Although this survey was conducted across multiple trusts, it was limited geographically and to single locations within these trusts. Increasing reach; having multiple sites in multiple trusts, would enable a more thorough analysis across each trust and enable comparisons at both single-site and trust level. Convenience sampling was utilised for the survey and therefore bias could have been introduced via self-selection. This could have also introduced age-bias, however the feedback spread across multiple age groups.

3.2.6. Summary

This survey results show that smartphone ownership is consistent across all clinical roles (with iPhone ownership being dominant). The use of applications (as opposed to web-based content) has increased with the most popular apps amongst clinicians and medical students (BNF, followed by MicroGuide) being used to aid in clinical practice. Potential factors that affect smartphone and app usage have been identified, such as clinical role, age, early adoption, and app store ranking. While there was a clear preference for the most popular app choices, among the less popular choices was a great deal of variation in app selection, with both clinicians and students utilising numerous applications not used by others. The data also suggests that consultants are less likely to utilise apps in their clinical practice which may be related to the relative ages of those clinicians since clinicians in the age ranges <56 years, are significantly more likely to use apps to support their clinical practice. In conclusion, medical app usage in a clinical setting is becoming ubiquitous. This has implications for not only Doctors and app developers but also for Hospitals and Trusts and their patients. With the majority of the applications reported in the study not being officially authorised by the NHS (as well as the smartphones themselves), there is a real need for further investigation in this area and for Doctors and app developers to work more closely

to align needs and develop standards. The App design should allow clinicians to utilise features during a clinical workflow, avoiding any design that will require the clinicians to engage for an extended time, e.g. manual calculations. This could be addressed by implementing the design aspects discussed in the App Analysis, integrating features such as a filter for efficiency, and easy access to the features any new app will offer. These findings have then informed the design and evaluation of a prototype application discussed in Chapter 4.

3.2.6.1. Recommendations from Observations and Survey

Based on the findings presented in this Chapter (observations and survey), an initial prototype application should consider the following recommendations.

It is recommended that any clinical application be:

- Cross-Platform

The survey (section 3.2) clearly evidences cross platform device use.

It is recommended that any clinical application support:

- List view with A to Z and Categories

The majority of applications analysed supported a list view layout using categories or A to Z contents.

It is recommended that any clinical application utilised the following:

- Basic filter
- Easy access menu (such as tabbed)

The application analysis (section 3.2.3.5) also supported functions such as a basic filter for access to information and a menu system which supported navigation using a tabbed view.

It is recommended that any clinical application:

- Minimise manual tasks (e.g. Manual calculations)
- Minimise the requirement to use other systems (if possible), e.g. if a drug dosage calculation is required, this should be available to the clinician without the need to use another app or system. As mentioned in section 3.1.4, this may not be possible due to security, organisational governance or limitations of technology.

Observation findings (section 3.1) discussed the inconsistent delivery of health information that leads to a mixed or multi-modal use of technology and the importance of providing clinicians with the necessary tools for efficiency.

These recommendations informed the design of an initial prototype which is discussed in the following chapter (Chapter 4).

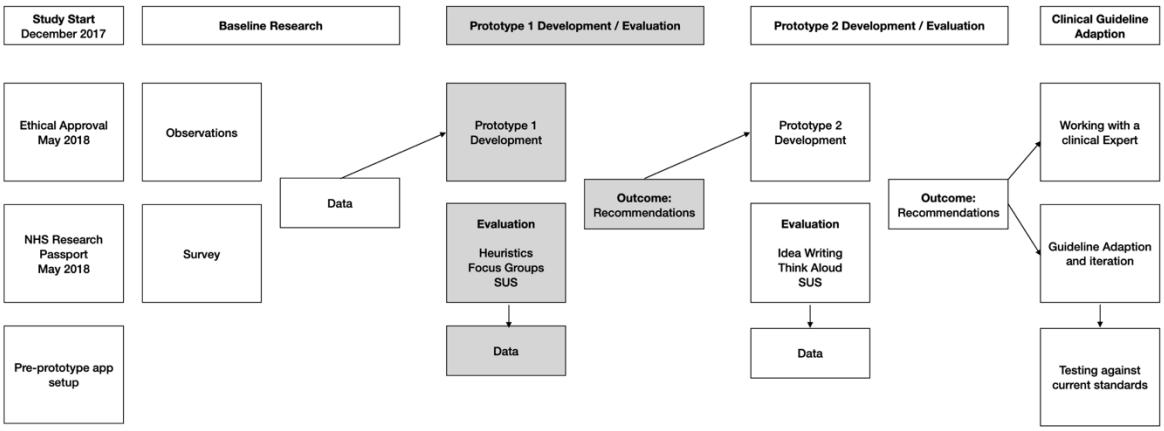
4. Co-Designing and Developing a prototype clinical guidelines mobile application (Developing the 1st Prototype)

Aims

- *The development of a prototype clinical guidelines application utilizing co-design*

Objectives*:*

- *understanding of the need and context of use for clinical guidelines*
- *deconstruct and evaluate the existing format of the clinical guidelines*
- *produce a prototype to utlise in UCD studies*
- *evaluate a prototype using UCD methodologies*
- *utilise results from UCD studies to inform a set of guidelines*



The placement of this Chapter within the PhD study is highlighted (Grey)

The research/results presented in this chapter were published in 'Springer Lecture Notes in Computer Science (volume 12202) - Design, User Experience, and Usability. Case Studies in Public and Personal Interactive Systems'. 9th International Conference, DUXU 2020, Held as Part of the 22nd HCI International Conference, HCII 2020, Copenhagen, Denmark, July 19–24, 2020, Proceedings, Part III.

4.1. Introduction

As mentioned in the introduction to this thesis and throughout the literature review, it is often the case that single UCD studies (i.e. the study of a single aspect of a software system rather than the system as a whole) are completed or that users are not involved in all aspects of the design and development. It is important to measure the impact of any recommendations elicited during UCD studies to ensure they can be implemented. This chapter discusses the need and context of use for clinical guidelines. It deconstructs and evaluates the existing BCGs and details the implementation of a prototype application

which has then been evaluated with users and adapted according to their feedback. The aim is to inform a set of recommendations for designing these types of applications. This is described in this chapter with the aims to investigate and develop efficient methods for presenting and authoring clinical guidelines for use on mobile devices. It is essential to establish if the recommendations created in chapter 3 can be implemented (discussed in this chapter) and evaluated (discussed in chapter 5). By producing clinical guidelines developed explicitly for mobile devices, the aim is to address many of the issues related to efficiency and ease of access. An example of a full guideline is provided in the appendix of this thesis (Appendix 1).

4.2. Design

The BCGs have an existing information architecture based on clinical practice and workflow (Pantin et al., 2006). This architecture has been established through the experience of the individual authors and this is discussed, along with technology implementation in the following sections.

4.2.1. Technology Selection

A key finding in Chapter 3 was the necessity for cross-platform applications to support access for the devices commonly used by clinicians. Hybrid Application Development methods (Budiu, 2013; Panhale, 2016) produce an application which employs web technologies such as HTML, CSS and JavaScript. The hybrid application files are then integrated within the native platform technologies (iOS and Android). This produces an application that can be distributed across multiple platforms, whilst still having access to

the fundamental technologies offered within the native system. This enables conversion to various platforms, offering a multimodal approach when distributing future versions of the app. Any future development can be integrated into other healthcare systems, e.g. electronic health records (EHRs) which are often web-based.

4.2.2. Methodology

The guidelines were analysed to deconstruct their structure and layout in terms of content (i.e. Headings, formula, decision algorithms), discussed in 4.2.4. A prototype application was developed to determine how each component could be displayed on a mobile device, this is discussed in section 4.3. Finally, the prototype application is evaluated utilising user centred design methods (discussed in section 4.4).

4.2.3. Development recommendations

As discussed in the summary of chapter 3 (3.2.4), the basic recommendations for the initial app prototype are as follows:

- Cross-Platform
- List view with A to Z and Categories
- Basic filter
- Easy access menu (such as tabbed)
- Minimise manual tasks (e.g. Manual calculations)
- Minimise the requirement to use other systems (if possible), e.g. if a drug dosage calculation is required, this should be available to the clinician without the need to

use another app or system. As mentioned in section 3.1.4, this may not be possible due to security, organisational governance or limitations of technology.

There are other considerations, including how the information contained within the guidelines can be presented within the limitations of a mobile device. The requirements above serve as a set of initial goals which contribute to the first prototype.

4.2.4. Clinical guideline information architecture

Before presenting the BCG information in a prototype application, it is essential to deconstruct the architecture of the BCG into individual components. An example of a full guideline is provided in the appendix of this thesis (Appendix 1). Understanding how the guidelines are constructed enables identification of existing IA and display types the clinicians are familiar with. The following sections describe each component or element and how they are utilised within the BCGs. In later sections, the components will be assessed for suitability and feedback in terms of integration into a mobile device application.

4.2.4.1. Titles and Headers

Each guideline contains a header which identifies the guideline and number of pages. The header is presented on every page of the guideline. Figure 5 shows an example of a guideline header.

Figure 5 - Clinical Guideline Header

Each guideline also contains numerous header styles to enable the user to identify the information hierarchy. The figure shows an example of a section header.

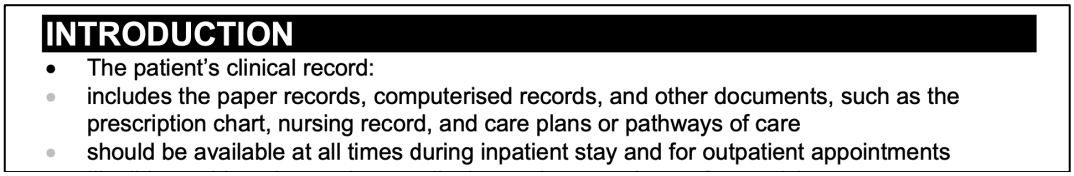


Figure 6 - Example of section header text

The guidelines also contain sub headers within a section. These are in two styles; a lowercase highlighted header (similar to the example shown in Figure 6). Subsections also contain text headers in bold text to highlight separate content relevant to the subsection An example of a sub-header and bold text headers are shown in Figure 7. Capitalisation remains from the original information architecture intended for book prints.

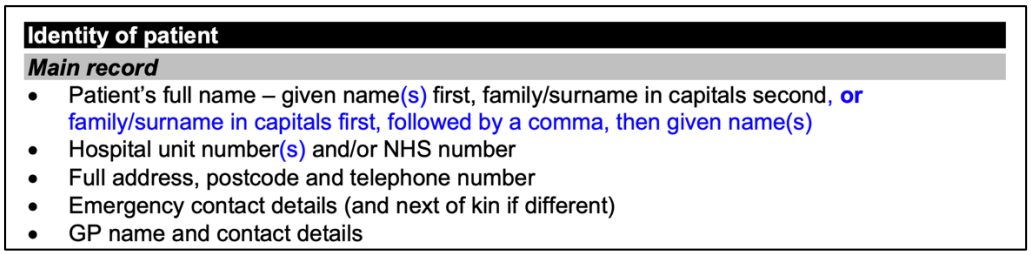


Figure 7 - Sub header and bold header examples

4.2.4.2. Text

As shown in Figure 7, the majority on information with the BCGs is presenting in bullet points within sections or sub-sections. The bullet points follow a simple set of rules, standard bullets are used for the main text, and grey bullets (sub-text bullets) are used for information which is relevant to the bullet point above. An example of these types of bullets can be seen in Figure 6. Standard text is also used in the guidelines. Figure 8 shows an example of standard text that is not presented in a bullet point format. This text is typically used to deliver introductory text to guidelines.

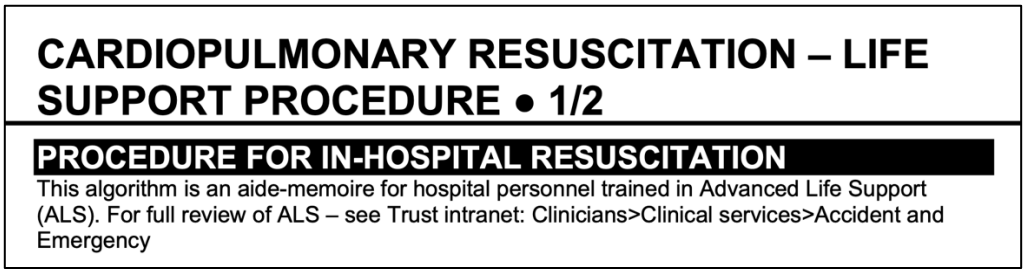


Figure 8 - An example of plain text used as an introduction to a guideline

4.2.4.3. Warnings/Alerts/Highlighted Medical Information

Figure 9 and Figure 10 show examples of highlighted medical information. This information is usually presented as a 'warning' or 'alert' to the clinician. In some cases, the information is critical to the patient outcome (e.g. a warning not to provide a particular drug). In other cases, the information is designed to highlight important information (e.g. a reminder to wash hands). In the 'Medical' guidelines utilised for this project, there are three hundred and eighty (n=380) examples of highlighted medical information.

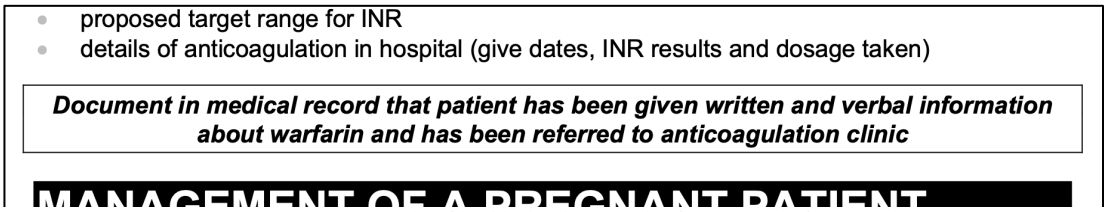


Figure 9 - An example of highlighted medical information (informative)

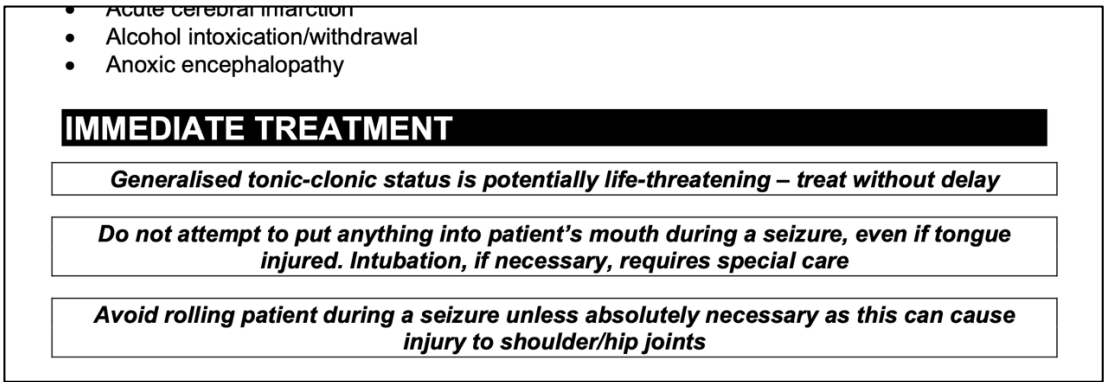


Figure 10 - An example of highlighted medical information (patient outcome critical)

4.2.4.4. Tables

Tables contained in the BCGs have two primary uses. Figure 11 is an example of a table utilised to present inline information, e.g. Grading or telephone numbers.

Table 1: Grading of anaemia symptoms

Severity score	Anaemia symptoms
Mild	• Fatigue • Shortness of breath on exertion
Moderate	• Shortness of breath at rest • Palpitations
Severe	• Chest pain • Heart failure symptoms

Figure 11 - Inline information table used for grading symptoms

Figure 12 is an example of a table utilised as a tool/diagnostic aid. The tables typically require the clinician to calculate a score which determines the treatment pathway for a patient.

Table 1: Two-level DVT Wells score

Clinical feature	Points
Paralysis, paresis or recent plaster immobilisation of lower extremities	1
Recently bedridden for ≥3 days or major surgery within 12 weeks requiring general or regional anaesthesia	1
Localised tenderness along distribution of deep venous system	1
Entire leg swollen	1
Calf swelling at least 3 cm larger than asymptomatic side	1
Pitting oedema confined to symptomatic leg	1
Malignancy (on treatment, treated in last 6 months or palliative)	1
Collateral superficial veins (non-varicose)	1
Previously documented DVT	1
An alternative diagnosis is at least as likely as DVT	−2
Clinical probability simplified score	
DVT likely	≥2 points
DVT unlikely	≤1 point

Figure 12 – An example of a table utilised as a diagnostic aid

4.2.4.5. Images

Images are used throughout the BCGs and have numerous functions. Images are mainly utilised to present an example of medical equipment or instructions for their use (see Figure 13).

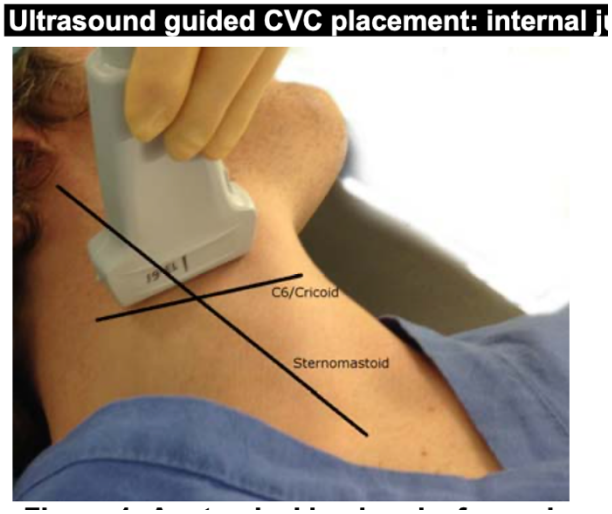


Figure 13 - An example of image use for medical equipment instruction

In some cases, images also deliver diagnosis aids, e.g. burn assessment or to highlight procedures/methods, e.g. washing hands (Figure 14).

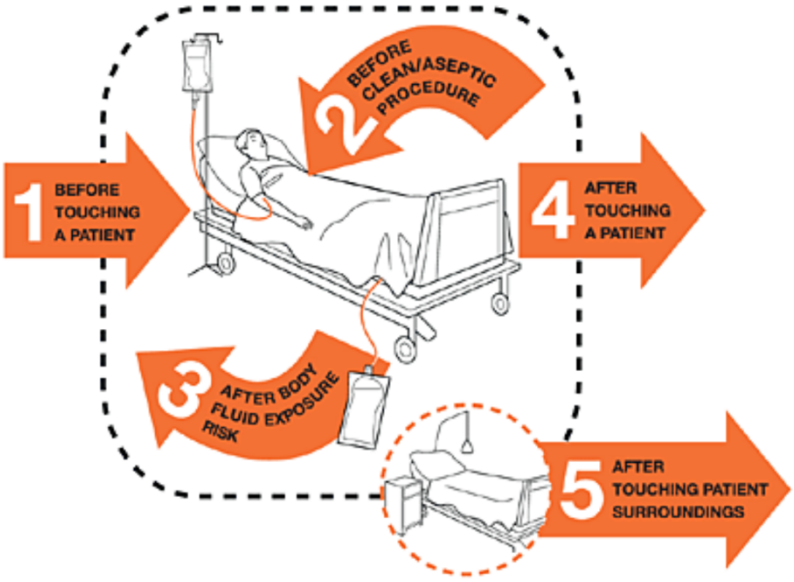


Figure 14 - An example of image use for procedures/methods

4.2.4.6. Decision Algorithms, pathways and Flowcharts

The BCGs rely heavily on the implementation of decision algorithms and flowcharts. In the medical guidelines utilised for this study, there are forty-six (n=46) different decision algorithms (in a flowchart design) which support clinicians in the care pathway for patients,

drug dosages or order (flow) of procedures. The algorithms do not follow any uniformity and predominantly differ in design and layout. Figure 15, Figure 16, and Figure 17 show examples of the decision algorithms within the BCGs.

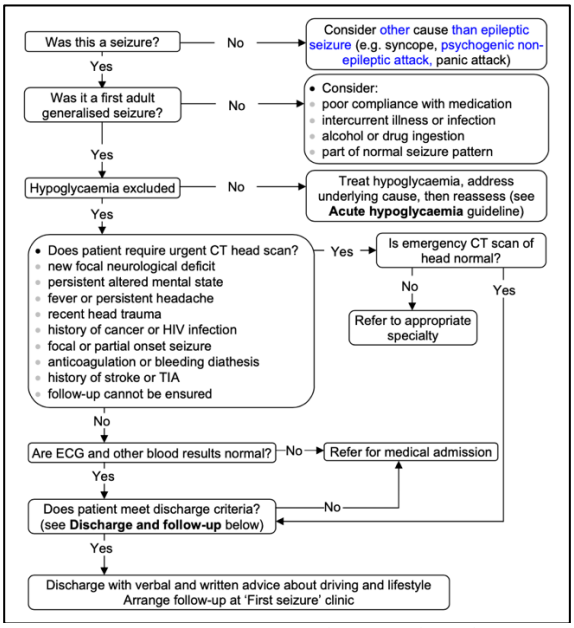


Figure 15 - First Seizure decision algorithm

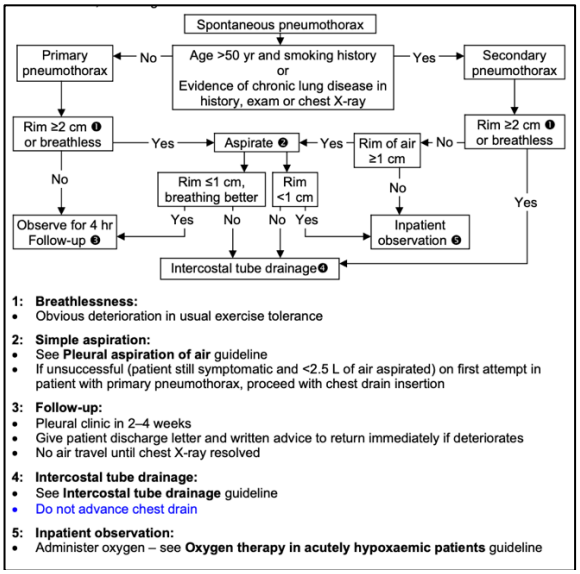


Figure 16 - Spontaneous Pneumothorax intercostal drain algorithm

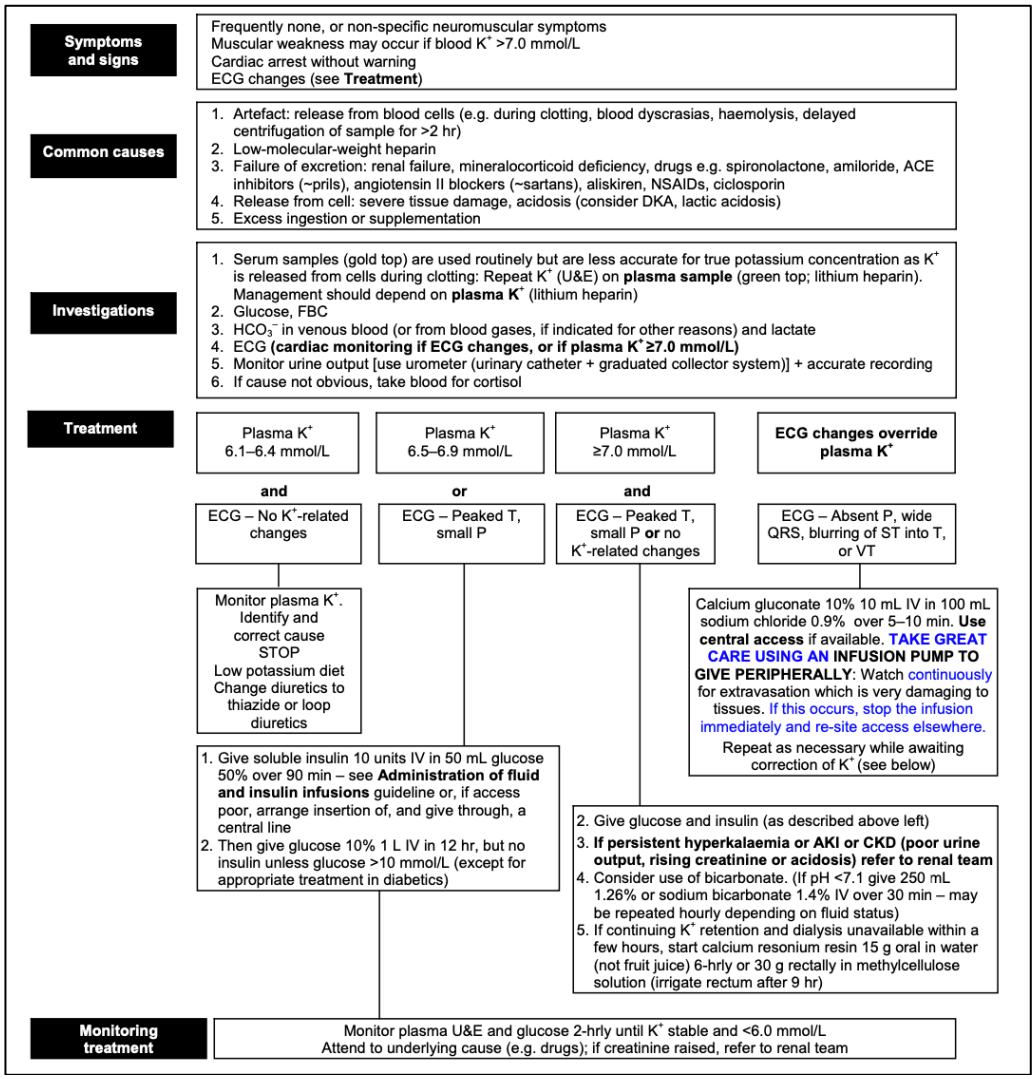


Figure 17 - Hyperkalaemia Treatment flowchart

These examples (figure 15, 16 and 17) highlight the heterogeneous nature and presentation of these tools within the BCGs. Other guidelines, such as the NICE guidelines (NICE, 2020), also utilise flowcharts and decision algorithms. The NICE guidelines refer clinicians to a tool called pathways (https://pathways.nice.org.uk), which presents clinicians with similar flowcharts to those shown in figures 15, 16 and 17 and allows clinicians to interact with some stages to present further information. Appendix 1 shows an example of how the NICE pathways tool is presented to clinicians on both Desktop and Mobile browsers.

4.2.4.7. Formulas

Some guidelines require clinicians to calculate drug dosages based on patient information such as ideal body weight (IBW) or other factors, e.g. Creatinine Clearance (CrCl). In these scenarios, clinicians are provided formulae to facilitate the calculation. Figure 18 is an example of how formulae are presented within the BCGs.

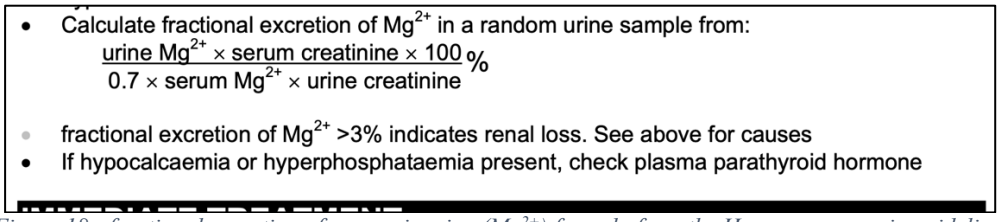


Figure 18 - fractional excretion of magnesium ion (Mg^{2+}) formula from the Hypomagnesaemia guideline

It is worth note that in other guidelines contained with the BCGs, formulas are presented in a way that is indistinguishable from the main text. i.e. difficult to differentiate. It is also worth note that in some guidelines, clinicians are required to calculate up to seven different sums to direct their treatment to a required dosage or care pathway. This can cause issues in terms of having to calculate in multiple stages, this takes time and increases the likelihood or error.

4.3. Initial Prototype

The nature of clinical practice means access to clinicians can be limited. Therefore, it was felt that developing an initial prototype and iterating would provide a more efficient approach that would benefit the research. Methods such as paper prototyping or design workshops would be difficult to facilitate and therefore presenting an initial solution would allow for feedback that can be implemented more efficiently. This is often a utilised technique in lean UX, where a minimum viable product (MVP) is created before each stage of user feedback (Roto et al., 2014).

4.3.1. Design

Results from the review of BCGs in word/pdf format (4.2.4), and the observation and survey studies (Chapter 3) have informed the design of the initial BCG prototype application. The following sections discuss the rationale and process of the prototype application design/development. Figure 19 highlights the stages of the 1st prototype which will then be used for initial feedback utilising a UCD process (*this is discussed in Chapter 5*).

Figure 19: 1st Prototype development stages

4.3.1.1. Design constraints

At this stage of the study, the application design was limited in how the information could be presented. Changing the format of the clinical guidelines from its current format requires evidence and verification in order to establish that the changes will not have an effect on clinical use and patient care. This affected the ability to present computerised calculations, e.g. drug dosages for vancomycin. As a research team (academic and clinical), it was decided that a verification pathway needed to be developed to ensure that information and drug dosage calculators could be provided within the application safely and therefore be approved for testing. To counter the impact that this would have for the study, it was decided that information contained with the medical guidelines would be utilised, but at this stage would be predominantly unchanged from its original format. The aim, therefore, was to present the information in a more 'usable' manner than currently available (pdf version of the book) and gather feedback using UCD methods such as focus groups to inform iterative changes in how the guidelines are both written and presented.

4.3.1.2. Initial Interface Design

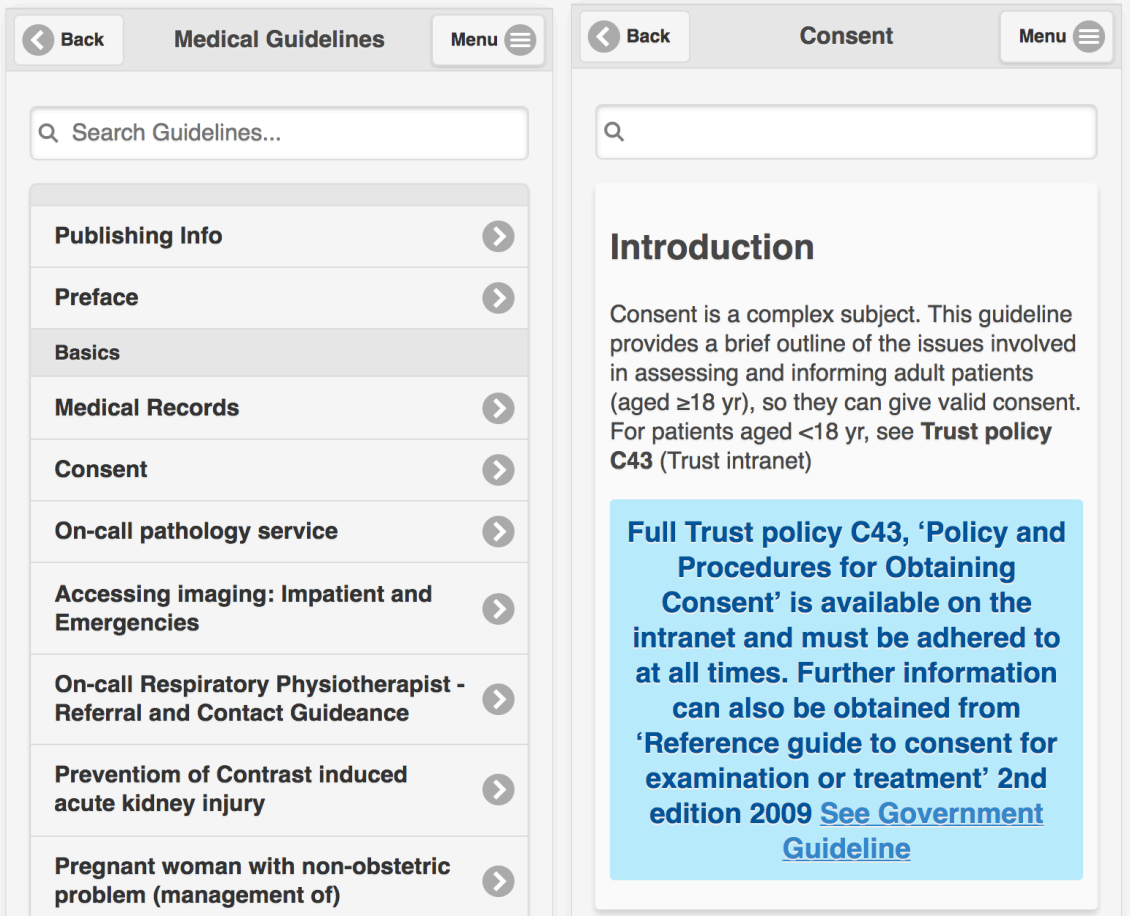
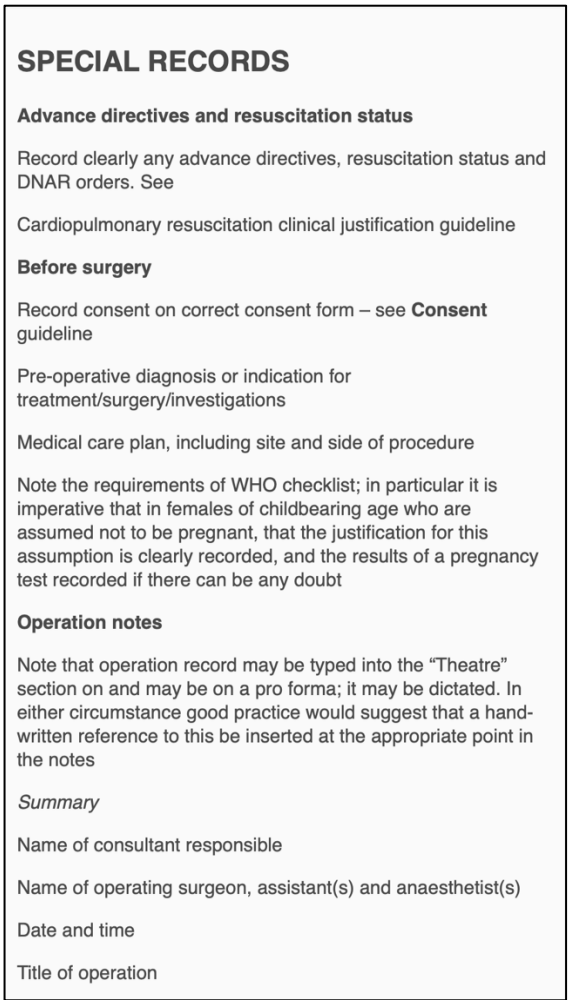


Figure 20 - The initial prototype of the BCG app.

Figure 20 shows the initial prototype design of the application based on the original format of the BCGs. In some areas (e.g. warnings and headers) different typefaces and designs were used based on best practice (Nielsen and Molich, 1990; Nielsen, 1995, 2006; Wroblewski, 2012; Potla et al., 2012). Specifically, this best practice related to aspects such as consistency and standards, error prevention, recognition, efficiency, and aesthetic design (Nielsen and Molich, 1990). Other aspects included mobile first (Wroblewski, 2012) and adapting information such as tables for mobile device screens (Potla et al., 2012). Note the

menu button in the top right, implemented during this prototype stage as the app functions were limited and did not require a 'tabbed' menu as the survey and app analysis suggested. Several design aspects were considered, these included how Warnings/Alerts were presented; Filtering/Highlights search text; Algorithms for diagnosis; Diagnostic Aids; Calculations; and the main content page to access individual guidelines.



SPECIAL RECORDS

Advance directives and resuscitation status

Record clearly any advance directives, resuscitation status and DNAR orders. See

Cardiopulmonary resuscitation clinical justification guideline

Before surgery

Record consent on correct consent form – see **Consent** guideline

Pre-operative diagnosis or indication for treatment/surgery/investigations

Medical care plan, including site and side of procedure

Note the requirements of WHO checklist; in particular it is imperative that in females of childbearing age who are assumed not to be pregnant, that the justification for this assumption is clearly recorded, and the results of a pregnancy test recorded if there can be any doubt

Operation notes

Note that operation record may be typed into the "Theatre" section on and may be on a pro forma; it may be dictated. In either circumstance good practice would suggest that a hand-written reference to this be inserted at the appropriate point in the notes

Summary

Name of consultant responsible

Name of operating surgeon, assistant(s) and anaesthetist(s)

Date and time

Title of operation

Figure 21 - Image of the Medical Records Guideline in the 1st prototype application

A heuristic evaluation (Nielsen and Molich, 1990; Nielsen, 1992b, 1994a, 1994b; Gerhardt-Powals, 1996) of the prototype refined several aspects; these included: Guideline sections requiring more distinction, the initial design shown in figure 21 has no distinction between each subsubsection the guidelines; warnings required more prominent colours, the blue design did not reflect the fact that it was important information that the user needed to notice; sections and headers also required more distinction; guideline information was not

presented similarly to what clinicians were used to (e.g. the bullet-pointed format). The subsequent sections contained in 4.3.1.3 discuss the design of these elements, as well as the decisions for why the designs were adopted to present the BCGs in the app. This includes how elements of the heuristic evaluations and established research helped to inform the initial prototype implementation

4.3.1.3. Guideline layout and elements

Titles and headers

It was essential to design titles and headers to ensure prominence; research suggests that users must know where they are within a system and navigation should be simple and easy to learn (Nielsen, 1995; usability.gov, 2019). The information architecture discussed in 4.2.4.1 highlights the four separate titles/headers: the guideline title; the section header, e.g. Symptoms and Signs; headers within the section; and sub-headers within.

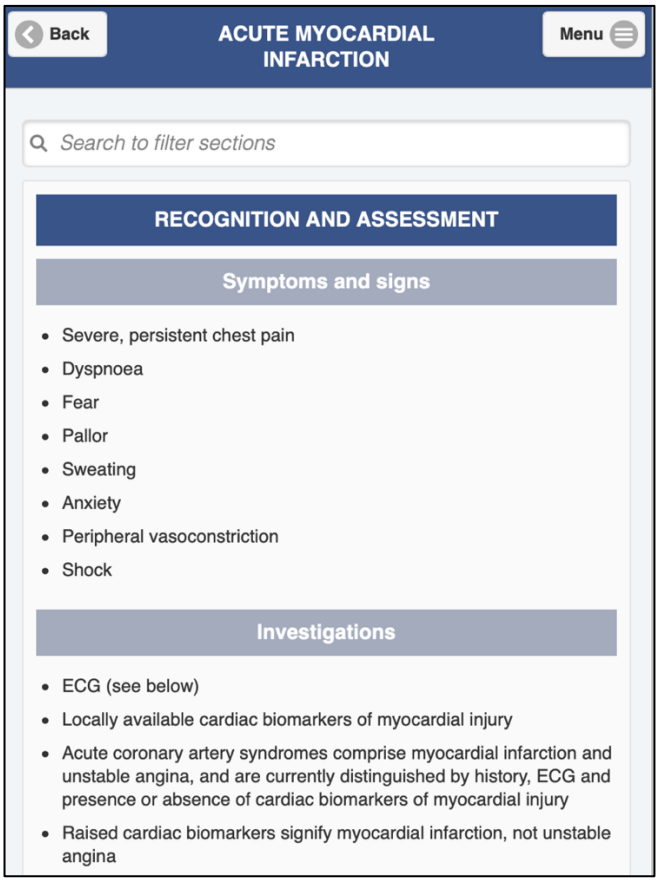


Figure 22 - Example of a Guideline title with section headers and sub-headers

As shown in Figure 22 the guideline header is located in a static header section which remains in place when the user is scrolling. The section header is made more prominent (Recognition and Assessment), as is the sub-header with the section (Symptoms and signs). This should enable the user to easily navigate the information as the hierarchy is more evident and consistent.

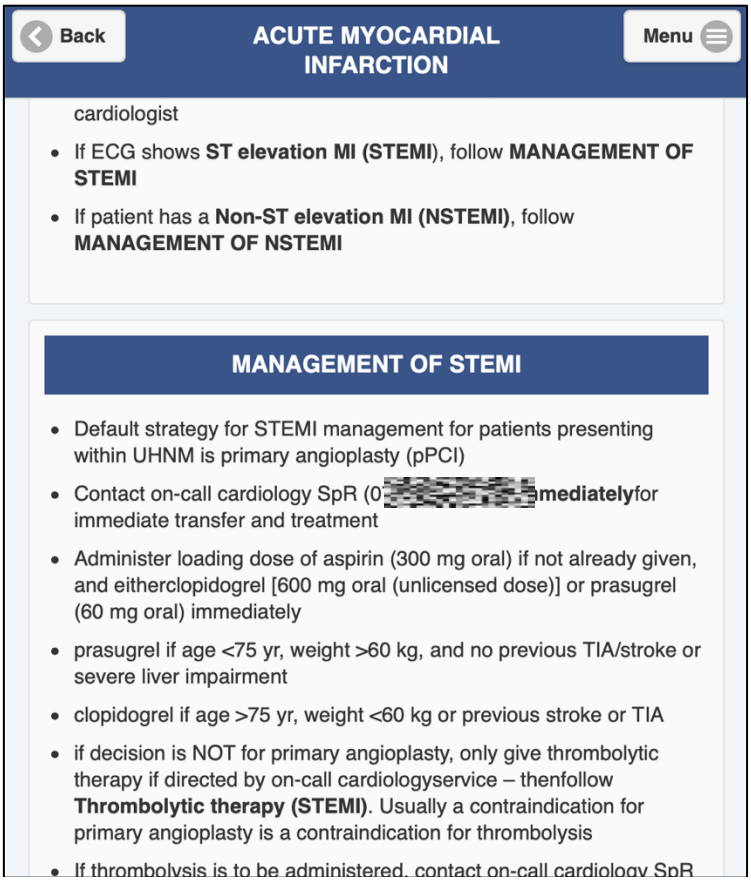


*Figure 23 - An example of section start and end with border and contrasting background**

** (telephone number redacted for privacy)*

Figure 23 shows how the sections have been separated. This informs the users that the section has come to an end and a new section, in this example 'Management of STEMI' has started. This is achieved with consistent use of the section header, a separation of the sections with a contrasting background, and the use of a small border around each section. This method should also enable the user to identify between each section when scrolling through the guideline.

Text

As with the original BCGs, the text is predominantly presented in a bullet-point format. The design in the original guidelines followed a simple architecture where main bullet points were black, and sub-bullet points were black, see the following example:

- Main bullet-point information
  - Sub bullet information
  - Sub bullet information
- Main bullet-point information

As the example shows, this architecture allows the hierarchy of information to be evident to the user. In the initial prototype, it was thought that this could be achieved using text indents, but this made the use of space less efficient and would be more difficult for users to read. Therefore, the text within the prototype was changed to present the information closer to the original format.

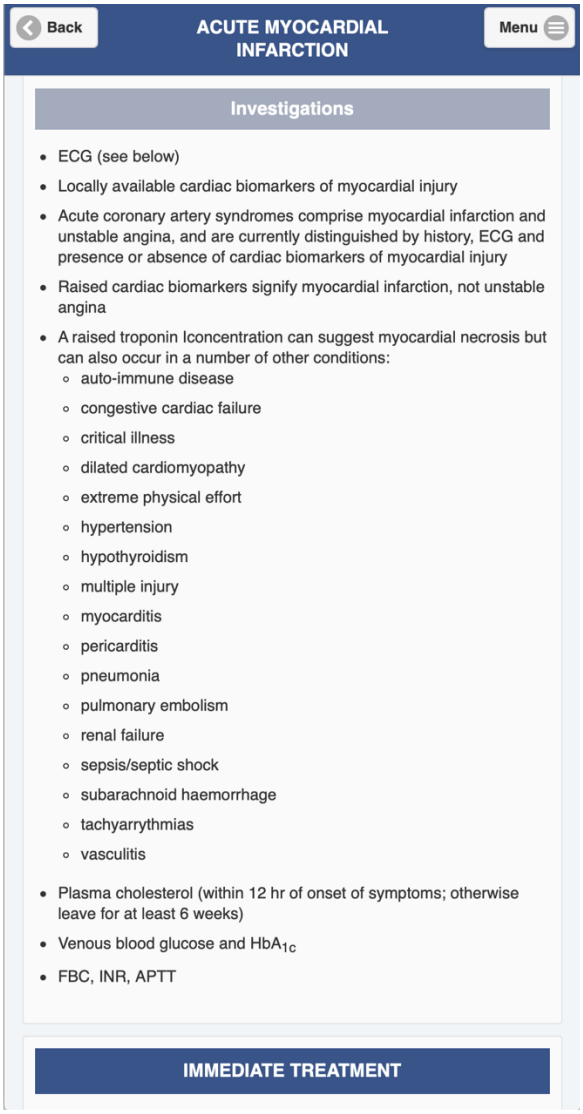


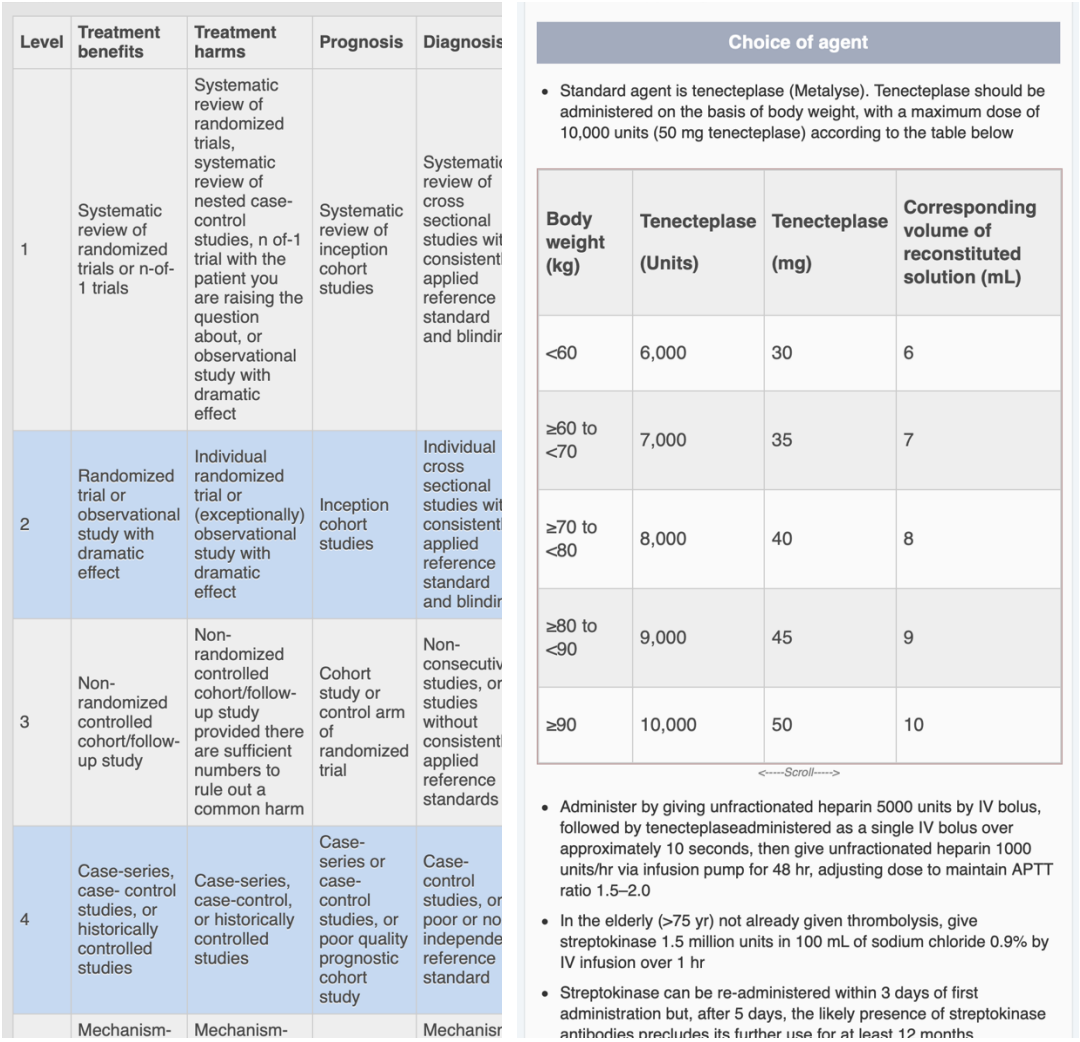
Figure 24 - BCG bullet point architecture example taken from the Acute Myocardial Infarction guideline

Figure 24 shows an example of how the bullet point architecture is utilised within the prototype application. It is worth noting that this method of presenting the information does increase the amount of scrolling a user is required to perform in order to read the guideline.

Tables

Tables are inherently challenging to display on mobile devices. They often require users to rotate devices, interact more, or display in such a way that makes them difficult to read (Schade, 2017). The original prototype had tables which appeared squashed or formatted

in such a way that makes it difficult for the user to assimilate information. The table shown in Figure 11 would display on a mobile device in a more usable manner than the table shown in Figure 12. Affordance may allow for scrolling or paging across tables, but may not be intuitive to the user. As the BCGs contain several tables, the solution at this stage was to contain the table in a frame.



Level	Treatment benefits	Treatment harms	Prognosis	Diagnosis
1	Systematic review of randomized trials or n-of-1 trials	Systematic review of randomized trials, systematic review of nested case-control studies, n of-1 trial with the patient you are raising the question about, or observational study with dramatic effect	Systematic review of inception cohort studies	Systematic review of cross sectional studies wit consistent applied reference standard and blindir
2	Randomized trial or observational study with dramatic effect	Individual randomized trial or (exceptionally) observational study with dramatic effect	Inception cohort studies	Individual cross sectional studies wit consistent applied reference standard and blindir
3	Non-randomized controlled cohort/follow-up study	Non-randomized controlled cohort/follow-up study provided there are sufficient numbers to rule out a common harm	Cohort study or control arm of randomized trial	Non-consecutiv studies, or studies without consistent applied reference standards
4	Case-series, case- control studies, or historically controlled studies	Case-series, case-control, or historically controlled studies	Case-series or case-control studies, or poor quality prognostic cohort study	Case-control studies, or poor or no independe reference standard
	Mechanism-	Mechanism-		Mechanisr

Choice of agent

- Standard agent is tenecteplase (Metalyse). Tenecteplase should be administered on the basis of body weight, with a maximum dose of 10,000 units (50 mg tenecteplase) according to the table below

Body weight (kg)	Tenecteplase (Units)	Tenecteplase (mg)	Corresponding volume of reconstituted solution (mL)
<60	6,000	30	6
≥60 to <70	7,000	35	7
≥70 to <80	8,000	40	8
≥80 to <90	9,000	45	9
≥90	10,000	50	10

<-----Scroll----->

- Administer by giving unfractionated heparin 5000 units by IV bolus, followed by tenecteplaseadministered as a single IV bolus over approximately 10 seconds, then give unfractionated heparin 1000 units/hr via infusion pump for 48 hr, adjusting dose to maintain APTT ratio 1.5–2.0
- In the elderly (>75 yr) not already given thrombolysis, give streptokinase 1.5 million units in 100 mL of sodium chloride 0.9% by IV infusion over 1 hr
- Streptokinase can be re-administered within 3 days of first administration but, after 5 days, the likely presence of streptokinase antibodies precludes its further use for at least 12 months

Figure 25 - a table formatted for the first prototype BCG application (left) and a framed Table (right)

Figure 25 (left) is an example of how the original table would display in standard code (HTML, CSS) which has issues conforming to a mobile display. Figure 25 (right) shows how the table can be constrained and scrollable within a frame to facilitate a more readable display of the information whilst conforming to a mobile display. The frame allowed users

to scroll without other guideline information being affected by the user interaction, e.g. other information would still be visible inline with the table data.

Images

The majority of images can be displayed in-line as they were presented in the original BCG format. In some cases, images may need to be dissected to conform to the constraints of mobile devices. At this stage, how images are presented is not a priority and therefore, will be discussed in later sections of this thesis.

Decision algorithms

Section 4.2.4.6 describes how decision algorithms are presented to clinicians in the BCGs. Figures 15, 16 and 17 are examples of the heterogeneity. The initial prototype presented the decision algorithms as images within the app.

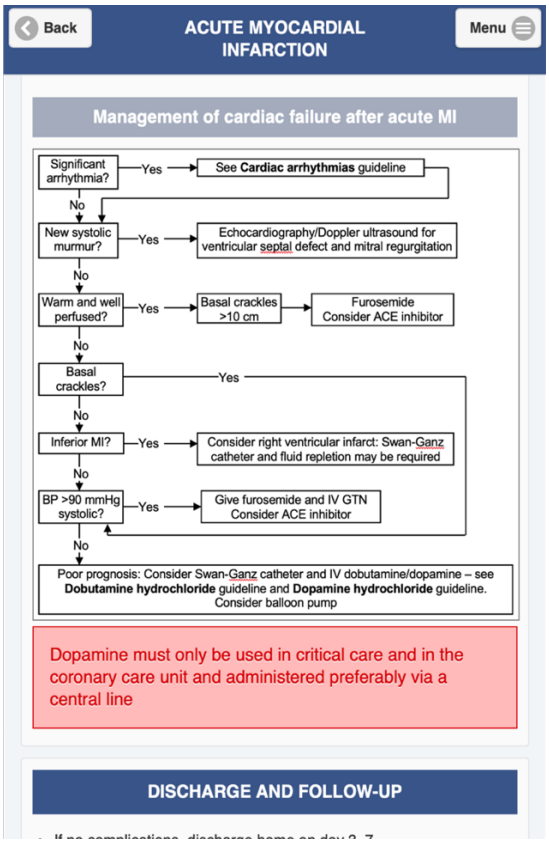


Figure 26 - An example of a decision algorithm presented as an image in the Acute Myocardial Infarction Guideline

Figure 26 is an example of a decision algorithm presenting in the Acute Myocardial Infarction guideline. This initial prototype method would allow clinicians to zoom into the images and follow the flow of information. It was evident during the heuristic evaluation that this method is not the most efficient method of displaying the decision algorithms as it displays information the clinician may not require. For smaller algorithm, such as the one presented in figure 26, this may not be an issue. For more complex algorithms, such as those presented in figure 16 and 17, the constraints of a mobile device may cause usability issues. Figure 27 highlights how a more extensive decision algorithm requires more space and therefore limits the clinician's view of the information flow. This issue is also apparent in the example of the NICE pathway tool shown in Appendix 1. The mobile version of this tool has similar issues in presenting the information for use on mobile devices.

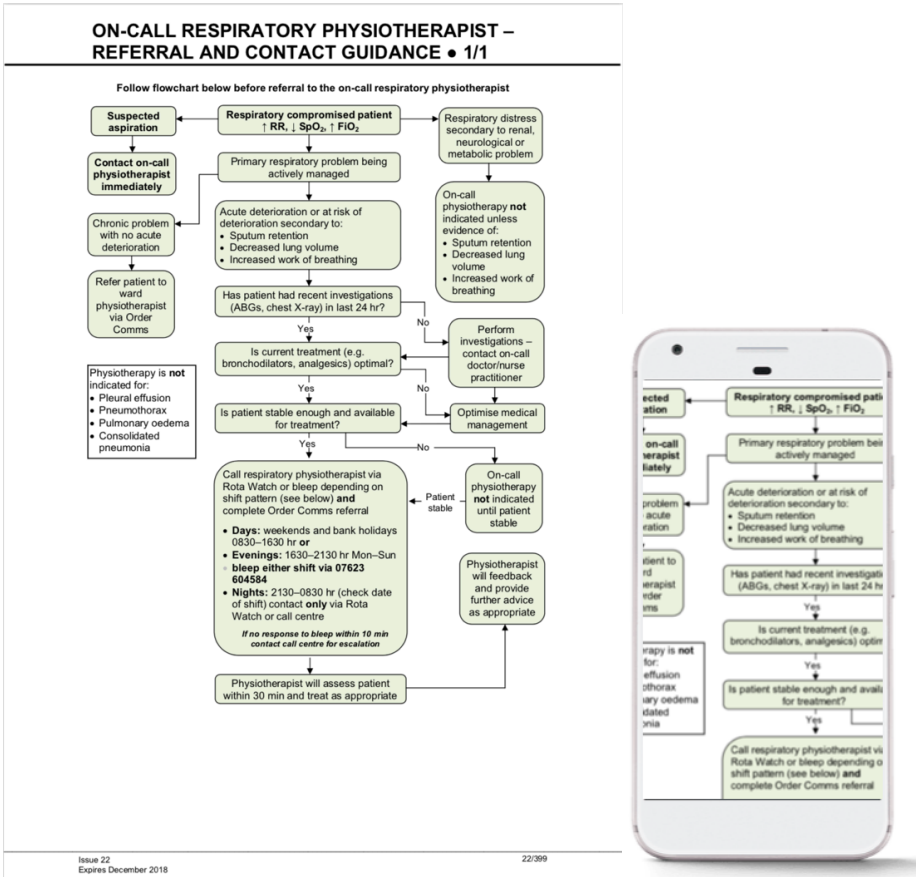


Figure 27 - A decision algorithm presented in its original format (left) and displayed as an image on a mobile device (Right)

A solution was required that would allow clinicians to not only navigate the decision algorithm but understand or be aware of the information flow they have followed. This ensures the clinician has not made an error in following the algorithm and allows the clinicians to validate the output or endpoint.

The solution was to present the decision algorithm in a clear format that allowed the clinician to navigate the same information and visually understand the information flow. The design was informed by general design guidelines and utilising similar adjustments to that of table designs.

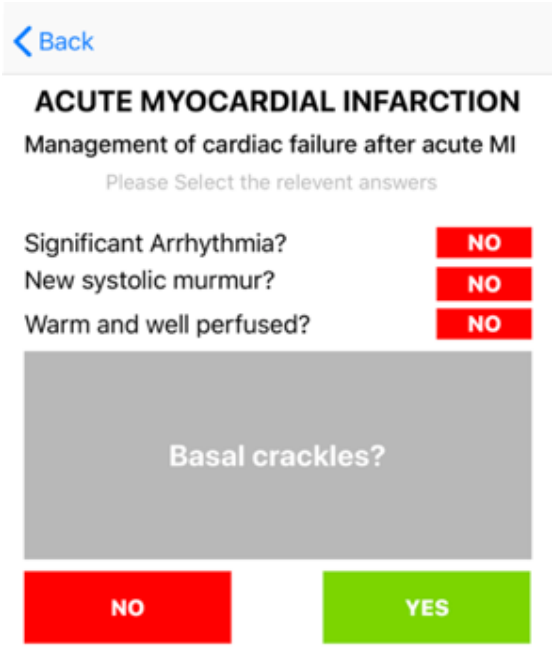


Figure 28 - An example of the first prototype decision algorithm designed for use on mobile devices

As the example in Figure 28 shows, the decision algorithm was presented in a questions and answers style. The concept is highlighted in Figure 29.

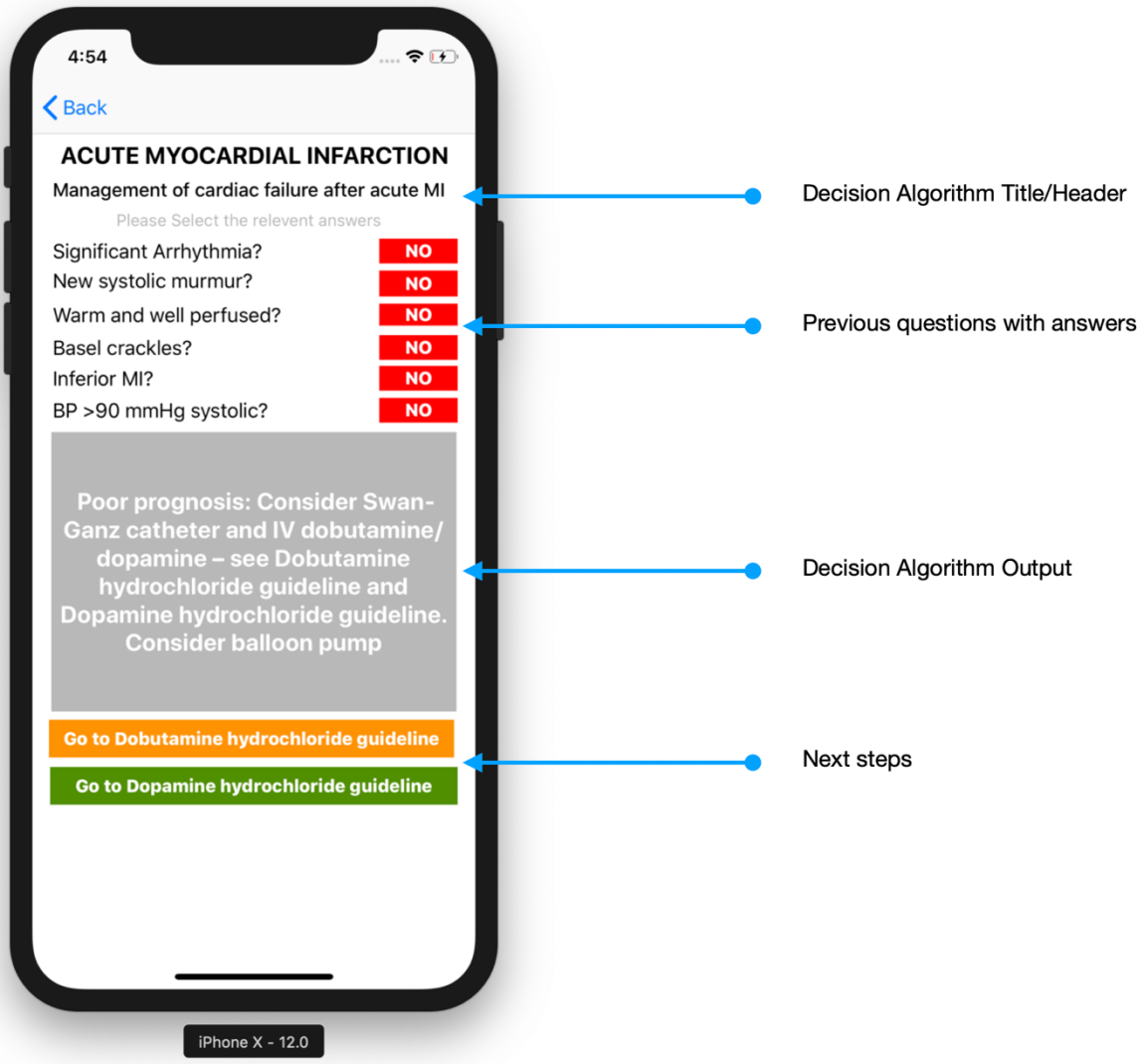


Figure 29 - A breakdown of the decision algorithm presentation for mobile devices

The concept shown in figure 29 was designed to ensure clinicians could still follow the information flow and allows for a more suitable presentation on a mobile device.

To access this tool, clinicians would be presented with an image of the decision algorithm, and by 'tapping' the image, it would navigate the user to a new page in the app which presented the concept format. A screenshot of this flow is provided in Appendix 3. The prototype version was developed using JavaScript, HTML 5 and CSS3. The design displays the selection or path the clinician has followed and therefore limits the algorithm to only the required information.

Formulas

At this stage of the research project, formulas would be presented similarly to those discussed in section 4.2.4.7. In later chapters, this work will discuss a solution to presenting formulas and similar information. A vital issue with formulas is that in some cases, they require clinicians to calculate up to seven (n=7) different figures, e.g. Ideal Body Weight or Creatinine Clearance before the formula can be utilised. A better understanding of these methods and how clinicians work with such information would be required before proceeding to present solutions. This can be achieved during utilising UCD methods; these are discussed in later sections.

Warnings

The initial presentation style of the warnings and highlighted information contained within the BCGs are shown in section 4.2.4.3 (Figure 9, Figure 10), this was developed into a more salient version for the initial prototype (Figure 20). Although the style is more prominent, a more visually noticeable colour was used to ensure users are aware that information contained within the box is of higher importance in comparison to the main text of the guideline. Studies researching colours and their impact on perceived hazards found that red, followed by orange, conveyed the highest level of perceived hazard when users were reading information (Braun and Silver, 1995). In this case, the red colour was utilised. An example of this can be seen in Figure 26.

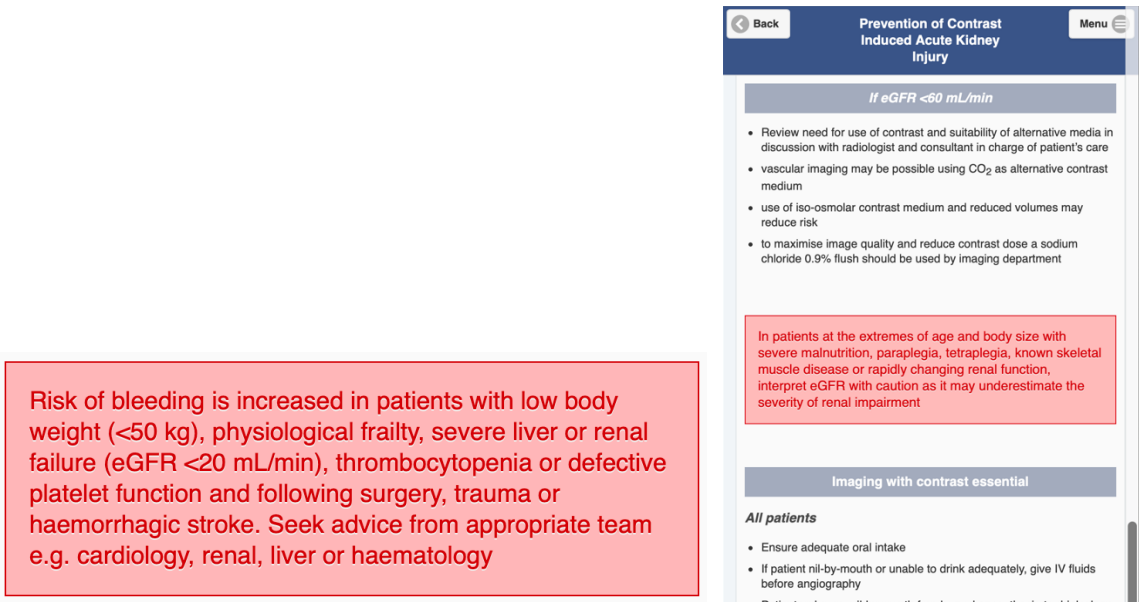


Figure 30 - Examples of red coloured warnings

Figure 30 is a set of warnings presented in the prototype BCG application. They differ in design from the original 'black box' information in the BCGs, but the content remains the same.

Filter function

To meet the initial requirements discovered during the observation and survey studies in Chapter 3, a filter function was added to both the content page and within each guideline of the BCG concept application. The filter for the content page utilises JQuery, a JavaScript framework, to filter the list view presentation of the page. The filter matches the text box input with the titles of each list view item. The example in Figure 31 shows the main content page presents only the items that match. As this was developed as part of the JQuery Javascript framework, no additional coding was required for the filter to function.

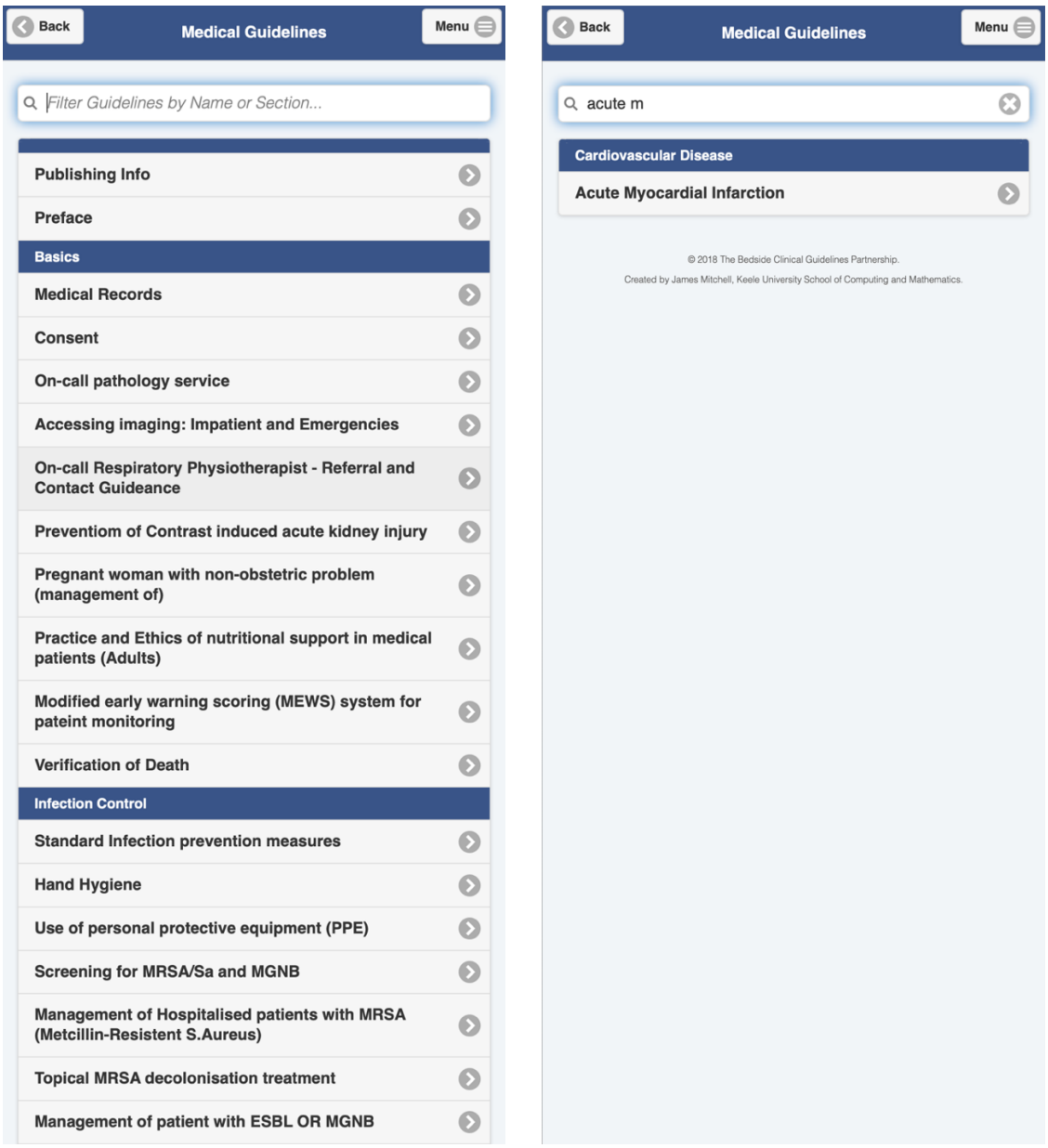


Figure 31 - The BCG concept application content page (Left) and the filter function in use (Right)

The filter function created for each guideline is contained within a single .php file and can be embedded into each guideline utilising the PHP include method. The method uses indexing to match the content of the input field with content contained in each section or 'card' of the guideline as the guideline's sections are presented as an individual DIV. Figure 32 is a code snippet to show how this was achieved. The filter also highlights the search text so the user can visually see the individual words they have entered into the input field. Fig* shows an example of the highlighted words for this function. This is achieved by

utilising and adapting the '.mark' method of a JavaScript framework created by Julian Kühnel (https://markjs.io) and is activated once the user starts to add text to the input field.

```
<script>


    $(document).ready(function(){
        $('#search').keyup(function(){

            //$.mobile.loading( "hide" );

            // Search text
            var text = $(this).val().toLowerCase();

            // Hide all content
            $('.card, .info, .warning, .card').hide();

            // Search inclduing ul li specified --
            $('.card, .info, .warning, .card, li, ul').each(function(){

            if($(this).text().toLowerCase().indexOf(""+text+"") != -1 ){
                $(this).closest('.card, .info, .warning, section, li,
ul').show();
            };

            });

            //Highlight Text
            $('.card, .info, .warning, section, li, ul,
p').unmark().mark(text);

        });

    });

</script>
```

Figure 32 - The JavaScript code for highlighting text within a guideline

Figure 33 - Examples of the filter function for key word searching in the guideline. Image left is a search for the letter 'c' and the image right is a search for the word 'shock'

4.4. Feedback and evaluation of the 1st prototype BCG app

Focus groups were selected as a method of collecting feedback from multiple users given the time constraints associated with clinical work. Focus groups are a heavily used method in similar studies (Donnellan, Sweetman and Shelley, 2013; Payne, Weeks and Dunning, 2014; Kwa et al., 2015; Narminathan et al., 2017). The main aim is to obtain functionality and design feedback for the prototype application from target users and to encourage discussion into different aspects of the prototype. Another method utilised during this study stage is the use of the System Usability Scale (SUS) (Brookes, 1996). The System Usability Scale (SUS) provides a "quick and dirty", reliable tool for measuring the usability. It consists of a 10-item questionnaire with five response options for respondents; from

Strongly agree to Strongly disagree. Some studies such as Bangor et al. (Bangor, Kortum and Miller, 2008) suggest results can be variable depending on the user interface type. However, the same study also found that the SUS is a useful tool for measuring changes to user interfaces (Bangor, Kortum and Miller, 2008). Fundamentally, the SUS enabled the gathering of quantitative user feedback that could then be utilised as a benchmark once further changes are made and evaluated.

4.4.1. Focus groups

The prototype discussed in section 4.3 was demonstrated to clinicians in a focus group of 21 clinicians in a single session (student, junior and senior) at the Royal Stoke University Hospital, part of the University North Midlands NHS Trust. The focus group was conducted utilising open discussion (Gibbs, 1997; Kitzinger, 1995). These open discussion sessions were audio-recorded and transcribed. The transcripts were then analysed using thematic analysis, basically analysing the text for concurrent themes (Fereday and Muir-Cochrane, 2006).

It was apparent during the initial focus group that another method would have to be adopted for large group feedback. Sessions were time-sensitive (scheduling constraints inherent in clinical roles) and individual sessions or smaller groups, though preferred, were not possible. Idea writing (Austin, 1994; VanGundy, 1984) was therefore adopted for the second focus group of 17 clinicians, which allowed all participants to contribute in a structured manner within the time constraints. Idea writing's core concept is that each 'idea', or in this case function, gets its own sheet of paper and that everyone writes their comments about the idea on each sheet. During this session, clinicians interacted with a prototype of the application and were asked to feedback on each aspect of the design, which was presented as a 'concept'. Although this limited open discussion (by design), it allowed for more specific feedback regarding the design of the BCG app.

Table 5 shows the themes and feedback provided by clinicians during the idea writing session. Idea writing session.

Table 5 - Outcomes from an Idea Writing session conducted with clinicians (Themes are the left column and feedback right)

Current Main Menu	• Generally fine • Familiar layout is available, Alphabet layout is also good • Prescribing menu on front main menu • A to Z layout is more specific • Clear easy to navigate • Can add more sections, such as flowchart/calculation etc
Highlight Function	• Filtering to the section with the highlighted word is useful however, we may need to read above that section. Maybe better to skip to section instead of filter
Images	• Functionality on a flow chart so clicks can lead to other info or links to evidence • Could be the best way to portray some management or diagnostic pathways • Link a disease with a typical illustration or image (CT, CXR, MRI) • Swipe to different images of same pathology
Calculation Layout	• Simple and clear layout. A link to a calculator would be amazing. Also, if the calculation could be separated into a separate box *(The above was seconded by 2 other group members using ticks)* • Simple tool. I like the MedCalc calculations and I understand that it is widely used. • Steroid equivalence doses and opioid equivalence doses *(The above was seconded by 2 other group members using ticks)* • Show the formula used in brackets or in an addendum. Easy switch between units (or conversion) *(The above was seconded by 2 other group members using ticks)*
Table Design	• I agree with the simple design and easy to read. However, the large tables do not fit the screen and attempting to view it sideways makes it difficult and takes you back to main menu • Ability to cast onto larger screen if possible • Clickable content and evidence link • Hyperlink directly to table • Table can be displayed as chart/graph
Flowchart concept	• Having the full pictographic flow chart is good because you can view the whole decision tree • Having a single question at a time is good for focus but it would be good to view the whole tree and highlight your position on it rather than being stripped down to only seeing "question yes no" • Nice clear format, I like that it can be changed to yes no • Clear format, would be more appropriate if we can get the full photographic picture • Viewing the full flowchart is ideal • Need an option to view the full chart as well as yes no options • Have both full view and the' answery' view

Text/Font/Colours	• Font and colours are clean but some users may wish for larger text • Clean and fine • Clear format, nice font size • Nice and clean • Clear
Headers and Sub-headers	• Make the sections within each page more distinct • Presentation in general is fine • Main menu -> sub headers, then have a drop down of sub headings rather than a long list, quicker to find what you are looking for, less scrolling • Fine, presentation is convenient to use
Guideline Layout	• Specific and clear layout, easy to understand • Clear and simple layout • Helpful to view by categories or A to Z list • A to Z list is long so an Alphabet shortcut to A -> <- Z in finding the desired guideline faster • The guidelines sections are clearly separated so it is easier to navigate yourself to the relevant section • Easy to follow search function is also easily visible • Source of guidelines clickable effect
Filter Function	• Useful. • Currently highlights filtered text, but does not text you to each highlighted word, like on Word. • More abbreviation for search criteria like DKA or CAP • Add to favourites (favourites section) • Some way to filter through the raw guideline contents would be greatly appreciated e.g. I might search for a symptom similar to Ctrl+F of the current PDF we use and if its only filtering through headlines nothing will come up
Warnings/Alerts	• Warnings and alerts are clear and very obviously identified by red boxes *(The above was seconded by 1 other group member using ticks)* • Some warning can be in amber *(The above was seconded by 1 other group member using ticks)* • Agree with use of red background, I would reduce the test to the minimum • Clickable warnings • Warnings or alerts to be repressible in different colours for example red for major, blue for mild etc. • Bolding
Sub Menu (List & A to Z)	• Clear division according to system -> Easy to understand • Simple. • List of A to Z, takes time to scroll through, additional shortcuts could be helpful • Easy to locate specific guidelines • Easy to find the relevant guide based on headings, could be better improved if all the sections are available in the menu as some such as hypocaelimia is not. • Sub group the menu and allow options to click to expand
Features not seen	• Easy share feature • Font size (up and down arrows) • Search with magnifying glass function • Links from pages to calculators • Favorites section

The feedback from both focus groups was analysed for consistent themes. Although the focus groups were different in approach, the outcome comments had similar themes in terms of feedback. The key aspects identified in the themes utilised during the focus groups are that clinicians appreciate the clean, clear layouts that do not impede workflow. This is evidenced in general comments such as:

"Clear easy to navigate"

***

"I agree with the simple design and easy to read. However, the large tables do not fit the screen and attempting to view it sideways makes it difficult and takes you back to main menu"

An example of this is the flowchart design within the prototype. Clinicians provided positive feedback regarding the prototype Q&A style format (Figure 8) but also suggested retaining the original flowchart design to give a gestalt view. This is evidenced in comments such as:

"Need an option to view the full chart as well as yes no options"

***

"Having the full pictographic flow chart is good because you can view the whole decision tree"

Clinician's feedback also suggested the use of acronyms (e.g. PE for Pulmonary Embolism) when searching or filtering guidelines. This is in contrast to standard usability guidelines (Spencer, 1988; Lin, Choong and Salvendy, 1997) and reflects the challenges faced when designing for experts. Participants commented specifically in terms of acronym use during a focus group session, stating:

> *"Something Ive found… One thing Ive found is that you have to write the whole thing in, I'd like MI or PE so PE doesn't come up with Embolism. I've just tried PE, MR, AF and nothing comes up, you'd have to type in Atrial fibrillation so I would like to type in shortened versions"*

Clinicians also suggested that warnings require a hierarchy based on their severity with the use of more noticeable colours. It was also stated that a reduction in text may be beneficial. The following comments are examples of this:

> *"Warnings or alerts to be repressible in different colours for example red for major, blue for mild etc."*

***

"Some warning can be in amber"

***

"Agree with use of red background, I would reduce the text to the minimum"

The focus groups highlighted changes (discussed above) that would be required in the next iteration of the prototype BCG app, they are as follows:

1. Decision algorithms to be displayed in-line with the guideline information

This enables clinicians to access the tools efficiently with as few steps as possible. However, there are few studies that have investigated how clinicians behave when having to access tools implemented within systems. Often, research focusses on the tools themselves and not the interaction or process the clinicians need to follow to activate or access them. However, results from the observations conducted as part of this study (discussed in chapter 3) does highlight the frustration the inefficiencies of having systems that require multiple steps to access.

2. The original 'flowchart' decision algorithm is provided

Clinicians expressed the requirement to have a gestalt view of the process the decision algorithms follow. A recent study investigating 'Reasons For Physicians Not Adopting Clinical Decision Support Systems' highlights the requirement of 'black box' algorithms and decision support tools to be more transparent in terms of the processes they follow and the outputs they produce (Khairat et al., 2018b). Clinicians are more likely to accept a

system if it is in line with their own decision-making processes (Khairat et al., 2018b). Therefore, providing original information in line with tools will address this issue.

3. Acronym use is prevalent in medicine, but not all clinicians have knowledge of acronyms. Methods to address both experts and novices should be adopted

It is clear from the results of the focus group that acronym use is desires (and expected) in medicine. Therefore, methods to adopt their use should be considered. However, knowledge will be a key factor in determining if a clinician is aware of acronyms and therefore a method to address the use of both acronyms and full wording should be introduced.

4. Minimise the amount of warnings/alerts to avoid 'alert fatigue'

5. Warnings should be more explicit and adopt better salience for the user

Both recommendations in terms of warnings are similar in their requirement. Research highlights the importance of considering alert fatigue (Ancker et al., 2017; Embi and Leonard, 2012; Carspecken et al., 2013), one factor is the number of warnings/alerts contained in the information being delivered. Therefore, it is imperative the number of warnings/alerts be reduced. Clinicians also stated reduced text would be beneficial, as stated in section 4.4.1.

6. Guideline sentences should be reduced

It was suggested that shorter sentences and shorter text in warnings. This is also reflected in research by Brumley (Brumley et al., 2006), who suggests shorter more succinct

information allows for faster dissemination and increases personal confidence in an individual's medical ability.

7. Content Pages should utilise icons/images as well as headers

This was another element suggested during the focus group and may have a positive effect on usability. Gatsou et al, which identified that icons increase visual search ability or recognition rates (Gatsou et al., 2012), evidence that the icons should produce a more efficient content menu for the app.

4.5. Usability Evaluation of the 1st Prototype (shown in section 4.3) (System Usability Scale)

The System Usability Scale (SUS) (Brookes, 1996) was used to establish the usability level of the prototype application from the clinicians' viewpoint. It also provided a baseline to measure future changes in the design and how they impact the usability. The System Usability Scale (SUS) provides a "quick and dirty", reliable tool for measuring the usability. It consists of a 10-item questionnaire with five response options for respondents; from Strongly agree to Strongly disagree. The participant's scores for each question are converted to a new number, added together and then multiplied by 2.5 to convert the original scores of 0-40 to 0-100. An SUS score above a 68 would be considered above average and anything below 68 is below average. The questions are as follows:

1. I think that I would like to use this system frequently.
2. I found the system unnecessarily complex.
3. I thought the system was easy to use.

4. I think that I would need the support of a technical person to be able to use this system.
5. I found the various functions in this system were well integrated.
6. I thought there was too much inconsistency in this system.
7. I would imagine that most people would learn to use this system very quickly.
8. I found the system very cumbersome to use.
9. I felt very confident using the system.
10. I needed to learn a lot of things before I could get going with this system.

During the two focus group sessions, twenty-six (n=26) clinicians were asked to complete basic information retrieval scenarios, developed in collaboration with senior clinicians at the Royal Stoke University (example is shown in Figure 9) and then complete the SUS.

In the management flowchart of Hyperkalaemia, what is the recommended action where Plasma K+ 6.0-6.4 mmol/L and Acute ECG changes are present?

Figure 34 - Example information retrieval scenario used in testing

The app was shown to have a high usability score, with an overall score of 81 out of 100 (calculated utilising the methods described in (Brookes, 1996)). Question 5 'how integrated features of the system are' showed the widest gap between the ideal and current usability scores.

The results from both focus groups are presented in Table 6 and Table 7.

Table 6 - SUS Analysis from 11 participants of open focus group

Participant	q1	q2	q3	q4	q5	q6	q7	q8	q9	q10	SUS Score
p1	4	1	5	1	4	0	5	1	5	1	**97.5**
p2	5	2	4	1	4	1	5	5	5	1	**82.5**
p3	4	1	4	1	4	2	4	1	4	1	**85.0**
p4	5	2	4	1	5	1	5	1	5	1	**95.0**
p5	5	3	4	3	4	3	4	4	4	3	**62.5**
p6	3	3	3	1	3	3	4	3	3	2	**60.0**
p7	5	2	4	2	4	3	4	3	4	5	**65.0**
p8	5	2	5	1	4	1	5	3	5	1	**90.0**

p9	4	2	4	1	4	2	4	1	4	2	**80.0**
p10	5	1	5	1	4	1	5	3	5	1	**92.5**
p11	5	1	5	1	4	1	5	1	5	1	**97.5**

Table 7 - SUS Analysis from 11 participants of idea writing focus group

Participant	q1	q2	q3	q4	q5	q6	q7	q8	q9	q10	SUS Score
p1	5	4	4	1	4	2	5	2	4	1	**80.0**
p2	4	2	4	1	3	2	4	2	5	1	**80.0**
p3	5	1	5	2	4	2	4	4	5	3	**77.5**
p4	5	1	5	1	4	1	5	5	4	2	**82.5**
p5	5	1	4	3	4	3	4	3	4	2	**72.5**
p6	4	2	3	2	4	2	4	2	4	3	**70.0**
p7	4	1	4	1	3	2	5	1	5	1	**87.5**
p8	5	3	4	1	3	2	4	2	4	1	**77.5**
p9	4	2	4	2	3	2	4	2	4	2	**72.5**
p10	5	2	4	1	4	3	5	2	5	1	**85.0**
p11	4	1	4	1	4	1	5	1	4	1	**90.0**

Both groups produced scores that are considered to be ‘excellent’ (adjective rating) in terms of usability. For all SUS score, the mean is 89.06, standard deviation is 9.87, and the standard error of the mean was calculated as 1.26. A one sample t-test was used to compare the mean SUS score (89.06) with the standard SUS score of 68 (p-value < 0.05).

4.6. Conclusion

It was evident using mixed methods (focus group, idea writing and SUS), that different methods can produce differing results. The SUS score indicates an initial high level of usability; however, the focus groups identified several specific areas of improvement. Although there is a dichotomy between these results (i.e., high usability scores but feedback to suggest usability issues), it does not necessarily mean that the app is not usable. It is more likely that users are providing feedback for improvement but still find the app satisfying to use. Focus group participants described the app as “a much more efficient approach to presenting this information”, “clear and easy to navigate”, “easy to understand”, “clean” and “Familiar”.

Assessing the results of the user feedback culminated into the set of recommendations discussed above. These are provided below for clarity:

- Decision algorithms to be displayed in-line with the guideline information
- The original 'flowchart' decision algorithm to be provided
- Acronym use is prevalent in medicine, but not all clinicians have knowledge of acronyms. Methods to address both experts and novices should be adopted
- Minimise the amount of warnings/alerts to avoid 'alert fatigue'
- Warnings should be more explicit and adopt better salience for the user
- Guideline sentences should be reduced
- Content Pages should utilise icons/images as well as headers

These results show that individual guideline can be influenced in terms of design by user feedback. It also evidences the need to involve users in the design process and individual guidelines add another layer of complexity to designing such applications.

The next stage of the study will implement the feedback gathered during the focus groups to adjust the design of the BCG prototype application. Once the prototype is complete, usability testing using cognitive walkthroughs (via clinical scenarios) will be utilised to inform a set of design guidelines for delivering clinical information on mobile devices. This is discussed in the following chapter.

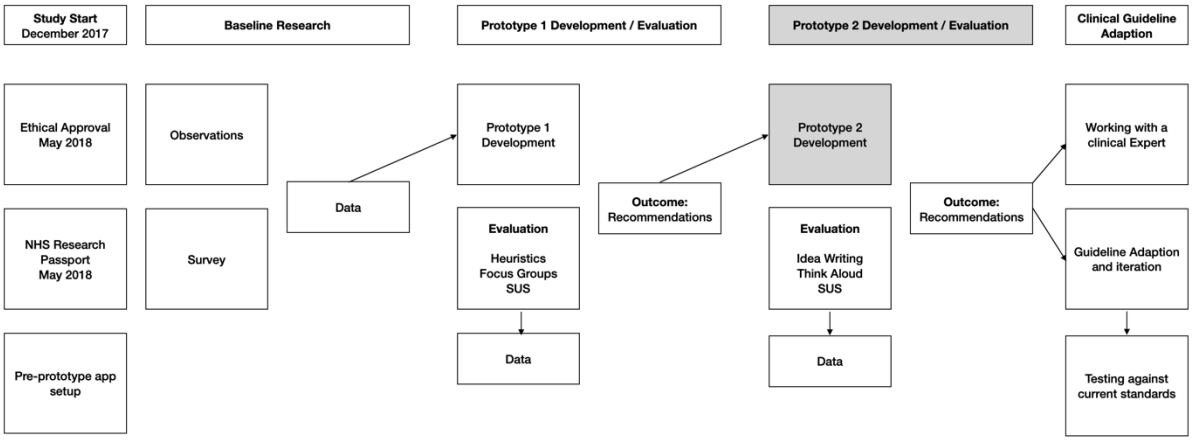
5. Adapting and implementing a prototype clinical guidelines mobile application based on user feedback (Developing the 2nd Prototype)

Aims

- *Utilise user feedback to adapt and implement a prototype clinical guidelines application*

Objectives*:*

- To implement and assess recommendations from the previous chapter
- To further develop a prototype BCG app



The placement of this Chapter within the PhD study is highlighted (Grey)

The research/results presented in this chapter were published in Proceedings of the 33rd International BCS Human Computer Interaction Conference 34. Mitchell, J., de Quincey, E., Pantin, C. and Mustfa, N., 2021, July. 15 Usability Heuristics for Delivering Clinical Guidelines on Mobile Devices.

5.1. Introduction

The research conducted in Chapter 4 produced a preliminary set of design recommendations (provided in the conclusion of Chapter 4) which were applied in the development of a 2nd prototype of BCG app (discussed in this chapter).

5.2. Aims

The aim of this study stage is to apply the recommendations discussed in Chapter 4. An assessment of how these recommendations can be implemented will be discussed in the following sections. This will culminate in the development of a 2nd prototype that can be used in further UCD assessments. This will allow for the evaluation of the recommendation implementation and their impact on clinical information retrieval and usability (discussed in Chapter 6).

5.3. Design Iterations

Each design iteration is discussed in the following sections, these adaptions have been informed by the recommendations in Chapter 4.

5.3.1. Guideline Menu

The main menu system was adapted to include icons for each sub section header. Icon and interface related studies have shown that icon-label interfaces had increased perceived usefulness (Wiedenbeck, 1999). Suggestions during the initial focus group and studies such as that by Gatsou et al, which identified that icons increase visual search ability or recognition rates (Gatsou et al., 2012), evidence that the icons should produce a more efficient content menu for the app.

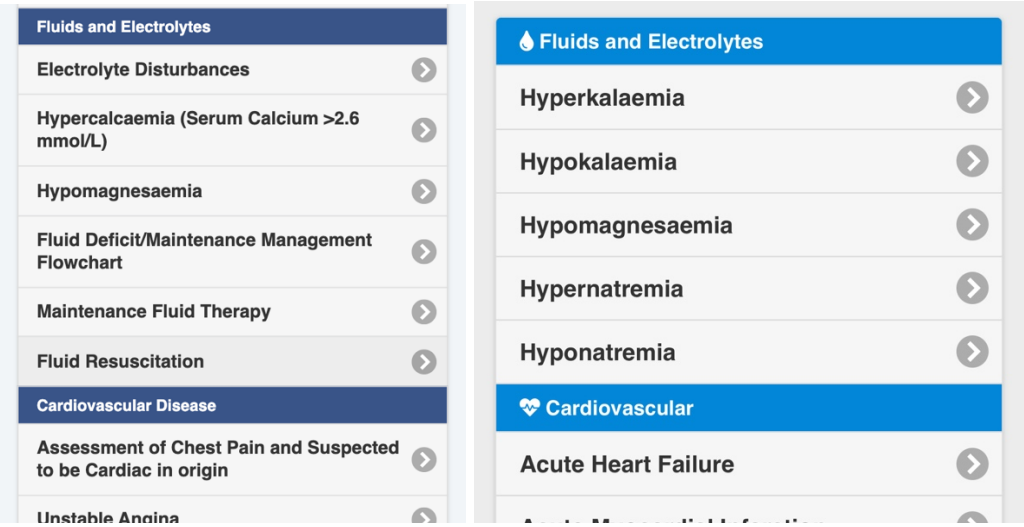


Figure 35 – Changes to the Content/Menu page headers with icons (original left, adapted right)

Figure 35 shows an example of the app content/menu page and how the icons have been implemented to assist in visual searchability, as suggested by previous research and the focus group feedback. A lighter blue colour was also introduced to allow for a higher contrast between the black text sections and main section headers.

5.3.2. Main layout

Each guideline layout was adapted to ensure it was visually apparent when a section ends and starts. The lighter blue colour used in the menu, mentioned in section 5.4.1, was also utilised for the sub-section headers. Each section header was also re-designed to ensure a more visually apparent section header.

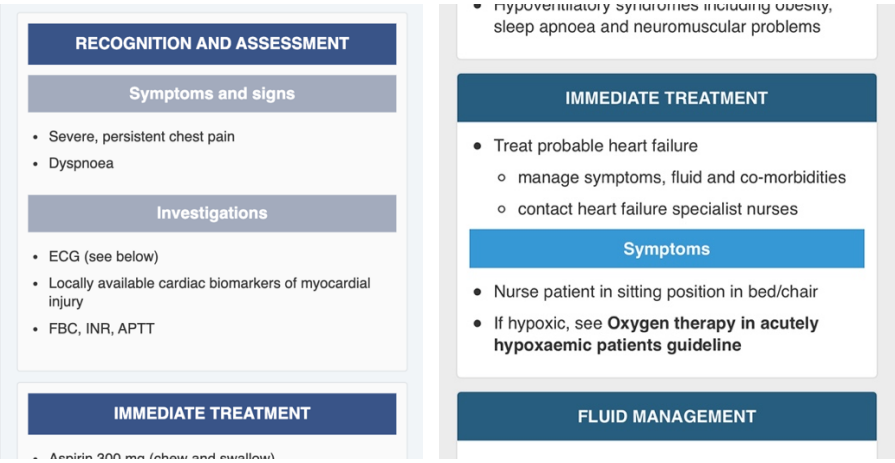


Figure 36 - Section headers, sub-headers and endings (original left, adapted right)

Figure 36 is an example taken from the Heart Failure guideline. The section header utilises a bold, capitalised text and sub-headers utilise a standard cased, bold font. This introduces a visual hierarchy for users, re-enforced by the full-width headers in contrast to the sub-headers which have a margin at each side. This is also achieved by capitalising the main headers, as larger items draw more attention than smaller items (Djamasbi, Siegel and Tullis, 2011).

5.3.3. Text including Headers and Sub-headers

It was evident through feedback from the Focus Groups, as mentioned in the conclusion to Chapter 4, that the guideline length would need to be reduced. Research agrees with this feedback, as it helps to avoid unnecessary scrolling and prevents potential impact on clinical workflow, especially in regard to memorability and usability (Harms et al., 2015). Design patterns such as accordions (Tidwell, 2010) were utilised to support this (Figure

37) which greatly reduced the length of some guidelines. An accordion is a vertically stacked list of headers that can be clicked to reveal or hide content associated with them. It allows the user to progressively reveal content. Accordions need to be implemented with consideration to the impact on user information behaviour. Longer pages can benefit users. Accordions shorten pages and reduce scrolling, but they increase the interaction cost by requiring people to decide on topic headings (Lorenger, 2014).

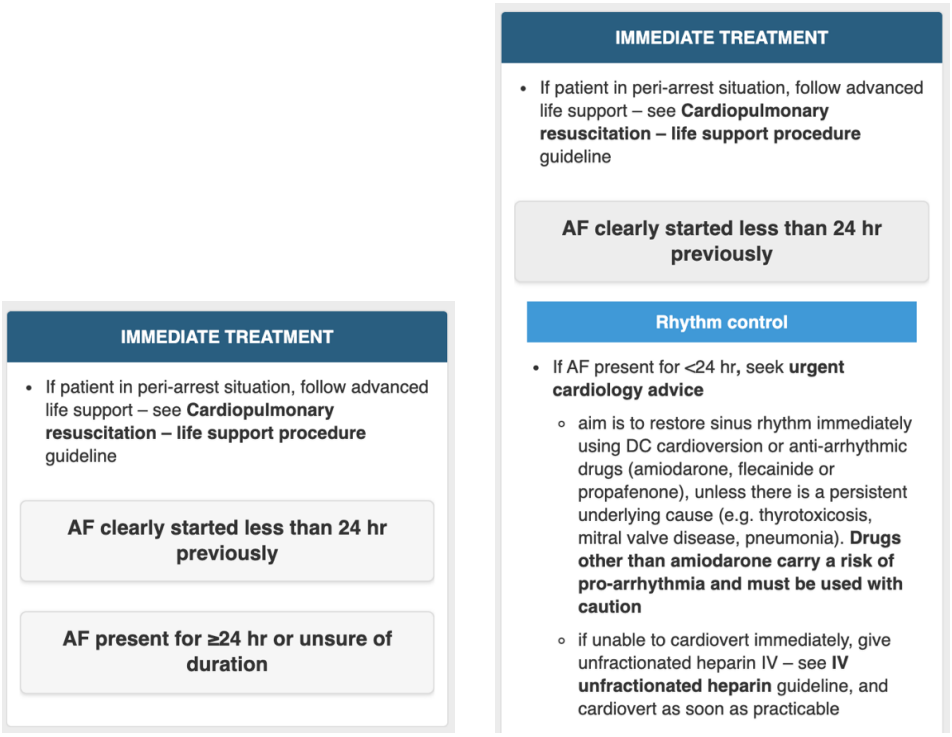


Figure 37 -Accordion implementation. Left image shows the closed format of the BCG accordion, Right image shows how the accordion displays the contained information.

5.3.4. Tables

The BCGs contain tables for easy presentation in the book format, however these can be problematic on mobile devices due to constraints inherent in their design and size (Monkman, Griffith and Kushniruk, 2015). It was clear that tables would continue to cause usability issues if they were presented in the app. One clinician noted during the 'idea writing session' discussed in chapter 4 that "I agree with the simple design and easy to read. However, the large tables do not fit the screen and attempting to view it sideways makes it

difficult". Tables, therefore, were either amalgamated into the main text of the guidelines or converted to a tool such as a calculator where possible. This reduced the necessity by presenting the same information linearly. In some cases (when a table was more efficient, fit within the constraints, or relevant) the table was retained. Later chapters (Chapter 6) will discuss the impact this method has had on reducing the length of the guidelines and the number of tables presented.

Figure 38 shows a guideline table converted to a diagnostic tool. This table, from the infective endocarditis guidelines, provides clinicians with the Infective Endocarditis diagnosis method 'Duke's classification'. The table requires clinicians to manually complete calculations. The BCG app version calculates the outcome and provides clinicians with clear and precise recommendations.

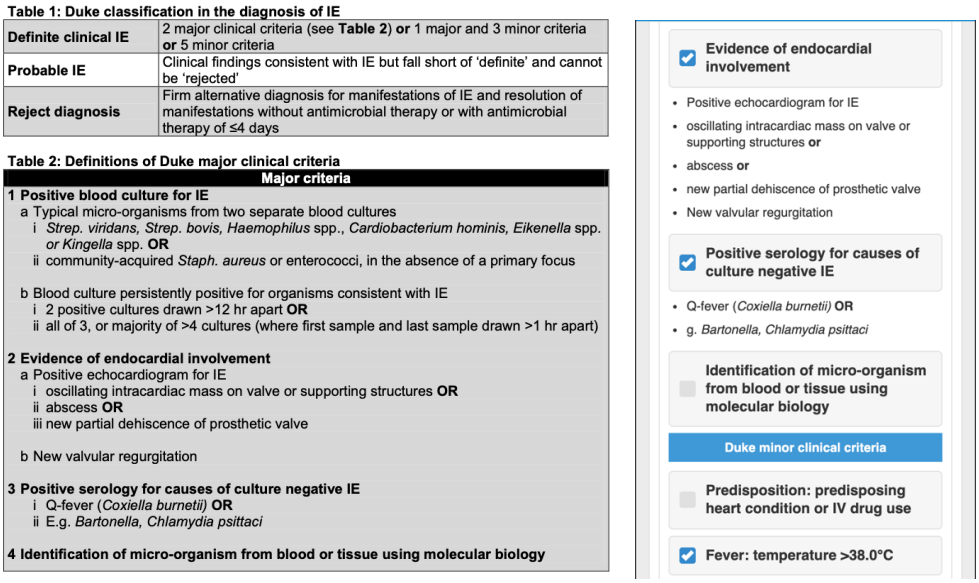


Table 1: Duke classification in the diagnosis of IE

Definite clinical IE	2 major clinical criteria (see **Table 2**) **or** 1 major and 3 minor criteria **or** 5 minor criteria
Probable IE	Clinical findings consistent with IE but fall short of 'definite' and cannot be 'rejected'
Reject diagnosis	Firm alternative diagnosis for manifestations of IE and resolution of manifestations without antimicrobial therapy or with antimicrobial therapy of ≤4 days

Table 2: Definitions of Duke major clinical criteria

Major criteria

1 Positive blood culture for IE
a Typical micro-organisms from two separate blood cultures
i *Strep. viridans, Strep. bovis, Haemophilus* spp., *Cardiobacterium hominis, Eikenella* spp. *or Kingella* spp. **OR**
ii community-acquired *Staph. aureus* or enterococci, in the absence of a primary focus

b Blood culture persistently positive for organisms consistent with IE
i 2 positive cultures drawn >12 hr apart **OR**
ii all of 3, or majority of >4 cultures (where first sample and last sample drawn >1 hr apart)

2 Evidence of endocardial involvement
a Positive echocardiogram for IE
i oscillating intracardiac mass on valve or supporting structures **OR**
ii abscess **OR**
iii new partial dehiscence of prosthetic valve

b New valvular regurgitation

3 Positive serology for causes of culture negative IE
i Q-fever (*Coxiella burnetii*) **OR**
ii E.g. *Bartonella, Chlamydia psittaci*

4 Identification of micro-organism from blood or tissue using molecular biology

Figure 38 - The original table format of the BCG classification tool (Dukes Classification for Infective Endocarditis) (LEFT), the right image shows the BCG App version which allows users to select criteria and display a single recommendation.

This method utilises *HTML*, *CSS* and *JavaScript* to present the same data from the table, but the calculation completed manually by the clinicians is automated, with a result presented (Figure 40).

Dukes Classification Test( ) Function (PSEUDO CODE)

var **countCheckedCheckboxesMajor** = countCheckboxes class Major
var **countCheckedCheckboxesMinor** = countCheckboxes class Minor

IF Major >2 **or** 1 Major **+** 3 Minor **or** 5 Minor
Output = **Definite Infective Endocarditis**

IF Major >= 1 **and** >=1 Minor **or** >=3 Minor
Output = **Possible Infective Endocarditis**

```
 function Test() {
                          var countCheckedCheckboxesMajor = $checkboxesMajor.filter(':checked').length;
                          //$('#count-checked-checkboxes-Major').text(countCheckedCheckboxesMajor);
//For Testing
                          var countCheckedCheckboxesMinor = $checkboxesMinor.filter(':checked').length;
                          //$('#count-checked-checkboxes-Minor').text(countCheckedCheckboxesMinor);
//For Testing

                         //Major Greater than 2 or 1 Major 3 Minor or 5 Minor
                         if(countCheckedCheckboxesMajor >= 2 || (countCheckedCheckboxesMajor == 1 &&
countCheckedCheckboxesMinor >= 3) || countCheckedCheckboxesMinor >= 5) {

                             //Display Content
                             resultsOutput.innerHTML = "<div class='card flowchartCard'><div
class='card-header flowchart'><strong><h2>RESULTS:</h2></strong></div><div class='card-body'><ul>
<li>Definite clinical IE</li><li>Start treatment</li></ul></div></div>";

                             //Restart Button
                             restartButton.style.visibility = "visible";
                             restartButton.onclick = function () {restart()};
                             restartButton.style.height = "";
                             restartButton.style.padding = "";
                             restartButton.style.margin = "";
                         }

                         //Major Greater = 1 and 1 Major or 3 Minor
                         if(countCheckedCheckboxesMajor == 1 && countCheckedCheckboxesMinor == 1 ||
countCheckedCheckboxesMinor >= 3) {

                             //Display Content
                             resultsOutput.innerHTML = "<div class='card flowchartCard'><div
class='card-header flowchart'><strong><h2>RESULTS:</h2></strong></div><div class='card-body'><ul>
<li>Possible IE</li><li>Consider treatment and look for confirmatory evidence</li></ul></div></div>";

                             //Restart Button
                             restartButton.style.visibility = "visible";
                             restartButton.onclick = function () {restart()};
                             restart
```

Figure 39 - Duke's Classification Pseudo code and JavaScript algorithm utilising checkbox counting to determine classification factor for diagnosis calculation

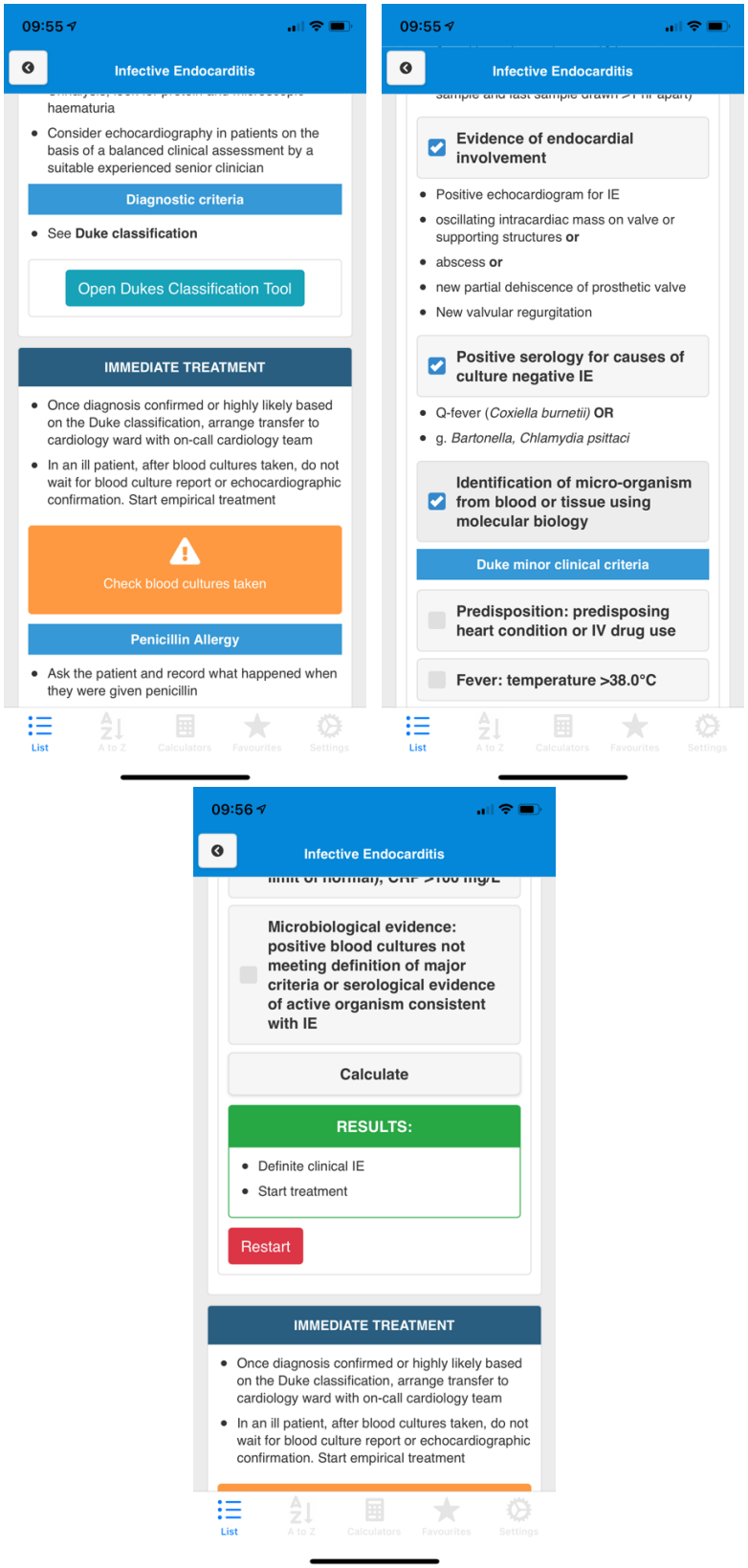


Figure 40 - Duke's Classification process from opening to selecting criteria and results output

The 'Duke's Classification' tool implements a count method (*.filter and ':checked'*) for each checkbox in both major and minor Duke's categories. The results are then output as

an inner *HTML* method (.innerHTML) in *JavaScript* to present the calculation to the user. The calculation results output is shown, as mentioned, in Figure 40.

5.3.5. Decision algorithms

Feedback during the initial focus groups suggested clinicians wanted to be able to use the decision algorithms in line with the information presented in each guideline. The feedback regarding the presentation method was positive (as mentioned in 4.4.1) and clinicians suggested providing both the Q&A version alongside the original 'flowchart' presentation of the decision algorithm. Clinicians are taught how to use knowledge to make a decision, a 'gestalt' view of the information allows the clinician to be confident in making an informed decision. A 'black box' style of presentation can lead to clinicians questioning the outputs of such systems, as research has suggested (Rudin, 2019; Hart and Wyatt, 2009). The 'black box' method can also lead to clinicians being less trusting of the information provided (Diprose et al., 2020).

The inline presentation style was utilised in the conversion of tables (see 5.4.4) and offers users the main guideline information, with the decision support tool and results output. In terms of the decision algorithms, such as those presented in 4.3.1.3.5, a similar method was implemented. Figure 41 and Figure 42 highlight how the tool is presented in the BCG app. This method, as with the table conversion method, utilises *HTML*, *CSS* and *JavaScript*. Figure 43 is an example of how the *JavaScript* was implemented for the Spontaneous Pneumothorax guideline using functions for each calculation route. In some cases, such as the example in Figure 26, the algorithm is simple as it only has a few possible outcomes. In contrast, the example in Figure 27 requires a more complex implementation due to its layers and potential pathways. In both examples, the method of presenting the pathway the user has followed and the presentation of results remain the same.

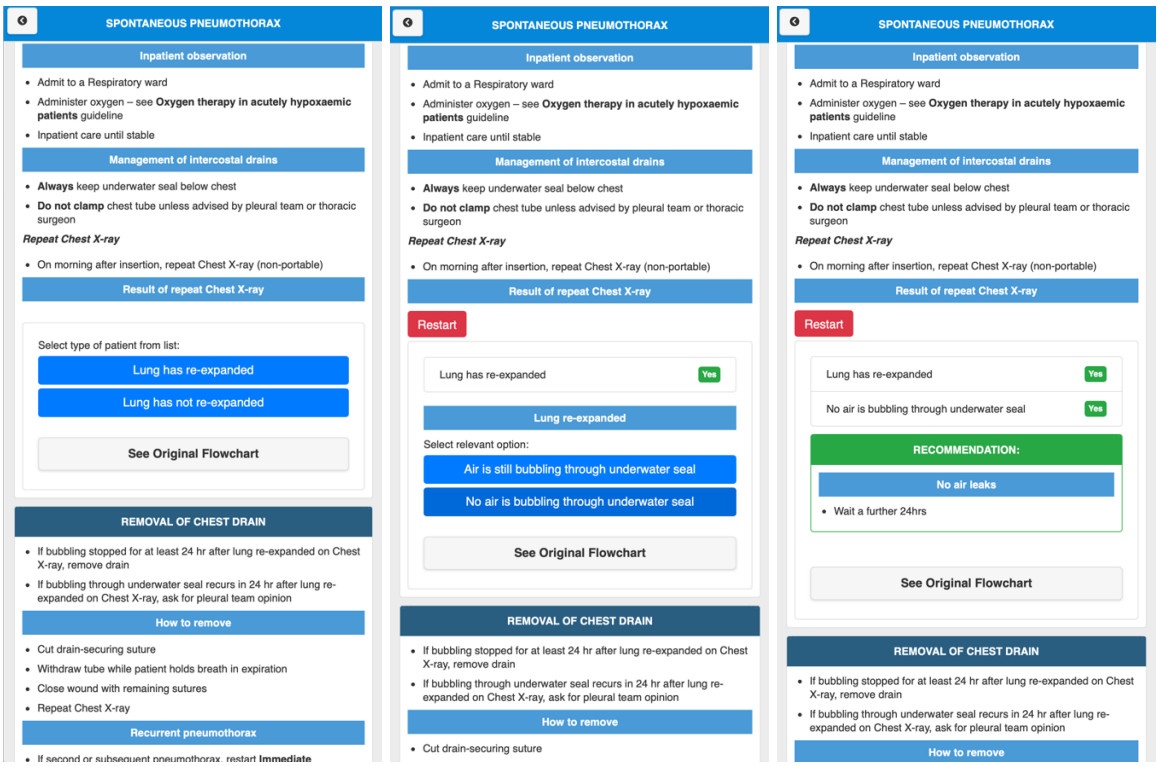


Figure 41 – Example of the inline decision algorithm

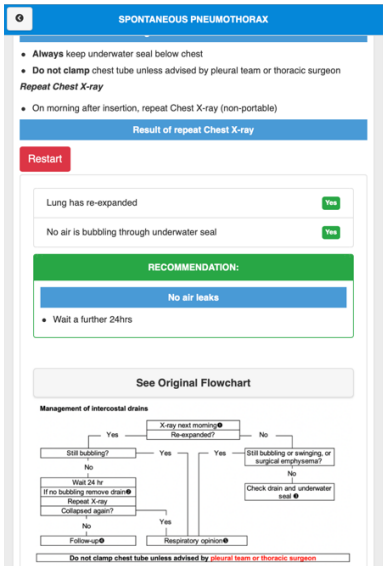


Figure 42 - Example of a 'flowchart' presented inline with the decision algorithm, users can zoom into the flowchart

```
        ansArray = []; //Always resets answers

        labelAnswers.style.visibility = "hidden";
        labelAnswers.style.height = "0px";

        labelQuestion.innerHTML = "Select type of patient from list:";

        button1.innerHTML = "Aged &gt;50 yr and smoking history <strong>OR</strong> Evidence of chronic
lung disease in history, examination or chest X-ray";
        button2.innerHTML = "Neither of the above";

        button1.style.visibility="visible";
        button2.style.visibility="visible";
        button3.style.visibility="hidden";
        button4.style.visibility="hidden";
        button1.style.height = "";
        button1.style.padding = "";
        button1.style.margin = "";
        button2.style.height = "";
        button2.style.padding = "";
        button2.style.margin = "";
        button3.style.height = "0px";
        button3.style.padding = "0px";
        button3.style.margin = "0px";
        button4.style.height = "0px";
        button4.style.padding = "0px";
        button4.style.margin = "0px";

        button1.onclick = function () {one()};
        button2.onclick = function () {two()};
        button3.onclick = function () {three()};

        restartButton.style.visibility = "hidden";
        restartButton.style.height = "0px";
        restartButton.style.padding = "0px";
        restartButton.style.margin = "0px";

        button1.onclick = function () {ansArray.push('<li class="list-group-item d-flex justify-
content-between align-items-center"><p>Aged &gt;50 yr and smoking history OR Evidence of chronic lung
disease in history, examination or chest X-ray</p><span class="badge badge-success">Yes</span></li>');
A();};
        button2.onclick = function () {ansArray.push('<li class="list-group-item d-flex justify-
content-between align-items-center"><p>Aged &gt;50 yr and smoking history or Evidence of chronic lung
disease in history, examination or chest X-ray</p><span class="badge badge-danger">No</span></li>');
B();};
```

Figure 43 - JavaScript snippet for the decision algorithm to highlight implementation at time of writing

The JavaScript shown in Figure 43 utilises an array which the onclick function push data to. The answer history section of the tool (shown in Figure 29 as ‘questions with answers’ and in Figure 41, Figure 42) uses this array to output the question flow the clinician has followed. As mentioned, this method allows the clinician to see their flow, therefore, providing the clinician with a method of checking previous answers and an information history.

5.3.6. Acronyms

During the focus groups, it was highlighted that the use of acronyms is prevalent during clinical practice. Searching using acronyms, such as AF for Atrial Fibrillation, is common practice. Clinicians also have an expectation that acronyms will be used in text. This was highlighted in a systematic review of clinical guidelines in a Norwegian study (Khodambashi and Nytrø, 2016) . The study found that "As clinicians' time constraints and information overload are two factors in GLs adoption, evaluation of the search function and its retrieval performance in efficiently identifying relevant GLs is needed (i.e. a trained search function for clinical terms, especially for synonyms, acronyms, and abbreviations)" (Khodambashi and Nytrø, 2016). It was interesting to find similarities during this study. Other studies have found that acronyms are not understood by some clinical staff (Duncan et al., 2012; Rees, 2013). Although it is clear that a method of utilising acronyms for search/filter functions, it is beyond the scope of this study.

A prototype method was created within a single guideline to demonstrate the potential of the BCG app and to support studies which suggest that methods to present acronyms have the potential to reduce errors due to misunderstandings (Duncan et al., 2012; Rees, 2013). In this case, it was identified that there is a dichotomy between the use of acronyms with student/junior clinicians and senior/experienced clinicians. In terms of usability, there is also a dichotomy between usability guidelines and the expectations of a system used by experts (clinicians in this case). Therefore, an option that considers both would need to be considered.

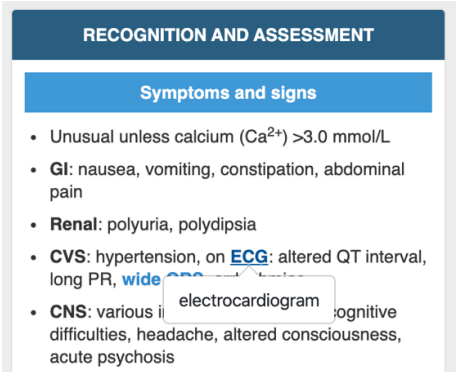


Figure 44 - The acronym hover effect prototype

Figure 44 is an example of how non-invasive methods can be implemented (a hover effect as an example) to enable users to establish the acronym meaning. This supports both types of clinicians (junior/senior) and also maintains the succinct presentation of the guidelines. This method was demonstrated during cognitive walkthrough sessions, discussed later in this chapter, and received positive feedback. However, further study is required to ensure this method is an optimal solution to support both clinical practice and clinical education. The is the possibility that highlighting in the way could cause usability issues (changes in colour of text). There is also the possibility that for learnability it is best to reduce the amount of 'hidden' information. There could also be other options available for implementing this type of learning that have yet to be researched i.e., require a full literature review.

5.3.7. Warnings

The BCG Medical guidelines contain over three-hundred warnings in a black box design, as mentioned in chapters two and three. It was initially attempted to categorise the warnings and develop a layered hierarchy related to severity and clinical impact. However, it was evident when consulting with a clinical expert (discussed further in Chapter 7) that the warnings would require a more complex hierarchy that considers the level of severity, as well as the type e.g. information based or critical, and the likelihood of occurrence. It became clear during piloting (utilising methods such as card sorting and interviews) that

due to the heterogeneity and scale of these warnings, it would be difficult to complete within the scope of the study. This will be discussed further in Chapter 7. In short, warnings require multiple levels of measurement and categorisation and therefore a simple hierarchy was implemented (figure 45) to ensure warnings had clear definition. These were determined by the clinical expert.

Studies utilising focus groups involving expert clinicians and authors discussed the design of a simple method of displaying and reducing the number of warnings to avoid alert fatigue (Embi and Leonard, 2012; Carspecken et al., 2013; Ancker et al., 2017).

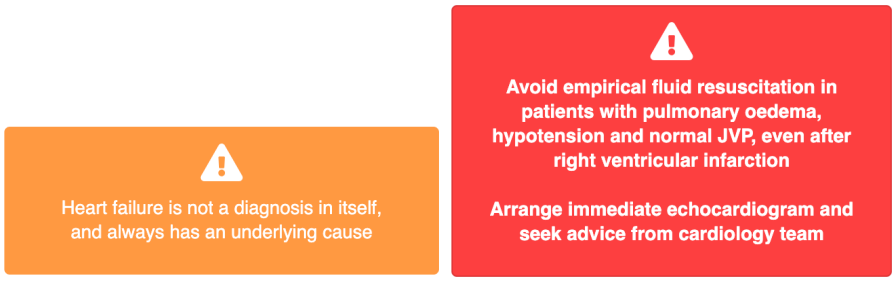


Figure 45 - Amber (left) and Red (right) warning designs

Figure 45 shows the iterated clinical warning designs. The use of colour and icons improves the impact of the warnings (Wogalter, Conzola and Smith-Jackson, 2002), as well as salience in terms of colour blindness. The colours utilised also add a hierarchy which will help clinicians identify the severity and importance of the information. Another example of this warning design, presented inline with the guideline text, can be seen in Figure 40.

5.3.8. Cross referencing guidelines and external links

The BCGs reference a number of internal and external links. In Chapter 3, one requirement was to 'Minimise the requirement to use other systems'. To ensure this requirement is met, cross reference and external links need to be active within the BCG app.

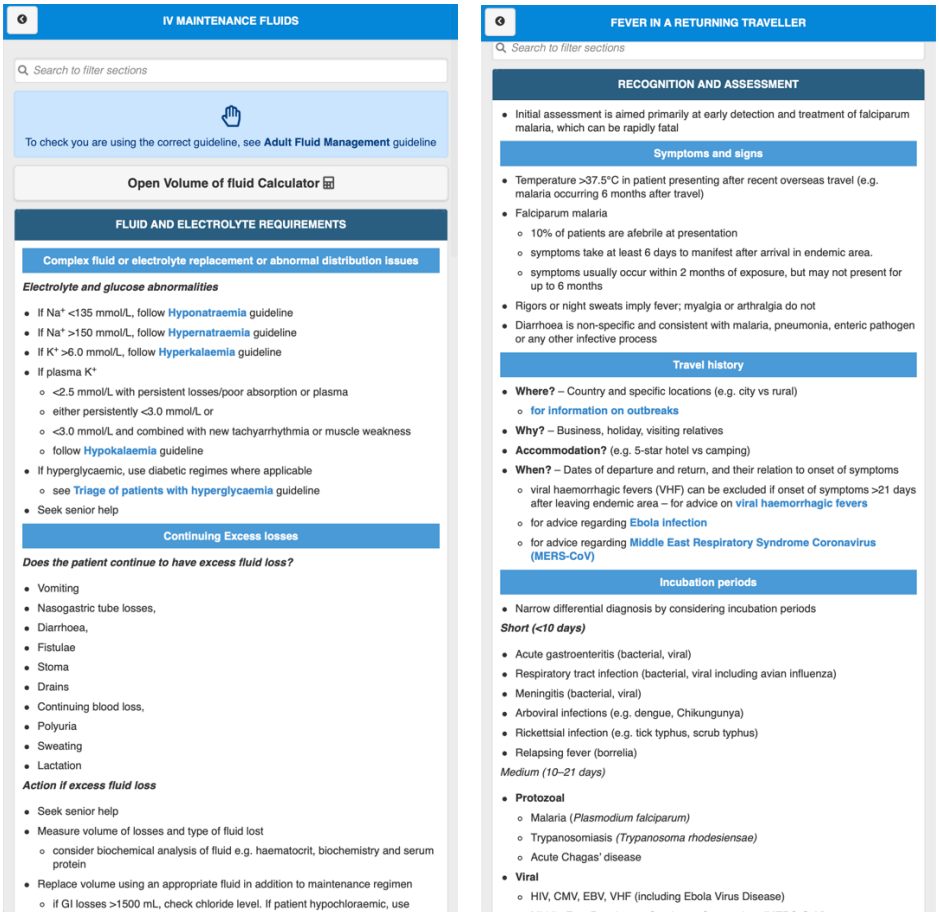


Figure 46 - Examples of inline links between guidelines (left) and external links (right).

In Figure 46 there are two examples of how cross referencing and external links are presented to clinicians. The example on the left, taken from the IV maintenance fluids guideline, shows how the internal links between guidelines offer inline, in context links to other guidelines. Once activated, the clinician is taken to the respective guidelines and can easily navigate back using the back button (top left) or by utilising native touch gestures. The same is possible when clinicians interact with external links.

5.3.9. Calculation tools

As with decision algorithms and table conversions, discussed in sections 5.4.4 and 5.4.5 respectively, presenting aspects of the clinical guidelines such as formulas requires development which provides clinicians with a more efficient method in comparison to text. Clinicians already access calculation tools which could be considered automated, e.g.

MDCalc. The use of such tools was evident in the survey results (presented in section 3.2.3.5) by the number of clinicians utilising calculation apps.

To address the need for efficient delivery, each calculation formula would need to be developed independently and presented inline. Some are presented as nomograms (figure 47), others are presented as formulas (figure 48) or charts (figure 49). There are many examples of these types of tools throughout the BCGs, the following will discuss select examples of how they have been developed for delivery on mobile devices.

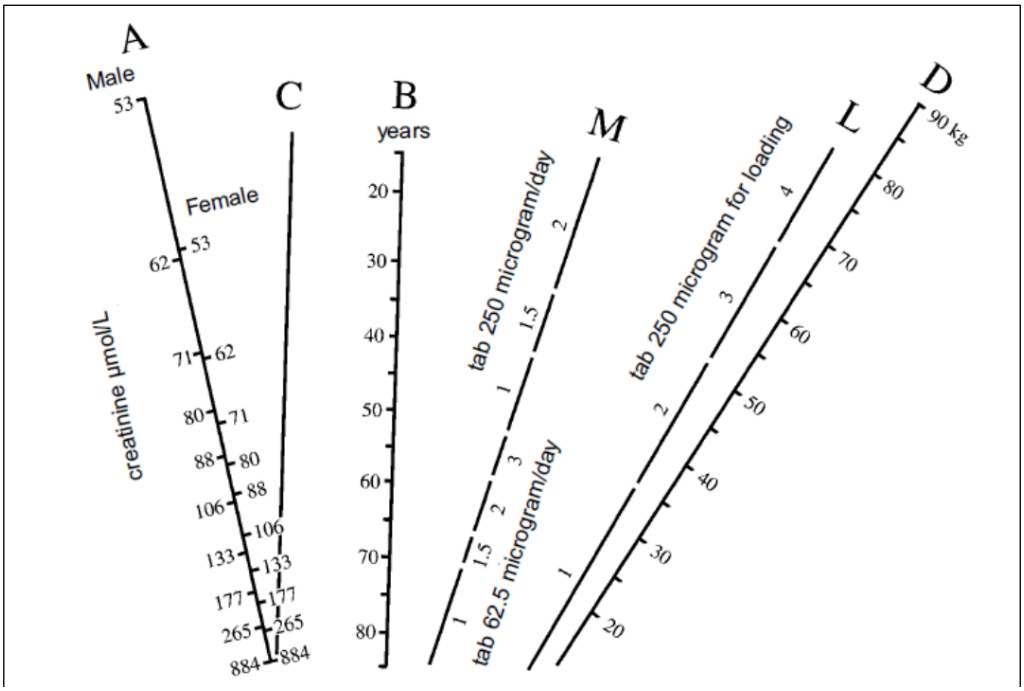


Figure 47 - Nomogram for calculating loading dose for Digoxin

- **If patient's creatinine <60 µmol/L use 60 µmol/L as a minimum value to avoid falsely producing high creatinine clearance**
- **Females:**

  $$\text{CrCl} = \frac{1.04 \times (140 - \text{age}) \times \text{weight*}\ (\text{kg})}{\text{Serum creatinine}\ (\mu\text{mol/L})}$$
- **Males**:

  $$\text{CrCl} = \frac{1.23 \times (140 - \text{age}) \times \text{weight*}\ (\text{kg})}{\text{Serum creatinine}\ (\mu\text{mol/L})}$$

*weight – use **ideal body weight (IBW) UNLESS** patient appears underweight – see **Ideal body weight** guideline

Figure 48 - Formula presented to clinicians in the Gentamicin guideline

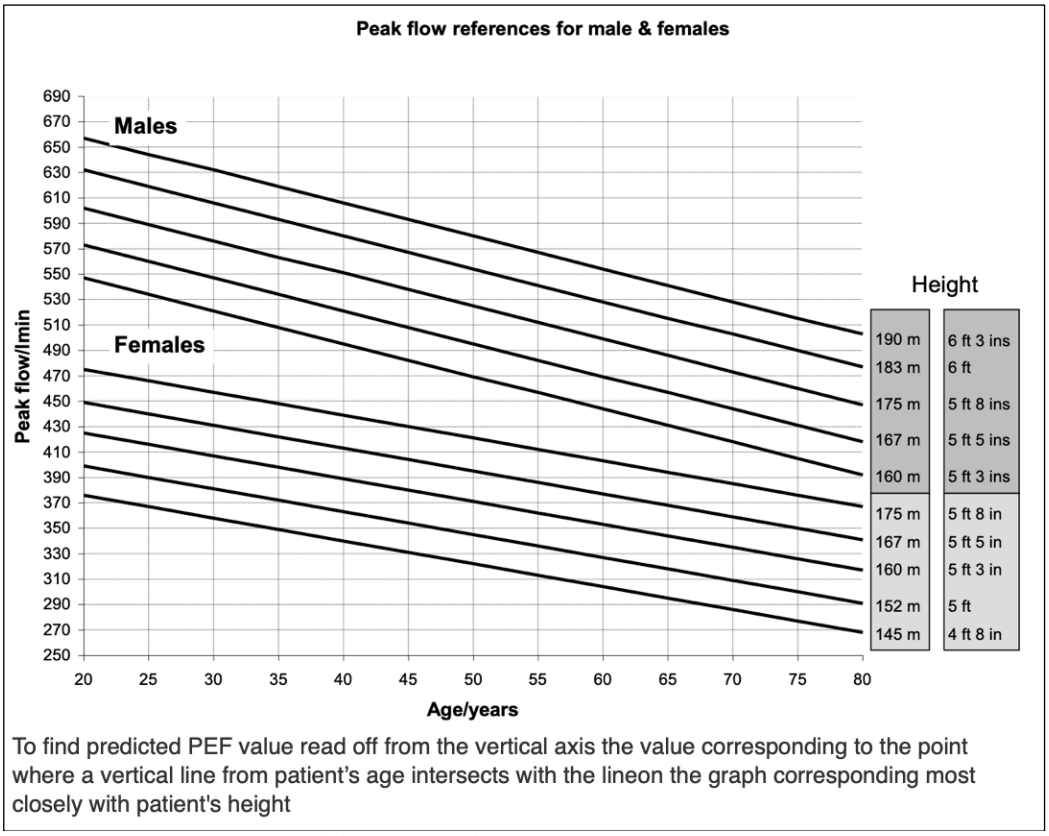


Figure 49 - Adult peak flow (PEF) reference chart presenting in the Asthma guideline

Figure 48 is an example of how clinicians are presented with a chart to calculate information required for patient treatment. In book (or PDF) format this presentation style offers clinicians a quick method of calculation, but as with many aspects of the BCGs previously discussed, it becomes problematic when attempting to present the information on mobile devices. To present the same information in an efficient manner, a calculation tool was developed. The following discusses two aspects of the development. The first is how the calculation tool is presented to clinicians in the BCG application. The second is the development methodology of how the calculation tool functions.

All calculation tools are accessible within their respective guideline. In the case of the example shown in Figure 49, the content page highlights that a calculation tool is present within the guideline. Figure 50 shows how the Asthma guideline and calculation tool icon are shown in the BCG content page. This method allows clinicians to visually identify a calculation tool is available in respect to a specific guideline. This is highlighted in a study

by (Gatsou et al., 2012) which found that icons increase recognition rates, as mentioned in section 5.4.1.

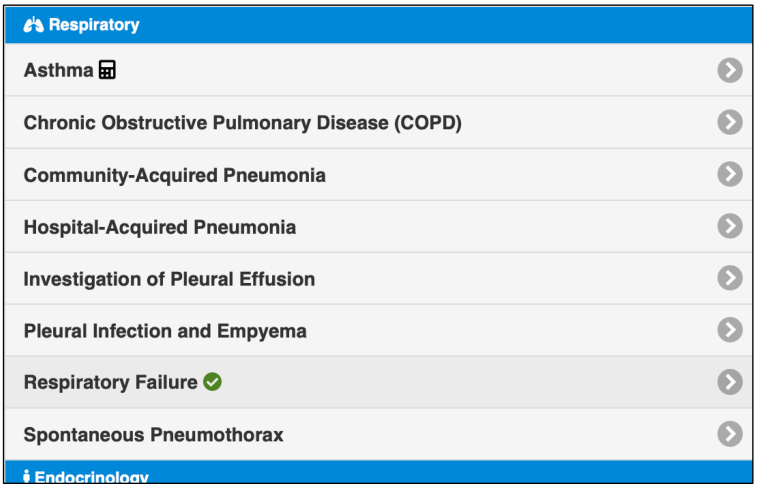


Figure 50 - Extract from the BCG app content page (respiratory)

Once the guideline is accessed, clinicians are presented with numerous ways to access to the calculation tool. In the Asthma guidelines, clinicians are presented with two options for activating the Peak Expiratory Flow (PEF) tool.

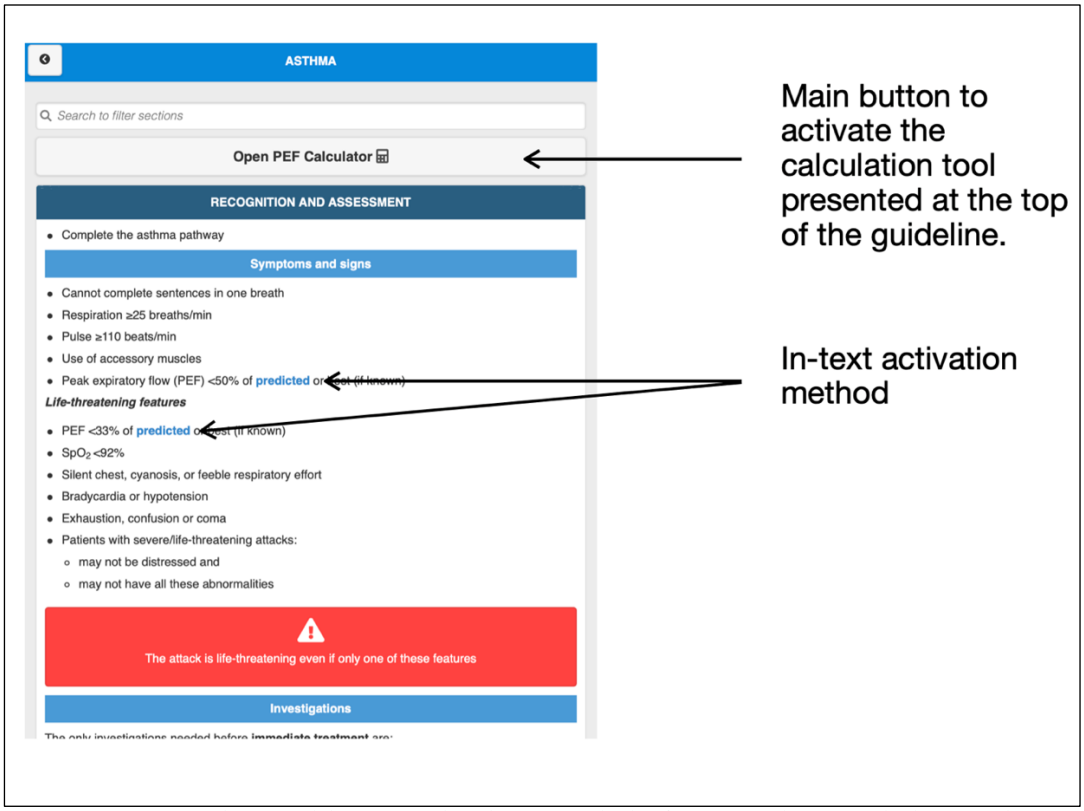


Figure 51 - Asthma Guideline screenshot showing methods of accessing the PEF calculation tool

Figure 51 shows a screenshot of the Asthma guideline. As highlighted, the two methods for activating the PEF tool are presented within the guideline. The first method is presented at the top of the guideline to provide clinicians needing to access the tool a method not contained within the guideline text. The second method provides an in-text activation method when PEF is mentioned. This allows clinicians to activate the tool in the context of the information being delivered. This is important in delivering an efficient guideline as it enables users to access tools in the context of what they are reading, rather than requiring the user to interact further by scrolling to or accessing another section of the BCG app, therefore taking less time. Once the PEF calculation tool is activated, the user is presented with a drop down (see figure 52).

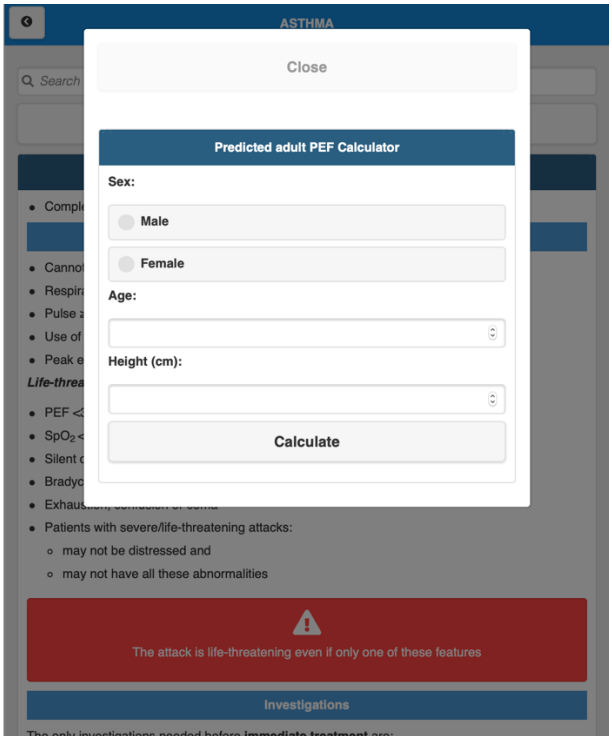


Figure 52 - PEF Calculation tool drop down

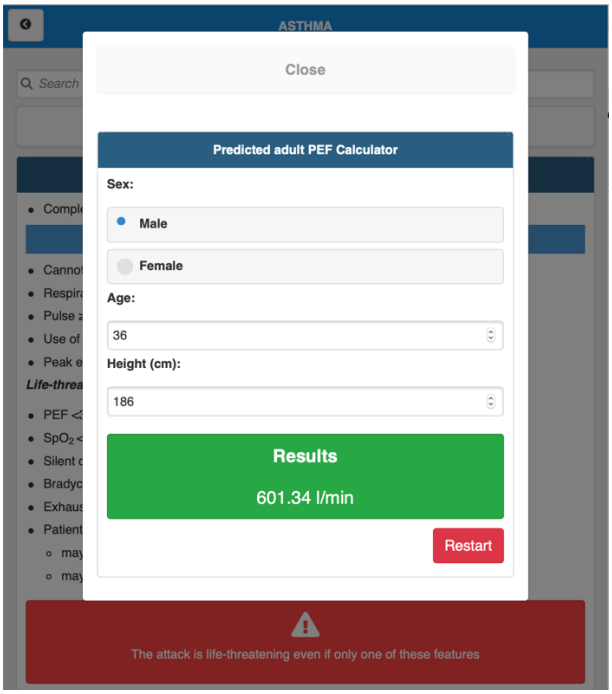


Figure 53 - Results output screenshot from the PEF calculation tool (Asthma)

In this case, the drop down asks the user for the sex of the patient, their age and their height. The tool then provides a calculated output based on the data the clinician has input. Figure 53 shows an example results output. The next part of this section will discuss how the result is produced.

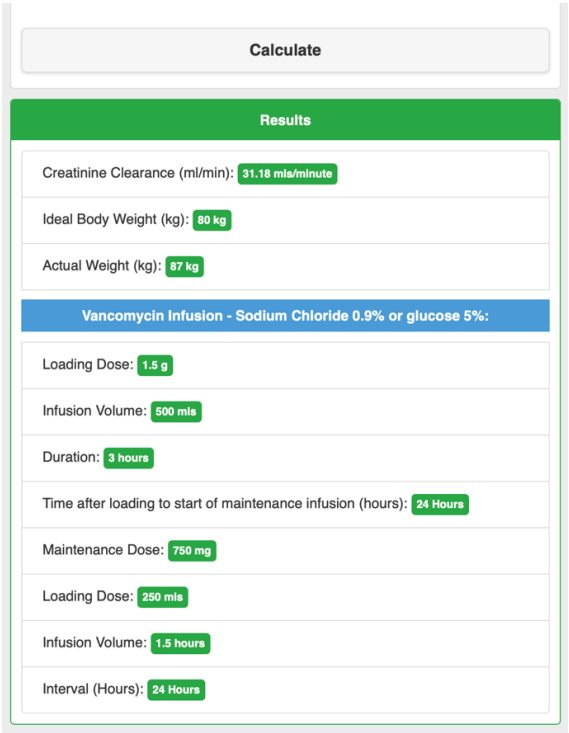


Figure 54 - Vancomycin calculation output

Figure 54 is another example of the results output, in this example users are presenting with a range of results required for Vancomycin drug delivery.

Each calculation tool contained within the BCG app utilises HTML, CSS and JavaScript. The tool created for the PEF calculation in the Asthma guideline has three fields: Sex of the patient; Age of the patient; and height of the patient (cm). These are required to measure peak expiratory flow of patients.

$$male = \{[(Height, m \times 5.48) + 1.58] - [Age \times 0.041]\} \times 60$$
$$female = \{[(Height, m \times 3.72) + 2.24] - [Age \times 0.03]\} \times 60$$

--

Equation 1: PEF Calculation

The formulas above were provided by the pharmaceutical department of the Royal Stoke University Hospital (UHNM), copied directly from the BCG medical guidelines (non-standard syntax). These are evidenced from both the NICE guidelines (NICE, 2020) and through evidence collected by the BCG clinical librarian. All of the calculation tools developed for the BCG App utilise a similar process, where evidence is provided from both national clinical guidance and academic sources.

```
        if(male.checked) {
            //window.alert("MALE"); //For testing
            //Calculation
            console.log(age.value);
            console.log(height.value);
            var agem = parseInt(age.value);
            var heightm = parseInt(height.value);
            var calculation = (((0.0614*heightm)-(0.043*agem)+0.15)*60);

            resultsOutput.innerHTML = "<div class='card calcResults'><div class='card-header
calcResults'><h2>Results</h2></div><div class='card-body calcResults'>" + calculation.toFixed(2) + "
l/min</div></div>";
        }
```

Figure 55 - JavaScript implementation of the PEF formula

Figure 54 shows how the formulas have been implemented in JavaScript within the BCG app. Appendix 4 shows the full version of the JavaScript created to calculate the PEF for clinicians. The tool initially validates the information input by the clinician, this is critical

to prevent any errors in output as these can pose a risk to patient care and clinical user confidence.

```
// form validation stage


    if(parseInt(age.value) < 16 || parseInt(age.value) > 100) {
        alert("Stop! Age must be greater than 16 or less than 100 years")
    }

    else if(parseInt(height.value) < 100 || parseInt(height.value) > 210) {
        alert("Stop! Height must be greater than 100cm or less than 210cm")
    }

    else {
        calculate();
    }
```

Figure 56 - Validation JavaScript for the PEF Calculation Tool

The validation method checks that the age and height ranges are within parameters set by the pharmaceutical department of the Royal Stoke University Hospital. If the data input by the clinician is outside of these ranges, they are presented with a modal message asking them to validate their input (see figures 56 and 57). A modal message is critical at this stage as it prevents the clinician with a modal message which requires them to stop and interact with the tool. This is necessary for both usability, in terms of Nielsen and Molich's heuristics and system status (Nielsen and Molich, 1990), as well as informing the user of the error for safety purposes.

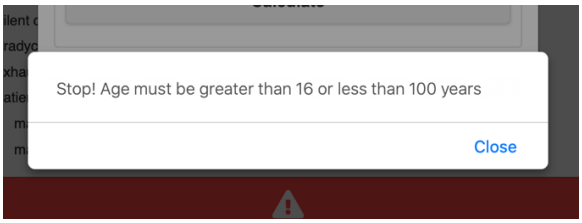


Figure 57 - Validation message presenting to clinicians in the event data is input outside of parameters

Other calculation tools have been developed for the app, but for the purpose of succinctness, they have not been discussed as they utilise similar methods of development and presentation. Each of these tools require clinical verification and testing, which is briefly discussed in chapter 6.

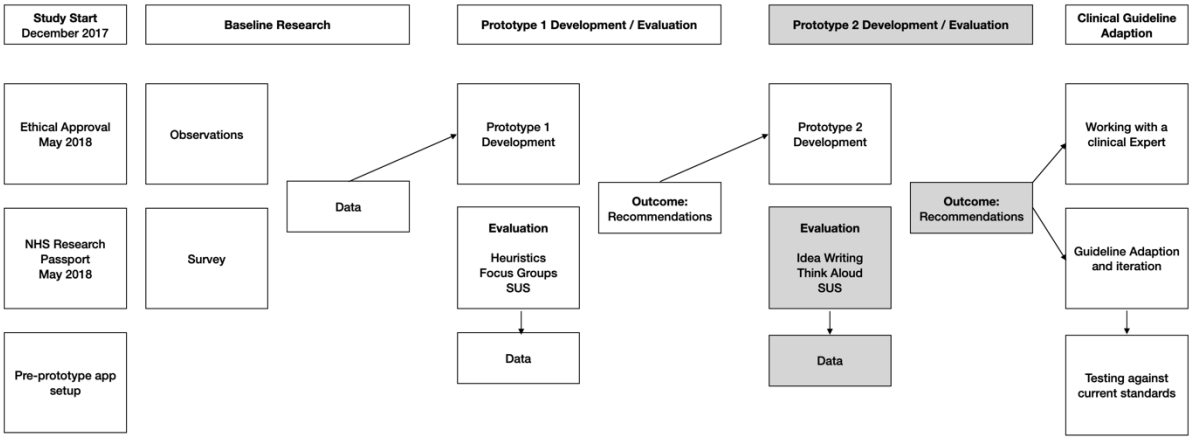
5.4. Conclusion

This chapter evidences the link from the recommendations in Chapter 4 to the design of the BCG app. This shows the recommendations elicited in the previous chapter (Chapter 4) are valid in terms of adapting the design of the BCG app, thus evidencing the need for a set of easy-to-follow recommendations. As highlighted, the recommendations have contributed to significant changes which are supported by other publications. It highlights the value that UCD can have in terms of iterative design in a complex field and that best practice alone may not lead to the ideal clinical application. It also evidences the complexity of converting paper based clinical information to a mobile device-based platform and the adaptions the BCG app was required to implement. This chapter also highlights the significant changes that will need to be evaluated further, this is discussed in the following chapter.

6. Usability Testing of the 2nd prototype BCG app (Feedback and Evaluation)

Objectives:

- *Evaluate the BCG app via usability testing*
- Assess if the design has contributed to any errors in information retrieval
- Assess if the changes have contributed to a more usable design
- Evaluate and adapt the current set of design recommendations



The placement of this Chapter within the PhD study is highlighted (Grey)

The research/results presented in this chapter were published in Proceedings of the 33rd International BCS Human Computer Interaction Conference 34. Mitchell, J., de Quincey, E., Pantin, C. and Mustfa, N., 2021, July. 15 Usability Heuristics for Delivering Clinical Guidelines on Mobile Devices.

6.1. Introduction

As with the first prototype of the app (discussed in Chapter 4), user-centred design methodologies (Norman, 1986; Abras, Maloney-Krichmar and Preece, 2004; usability.gov, 2019) were utilised to assess the changes made and gather feedback on the second prototype (dicussed in chapter 5). The aim was to answer the following:

1. To what extent is the presented format of the BCG app usable?

2. To what extent is does the app cause errors (usability)?

3. To what extent is the app satisfying in terms of design (measured by SUS)?

4. To what extent is are the selected methods of user centred design suitable when working with limited access to users?

5. What design recommendations can be elicited/changed by utilising user centred design (UCD) methods to gather feedback on features and functions?

In previous evaluations, focus groups were used to gather input from clinicians. However, access to clinicians is limited (especially in groups), and therefore more appropriate methods were required. This chapter discusses the evaluation of the second prototype BCG app (discussed in Chapter 5) and if other UCD methods (e.g. Think-aloud) are appropriate for use in assessing clinical guideline information delivery. Another factor to consider in the area of clinical information delivery and user centred design is knowledge. Tacit and semi-tacit knowledge requires techniques such as the think-aloud to ensure aspects of a clinicians workflow can be considered (Hyde and Rugg, 2013). Other UCD methods (i.e. focus groups) are not necessarily optimal in gathering this type of information therefore, other methods such as the think-aloud have to be utlisied. This chapter also discusses the implementation and adaption of the recommendations discussed in Chapters 3 and 4. A total of thirteen (n=13) recommendations were developed during these studies and then implemented in Chapter 5, they are as follows:

- Cross-Platform
- List view with A to Z and Categories
- Basic filter
- Easy access menu (such as tabbed)
- Minimise manual tasks (e.g. Manual calculations)
- Minimise the requirement to use other systems (if possible), e.g. if a drug dosage calculation is required, this should be available to the clinician without the need to use another app or system. This may not be possible due to security, organisational governance or limitations of technology.

- Decision algorithms to be displayed in-line with the guideline information
- The original 'flowchart' decision algorithm is provided
- Minimise the number of warnings/alerts to avoid 'alert fatigue'
- Acronym use is prevalent in medicine, but not all clinicians have knowledge of acronyms. Methods to address both experts and novices should be adopted.
- Warnings should be more explicit and adopt better salience for the user
- Guideline sentences should be reduced
- Content Pages should utilise icons/images as well as headers

6.2. Methodology

A mixed-methods UCD approach has been used based on the triangulation technique (Noble and Heale, 2019; Heale and Forbes, 2013) represented in *figure 58.* This enabled qualitative and quantitative data collection to inform design recommendations. The methods (Think-aloud and idea writing, screen recording and the system usability scale), rationale for selection and results are discussed in the following sections in more detail.

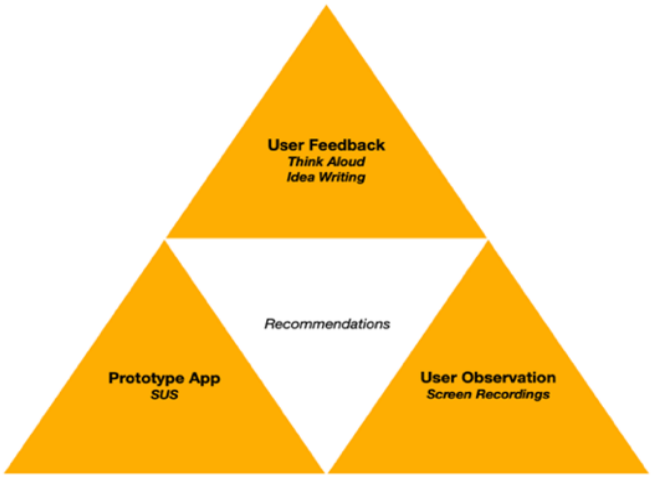


Figure 58: Triagulation techniques used to evaulate the prototype

The think-aloud (Nielsen, 1992a) technique was utilised to elicit feedback from participants in a test environment. The think-aloud technique was utilised as it provided a method of understanding how users navigated the structure of the BCG app as well as their thoughts during the process of using the app to complete basic clinical information retrieval scenarios. This method also allowed for the discovery of usability issues during information retrieval which may not have been identified during other methods of testing (i.e. focus groups). The think aloud method allowed for observations and the ability to ask further questions in terms of cognitive process, as discussed by Nielsen (Nielsen, 1992a) and Katlin (Katalin, 2000). This method also allows for the extraction of tacit and semi-tacit knowledge (Hyde and Rugg, 2013).

There are numerous ways in which clinicians work, and this is dependent on the area of work (e.g. Ward, Specialism, location) and the experience of the clinician. Numerous studies identify how to utilise clinical scenarios to emulate clinical workflow. Research by Tu et al. (Tu et al., 2004) discusses the modelling of clinical guidelines for integration into clinical workflow. Although the study is based in the United States, it does identify that a clinical workflow can be modelled using clinical scenarios. This is echoed in other studies such as Cossu et al. (Cossu et al., 2014), and UK based studies by Payne et al. (Payne, Weeks and Dunning, 2014) and Kwa (Kwa et al., 2014, 2015) where clinical scenarios were utilised during initial testing. The results are presented based on methods utilised during a think aloud study for clinical decision support (Li et al., 2012).

As with the previous prototype, participant evaluations are conducted to quantitively assess the usability of the second prototype BCG app. The SUS and a further 'idea writing' focus group were conducted and evaluated. These are then compared to previous results further in this chapter.

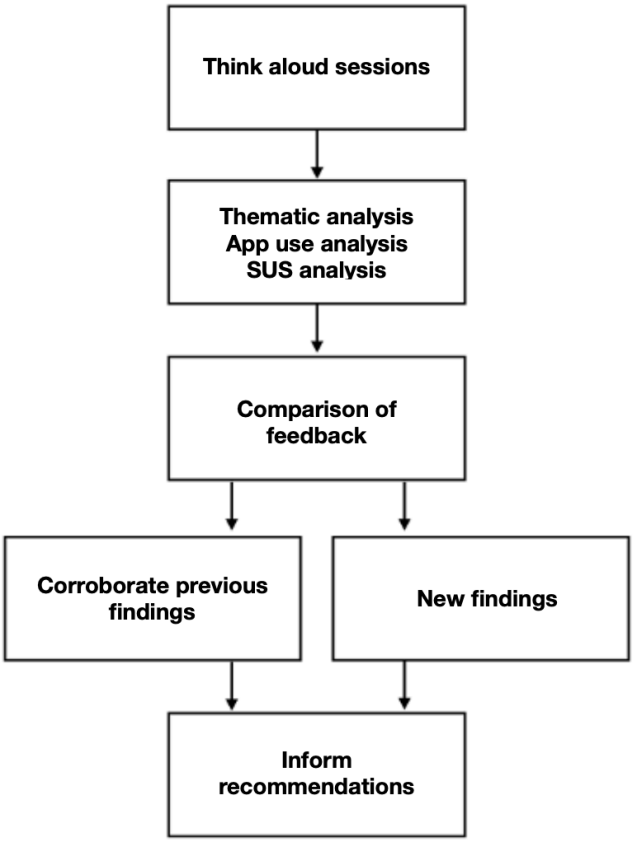


Figure 59 - Overview of evaluation methodology

Figure 59 provides an overview of the methodology utilised. The feedback elicited during the think aloud sessions, as well as screen recordings informs the creation of a set of recommendations for clinical information delivery on mobile devices. At the time of writing, no previous studies have been identified where the think-aloud method is utilised to assess the usability of bedside clinical guidelines on a mobile device. This is also true of utilising the think aloud method with novel methods such as Idea Writing. Combining these methods with SUS results will enable a more complete overview of user perceptions and usability. Not only will the feedback and analysis potentially provide feedback that could inform the creation of recommendations, but also assess the suitability of the think-aloud method and further assess the idea writing method for eliciting feedback of bedside clinical guidelines on a mobile device.

6.3. Think-aloud

6.3.1. Recruitment

Participants for this study were recruited via invitation emails. The emails were sent via the year four medical lead to all fourth-year medical students at Keele University School of Medicine.

6.3.2. Protocol

One to one sessions of fifteen minutes were arranged with all respondents. Participants were offered certificates of participation. Think aloud sessions were audio recorded and the device screen was video recorded, both using Apple QuickTime (10.4). Participants were greeted and a brief overview of how think-aloud sessions are conducted was provided to allow users to understand the purpose and process of the sessions. As each session was conducted, the researcher asked further questions to clarify comments made by participants (when required).

6.3.3. Participants

Participants were selected using a convenience sampling method. This was influenced by several factors. The requirements of the think aloud sessions were that participants had some medical knowledge and were aware of the bedside clinical guidelines. As access to clinicians was severely limited, it was decided that fourth year medical students would provide the adequate medical knowledge required for the basic information retrieval tasks and be accessible to the researcher. Demographics were not collected as all participants were selected for convenience. The purpose was to test the usability of the BCG app and therefore, selection based on demographics would not offer any further information required in terms of usability feedback. The homogenous convenience sampling method was considered as it allowed feedback to be elicited from participants of similar knowledge.

Although normally convenience sample methods are not desirable, this method has been shown to still produce results which offer feedback that can be considered generalisable (Jager, Putnick and Bornstein, 2017). Participant numbers were not limited as usability evaluation with limited numbers, such as diminishing returns discussed by Nielsen (Nielsen) may detect severe problems. However, in some cases not all problems are identified. Research by Faulkner (Faulkner, 2003) suggests that in some cases as low as thirty-five percent of usability issues are identified with low user numbers. As this research is informing critical information that can potentially cause harm to clinical patients it is important to ensure a robust approach to identifying issues. It is also of interest to gather as much data as possible for evaluation, as opportunities to access participants is limited.

6.3.4. Session overview

Think aloud sessions were conducted with thirty-eight (n=38) medical students at the Keele University School of Medicine. Participants did not have access to the BCG app prototype prior to the session. They were also not provided information on how the BCG app functions. Participants were given an overview of how the session would be conducted and the purpose of the think-aloud. Participants were asked to follow a procedure containing basic clinical scenarios. These scenarios were developed with assistance of a Lead Respiratory Consultant (project advisor) at the Royal Stoke University Hospital. They were developed to ensure participants accessed specific guidelines and utilised guideline components such as text, warnings and decision algorithm tools. They were taken from internal audits for other systems utilised within UHNM. For all sessions, the following procedure was followed:

1. Participants were provided with an overview of how to open the BCG app (the app was not opened at this stage).

2. Participants were provided with the three basic clinical scenarios. The clinical scenarios were based on three information retrieval tasks:

    a. In the subsequent management of Unstable Angina, what is the recommended dose and method of administering Aspirin?
    b. During fluid management in Acute Heart Failure, when should an echocardiogram be sought?
    c. In the management flowchart of Hyperkalaemia, what is the recommended action where Plasma K+ 6.0-6.4 mmol/L and Acute ECG changes are present?

    Scenario (a) was design to ask participants to retrieve basic text-based information. Scenario (b) was created to ask participants to retrieve text information contained in a warning, this enabled the analysis of how clinicians interact with the warnings contained in the BCG app. Scenario (c) was created to ask participants to retrieve information which is contained within a decision algorithm, again allowing analysis of how participants use the inline algorithm tools.
3. Audio and device screen recording was started
4. Participants were asked to access the BCG app and retrieve the required information (via scenarios) whilst discussing their actions and thoughts. Participants were asked to clarify comments during the session.
5. After completing the basic clinical scenarios, participants were given a brief demonstration of other features in the app e.g. Acronym support and Calculation tools.
6. Participants were asked to complete an SUS questionnaire.

During the think aloud, prompting questions were utilised were certain feedback was required but did not naturally occur during the session i.e. where a participant describes something as good they would be asked to elaborate and explain why it is “good”. These questions related to aspects such as design, layout, content and usability.

6.3.5. Results

The results are comprised of a thematic analysis of the think aloud sessions in terms of features and categories of coded comments made by participants. Also included is an analysis of positive and negative coded comments and later in the section an analysis of issues/errors identified in the session. Each of these will also be discussed in the following section (6.3.6).

6.3.5.1. Think-aloud Analysis

6.3.5.1.1. Data Analysis

To identify themes from the think aloud session, audio recordings were transcribed verbatim and analysed by the primary researcher. Screen recordings were analysed inline with transcribed text and coded to specific actions during each encounter (e.g. section of the app).

6.3.5.1.2. Coding theme and category analysis

Six themes were identified during the analysis, these themes and a description are identified in Table 8. For each participant, an average of 3 (n=3.23) themes were identified with a range of two to five (2 – 5). On average participants made seven (n=6.63) comments that were coded/themed with a range of three to eighteen (3 – 18). The themes are analysed further in section 6.3.5.1.3. A total of 252 comments were coded over the 38 sessions analysed. A full analysis table is provided in the appendix (appendix 5). In some cases,

comments were considered neutral or irrelevant and therefore excluded from the final analysis. Examples include comments where participants would discuss unrelated information such as medical knowledge not relevant to the scenario or BCG app.

Table 8 - Main themes identified during the Thematic Analysis

Theme	Description
Main Menu	*The BCG app content page*
Guideline Layout	*The design of the guidelines including Text/Font/Colours and how the information is presented*
Warnings/Alerts	*Feedback related to the presentation and content of warnings/alerts contained within the guidelines*
Decision algorithm	*Feedback related to the presentation and content of decision algorithms contained within the guidelines*
Filter function	*Feedback related to the presentation and content of filter functions contained within the guidelines and on the main menu*
Features or functions not present	*Related to the suggestion or requirement of features and functions that are not currently available in the BCG app*

Table 9 - Number of comments related to each theme

Main Menu	Guideline Layout	Warnings/Alerts (not specific to task)	Flowchart/Decision Algorithm tool	Text/font/colour	Filter Function
9	94	52	74	7	16

Of the six categories identified in table 8, the themes most discussed (both positive and negative) were *GUIDELINE LAYOUT* (37.3% of comments) and *DECISION ALGORITHM* (29.37% of comments). Details of the number of comments for each theme are provided in Table 9. From overall comments, guideline layout and decision algorithm represented a combined total of 66.67% (n=168/252). Figure 60 shows the overall comment analysis for each theme. WARNINGS also represented a large portion of comments (20.6% of comments).

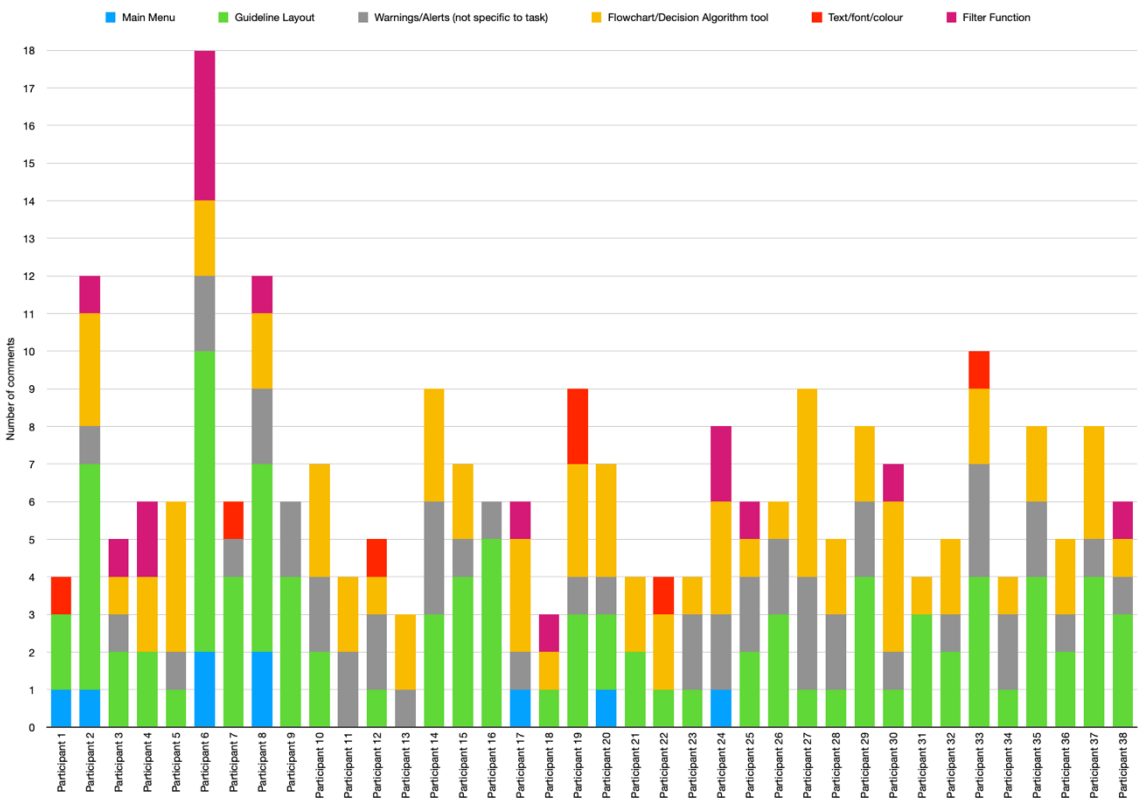


Figure 60 - Individual comment coding analysis for each theme

Session themes were also identified and categorised in terms of the categories which described comments overall. Table 10 identifies these categories and provides a description of each. Of the six themes identified (Table 8) four categories were created to code each comment (Table 10).

Table 10 - Categories of coding and description of each category

Category	**Description**
Usability	*Comments which are considered to refer to how the app is used, how the information can be accessed and how the users 'feel' in terms of its use. (e.g. "I like how this looks")*
Visibility	*Comments which refer to the visibility, colour, salience, layout etc. (e.g. "I didn't notice it because it didn't stand out")*
Clinical Workflow	*Where the participants comments specifically refer to use of the app and its functions in wards/hospitals (e.g. "this would be really useful when treating patients as it can get busy on the wards")*
BCG Content	*Comments which specifically refer to the content itself – including text, knowledge*

	and specific medical information/methods (e.g. "I would have expected this section to be above investigations")

Of the four categories identified (table 10), the categories most discussed (both positive and negative) were *USABILITY* (56% of comments) and *VISIBILTY* (23% of comments). From overall comments, usability and visibility represented a combined total of 79% of all comments (n=199/252). Figure 61 shows the overall comment analysis for each category.

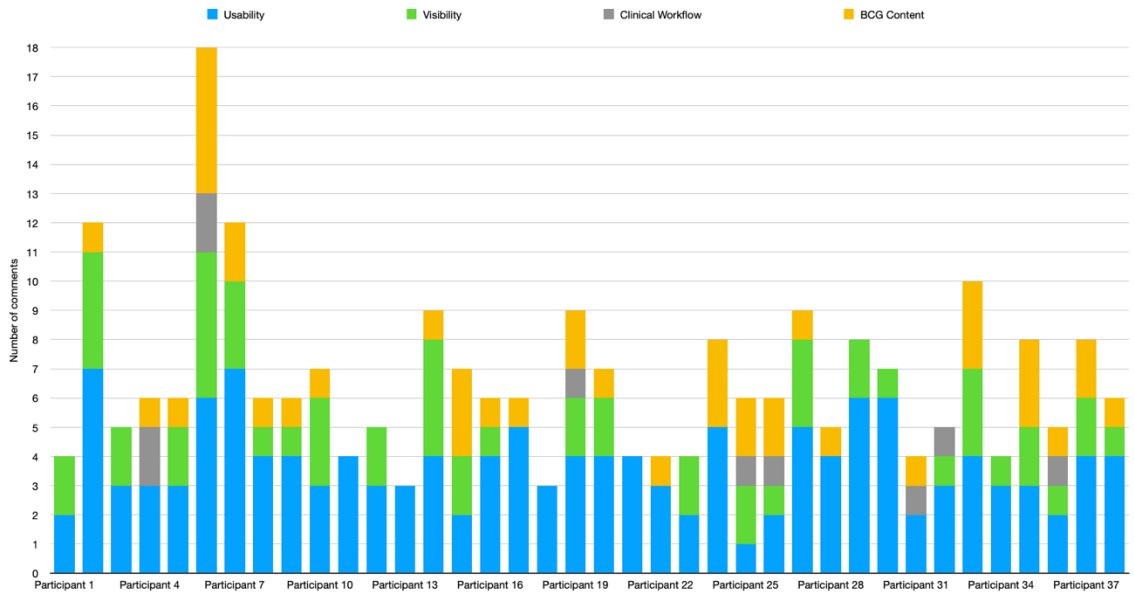


Figure 61 - Individual comment coding analysis for each category

As well as identifying themes and categories, sessions were also analysed in terms of whether comments were positive or negative. This allows for an overall analysis of participants attitude towards to BCG app and enables the identification of specific features/themes where participants described in negative or positive terms. Table 11 provides a description of how comments were coded as negative or positive.

Table 11 - Comment types (Positive/Negative) and their identifying characteristics description

Comment type	Description
Positive	*A positive reaction or general comment (e.g. "this is really great" or describing the use of a feature in a positive manner (e.g. "This would be really useful when…")*
Negative	*A negative reaction or general comment (e.g. "I don't like this..") or any criticism, suggestion of alternative methods or ways in which the user prefers (e.g. "this is good but I would like it if it did…"*

Each coded comment considered negative or positive was analysed by theme. Figure 62 shows the results of the analysis. Overall, of the 252 comments coded, a total of 182 were coded positive and 70 were coded negative.

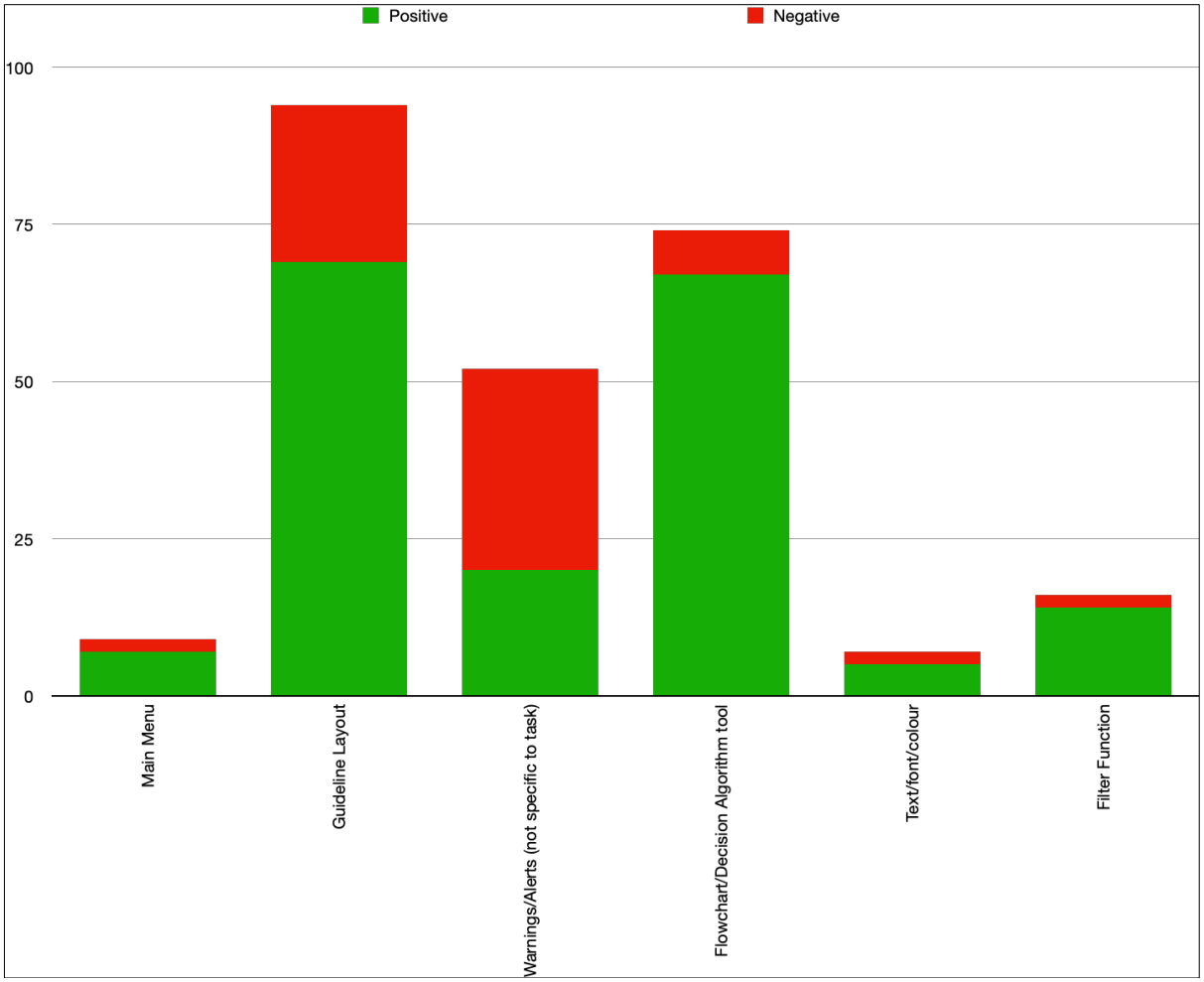


Figure 62 - Positive and negative comment analysis (number of overall comments)

The majority of coded comments considered positive (n=182/252 or ~82%) focussed on *GUIDELINE LAYOUT* and the *DECISION ALGORITHM*, both of which, as mentioned, received the most comments overall. Interestingly, the majority of negative coded comments also focussed on *GUIDELINE LAYOUT* (36% of all negative comments). However, this was most likely due to the high number of comments received overall. *WARNINGS/ALERTS* (46% of all negative comments) received a greater proportion of negative comments relative to overall comments. Of the 52 comments referencing warnings/alerts, 32 were coded negative and 20 coded positive. Details on the causes of the negative comments are provided in the discussion section of this chapter (section 6.4) and in the think-aloud theme analysis in the following section (6.3.5.1.3).

Sessions were also analysed for consistent patterns in how participants utilised features of the BCG app, specifically the filter function in the main menu and in each guideline. This is discussed in a subsequent section (6.3.5.1.3.5). An analysis was also conducted to identify if users made errors or if the guidelines contributed to any error, this is also discussed further in this chapter (section 6.3.6).

The following sections discuss the results of each particular theme and provides examples of comments made by participants in relation to each theme.

6.3.5.1.2.1. Main Menu

All participants navigated the main menu without the need for prompting or further instruction. All participants were able to access the specific guidelines. In some cases, they utilised the filter function (n=30) – this is analysed further in section 6.3.5.1.5. Some participants made specific positive comments in relation to the use of icons and headers for the sections provided. This can be summarised by the following participant quote:

"that's nice that you have this at the beginning so that you could flick through and see just an overview of all the things that you have on it".

Of the nine (n=9) comments made by participants in reference to the main menu, seven (n=7) were considered positive and two (n=2) were considered negative. An example of a positive comment referenced the use of categories:

"You've got headings which I like"

The majority of positive comments reference the layout and ease of use in terms of finding what they need. An example of a negative comment mentioned the following:

"maybe it'd be nicer if it was just the big blue header and then you can open and close"

The negative comments (n=2) in reference to the main menu all have similar themes in terms of presenting the content in an accordion type (open and close) view, as the above comment suggests.

6.3.5.1.2.2. Guideline Layout

The majority of respondents made general comments regarding the layout of the guidelines. A total of 94 comments were coded in reference to the guideline layout, a large proportion of all comments that were coded (37.3% of all comments). Of that total, 69 were considered positive and 25 were considered negative. As the following example highlights, most positive comments referenced the ease of finding information or the clarity of the layout:

"I think just how it's laid out signs and symptoms and then investigations and then differential diagnosis. I feel like it's laid out in a good order and there's not too much text as well. Cause I find that when I'm using NICE and stuff like that, there's so much text."

In terms of negative comments, the majority of participants suggested a more collapsible layout may be beneficial. It could also refer to the screen size being too small. One user did specifically mention that in one of the guidelines, scrolling was undesirable. The participant stated:

"I think it's a bit long to like scroll down on set. I think just separating it a bit and bit might be a bit useful".

Other comments suggested that there should be an overview of all the content (e.g. a content section or titles at the top of each guideline) to facilitate user understanding of the guideline layout:

"Maybe like at the top there could be like a mini, like contents where you could click on, for example, subsequent management and anything"

Feedback also suggested that the order of the content would be more beneficial if different from its current layout, for example:

"my only sort of thought with that is having the differentials above investigations. So as you read an investigations, you already know what really not helped."

6.3.5.1.2.3. Warnings/Alerts

A large proportion of respondents specifically mentioned the layout of warnings or gave specific feedback regarding the information contained in the BCG app warnings (n=52/252, 20.63% of all comments). Of all the comments coded to particular themes, warnings/alerts received the majority of negative comments (45% of all negative comments). This was due to participants expecting the use of acronyms or shortened versions such as 'ECG' or 'ECHO'. This was evident through comments such as:

"So you would expect acronyms to be in there too"

**

"It was more because I didn't see that it was anything to do with an echo"

Some participants suggested the information should be repeated in context within the guidelines. Summarised by some participant in the following comments:

"So I was expecting it to be in the standard text. Um, I normally would have looked at that… Perhaps a repeat of that. So, repeating the warning, in the information."

**

"I was actually looking for a bullet that said echocardiogram. Okay. Um, so perhaps you could include it as both. It's like in the red and as a bullet point."

Some participants also suggested warnings that contained too much text were harder to assimilate when scrolling through the BCG guidelines. In reference to the amount of text contained in a warning, one participant mentioned:

"I like things that are bullet pointed and then inset bullet point, and then the detailing."

In some cases, negative comments were associated with users not finding the information contained within the warning. Whilst some suggested that the information should be repeated, other users specifically mentioned that they felt the medical procedure would not necessarily be presented in a warning box, as the comment below suggests:

"I think I just assumed. That, that wouldn't be. I didn't read that. I don't know why, although it looks like it's designed to be more important. I guess I assumed that an echo wouldn't be that important"

However, other participants suggested that the information in refence to an echocardiogram would not necessarily be expected to be in a section with fluid management.

> *"so maybe it's just me missing it. And then if we hadn't, since it's about an echocardiogram, ...put that in the fluid management"*

These echoes other participant comments referencing the repeat of information in the main text. It also highlights individual user behaviour and how participants assimilate the information contained in the guideline. One participant specifically mentioned their workflow may have contributed to them missing the information contained within the warning:

> *"I'm so used to just looking straight at the text rather than in boxes. Um, and usually I go back to boxes to see if things are important. Yeah. Um, but I'm usually, yeah, that's hard to get straight to text, so that's why I missed it"*

The majority of positive comments referred to the salience of the warning, in particular the use of colour. Participant specifically mentioned the warning salience during the sessions:

> *"I definitely saw like the red warning thing, so I guess that is quite, it shows that it's important. I guess if it's immediate, that*

means that you probably want to put at the top, which you guys did and. This pops out because you don't see this kind of thing on the other, on the other one that I saw"

**

"That's quite nice to have like a big warning to make sure that you do what you need to do"

**

"Cause it's an, a red box with a warning and like, I think anyone would automatically look and make sure like, what's that warning about"

6.3.5.1.2.4. Decision Algorithm

All sessions were analysed in terms of how the participants interacted with the decision algorithm tool. The users had two options in terms of how to access the flowchart information they required to complete the scenario. However, they were not made aware of this in order to assess which method they would instinctively access. It is worth note that the decision algorithm tool is more salient in terms of design than the button to access the original version. Although this could also be impacted by the novelty effect of the algorithm. However, participants had access to both programmatic and original version of the decision algorithm within the same area of the guideline. Table 12 shows the results of how many participants utilised each version.

Table 12 – Numer of particpants utilising each version of the decision algorithm

Utilised programmatic version	Utilised original version
37	1

Of all participants (n=38), all but one (n=37) accessed the programmatic version of the decision algorithm. Comments made by participants on the design and use of the inline decision algorithms were overwhelmingly positive. Of the seventy-four (n=74) comments made by participants in reference to the tool, sixty-seven (n=67) were positive and seven (n=7) were classified as negative. Specifically, one participant mentioned when comparing the two decision algorithms:

> *"so this is just a different way of presenting that digital flow chart. I think I liked the other (ref to new method) because this is too complicated (ref to original). And I think when needed quickly on the ward and you want to see something that probably not the best way"*.

Another participant also reflected on the design, specifically stating:

> *"it helps you follow in your head. I find that flowcharts can be a bit much sometimes following it. Whereas this specifically just gives you the answer you need rather than everything on stuff. So, it makes it a bit easier to follow and easy to get the information you need"*.

One participant also dicsussed the decision algorithm. Directly referencing the amount of information presented and reflecting on the need for specific information. This was also reflected in their comment, were they stated:

"*sometimes when it's like branching and you having to look everywhere to find exactly what you need, it's to the point*"

Interestingly, there appeared to be a separate viewpoint on the use of information for learning as opposed to clinical use. This was highlighted specifically by one participant in reference to the presentation of the original decision algorithm (flowchart), stating

"*I guess the original flow chart be good for learning*".

6.3.5.1.2.5. Filter Function

Participant screen recordings were analysed to see if any utilised the filter function, both on the main menu and within the guideline. Table 12 shows the results of this analysis.

Table 13 – Number of times participants accessed the filter function

Utilised filter in the Main Menu	Utilised filter in the guideline
18	12

As the table highlights, participants accessed the filter function during the session with no prompting or instruction. The main menu filter was accessed by eighteen of the participants (n=18/38), and the guideline filter function was accessed by twelve participants (n=12/38). Participants also specifically mentioned using the filter function during use, describing it as a "quicker" or "faster" method of retrieving information. Overall, 16 comments were coded in reference to the filter functionality of the BCG app. Of these comments, 14 were considered positive, with general positive comments as mentioned. In terms of negative

comments, 2 were identified by separate users. One user specifically mention in terms of clinical workflow the following:

"If you didn't know, you could type in potentially the symptoms or to go into cardiac"

Another participant also suggested that the filter function may be more useful if it allows the user to:

"move to the next part"

This suggests that the user is navigated to each highlight of the filter in a similar method that some PDF/Browser word filters function.

6.3.5.1.2.6. Features or functions not present

Participants mentioned aspects of clinical information that may be useful within the bedside clinical guidelines. In particular, drug calculation tools or information on specific treatments. As the scope of this study is to investigate the delivery of existing guidelines, it is beyond the scope of this study to investigate information on guidelines that do not currently exist. However, it is interesting to highlight that the information needs of participants does differ especially in terms of clinical expertise and interest.

6.3.6. Error/Issue Analysis

The think-aloud sessions were also analysed for any occasions were participants encountered issues related to three areas. Table 14 describes the three areas used to describe the issues found.

Table 14 - Issue types and descriptions

Issue Type	Description
Information retrieval issue	*Where a participant is unable to retrieve the necessary information to complete the scenario or where the user selects the wrong information.*
Usability issue	*Where a participant interacts with the app in a way they perceive negative due to its design or functionality*
Other	*Where a participant discovers a bug or app issue not related to information retrieval or usability*

A total of 26 issues occurred over the 38 sessions, 68% of sessions. The 26 issues occurred in 21 sessions of the 38 with a range of 0 – 2 issues per session. Table 15 provides an overview of the types of issues and the number of occurrences for each type.

Table 15 - Number of occurrences of each issue during think-aloud sessions

Issue Type	Number of occurrences
Information retrieval issue	18
Usability issue	*9*
Other	*1*

Of the 18 occurrences of issues related to information retrieval, 9 occurrences were related to participants locating information incorrectly. Despite the scenario specifically asking users the ‘dose of aspirin in subsequent management’, 9 participants provided the initial dose contained in the management section. When prompted to locate the information in ‘subsequent management’ some users did state that an overview of the sections available in the guideline may be useful. This was highlighted in the comments contained in the Guideline layout section. The 9 other occurrences of information retrial errors all related to user not able to locate information contained in the warning box provided in the Acute Heart Failure guideline. This was due to the expectation of acronyms/short versions and the expectation of text contained in the warning would be repeated or available in the main guideline text, as mentioned in section 6.3.5.1.2.3 (Warning/Alerts).

Of the 9 occurrences of usability issues, 2 occurrences related to locating the decision algorithm tool. During the first 3 sessions, the decision algorithm had to be activated by clicking the start button. After the initial usability issues this was changed to be inline without requiring activation, see Figure 63. No further occurrences of this issue occurred in the remaining 36 sessions.

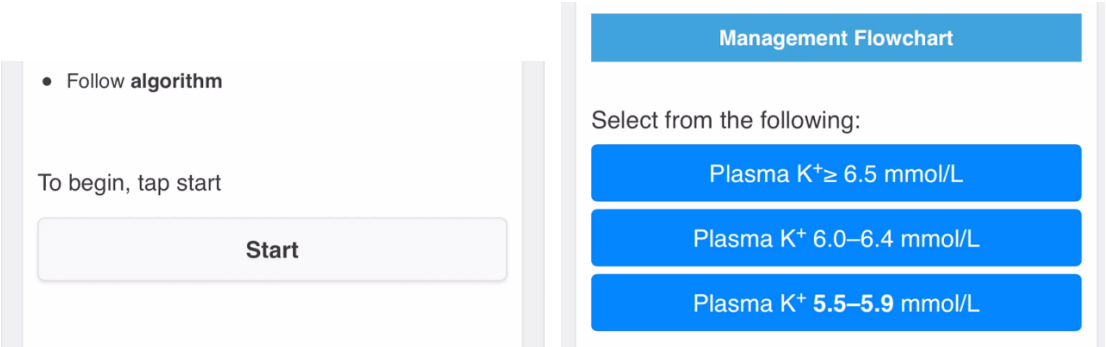


Figure 63 - Changes in how the decision algorithm tools are displayed

The most prevalent usability issue was related to users mistaking a header for a button. 5 participants (13.5% of participants) attempted to click the header for the tool before realising the tool was already present in the guideline. This represents 56% of the usability issues identified. Upon analysing the screen recording of these issues, all 5 participants failed to scroll down far enough to visibly see the tool and therefore assumed they could activate it using the header. Most users acknowledged the error and, on some occasions, mentioned that this would not occur after they have become more familiar with how the BCG app works.

Other usability issues included an occasion where one participant could not initially locate the ‘Acute heart failure’ guideline in the main menu, this was because the participant was looking for heart failure and did not expect ‘acute’ to precede the title. Another issue identified was related to the filter function within the guideline. One participant attempted to move to the next guideline by searching for it in the filter tool, this was corrected by the participant without any interjection from the facilitator.

A further issue was identified during the 18th think-aloud session. A bug was identified where the warnings did not display when a participant utilised the filter function. This was categorised as an 'other' issue as it was not specifically related to usability or information retrieval. This issue was fixed before further sessions were conducted. Analysis of previous 17 sessions did not identify any other occurrences of this issue and the issue did not contribute to any negative comments or other issues identified during the previous sessions.

6.3.7. Results of the participant usability evaluation (SUS) for the 2nd prototype

In section 4.4.1 the System Usability Scale (SUS) (Brookes, 1996) was used to establish the usability level of the 1st prototype application from the clinicians' viewpoint. It also provided a baseline to measure future changes in the design and how they impact the usability. After the think aloud sessions were completed (section 6.3), participants were asked to complete the same SUS questionnaire provided to clinicians during the initial prototype testing. A total of 39 SUS questionnaires were completed.

The app was shown to maintain a high usability score, with an overall score of 93.6 out of 100 (calculated utilising the methods described in (Brookes, 1996)). This result was higher than previous SUS scores completed on the first prototype application. The results from both focus groups are presented in Tables 16 to 20. These tables have been split as each represents a different session of users.

Table 16 - SUS Results for Think Aloud session

Participant	q1	q2	q3	q4	q5	q6	q7	q8	q9	q10	SUS Score
p1	5	1	4	1	5	1	5	1	5	1	**97.5**
p2	5	2	4	1	4	1	5	1	4	1	**90.0**
p3	4	2	4	3	4	1	5	1	4	1	**82.5**
p4	4	1	4	1	4	2	5	1	4	2	**85.0**
p5	5	1	5	1	5	1	5	1	4	1	**97.5**
p6	5	1	5	1	5	1	5	1	4	1	**97.5**
p7	5	1	5	2	5	1	5	1	5	1	**97.5**
p8	5	1	5	1	5	2	5	1	5	1	**97.5**

p9	5	2	5	1	4	1	4	1	3	1	**87.5**
p10	5	1	5	2	5	1	5	1	5	1	**97.5**
p11	5	1	5	1	5	1	5	1	4	1	**97.5**
p12	4	2	4	3	4	1	5	1	4	1	**82.5**
p13	5	1	4	1	5	1	5	1	5	1	**97.5**

Table 17 - SUS Results for Think Aloud session

Participant	q1	q2	q3	q4	q5	q6	q7	q8	q9	q10	SUS Score
p1	5	1	4	1	5	2	5	1	4	1	**92.5**
p2	3	2	4	1	4	1	4	1	4	1	**82.5**
p3	5	1	4	1	5	1	5	1	5	1	**97.5**
p4	5	1	5	1	5	1	5	1	5	1	**100.0**
p5	4	1	5	1	5	1	5	1	4	1	**95.0**
p6	5	1	4	1	5	1	5	1	5	1	**97.5**

Table 18 - SUS Results for Think Aloud session

Participant	q1	q2	q3	q4	q5	q6	q7	q8	q9	q10	SUS Score
p1	5	2	4	1	5	2	4	2	4	1	**85.0**
p2	4	1	4	1	5	1	5	1	5	1	**95.0**
p3	5	1	5	1	4	1	4	1	5	1	**95.0**
p4	5	1	5	2	5	1	5	1	4	1	**95.0**
p5	5	1	5	1	5	1	5	1	5	1	**100.0**
p6	5	1	5	1	5	1	5	1	5	1	**100.0**
p7	5	1	4	2	4	2	4	1	4	2	**82.5**
p8	5	1	5	1	5	1	5	1	4	2	**95.0**

Table 19 - SUS Results for Think Aloud session

Participant	q1	q2	q3	q4	q5	q6	q7	q8	q9	q10	SUS Score
p1	5	1	5	2	5	1	5	1	4	1	**95.0**
p2	5	1	5	1	5	1	5	1	5	1	**100.0**
p3	4	2	4	1	5	2	5	2	4	1	**85.0**
p4	5	1	5	1	5	1	4	1	5	1	**97.5**
p5	5	1	5	1	4	1	5	1	5	1	**97.5**

Table 20 - SUS Results for Think Aloud session

Participant	q1	q2	q3	q4	q5	q6	q7	q8	q9	q10	SUS Score
p1	5	1	5	1	4	2	4	1	5	2	**90.0**
p2	4	1	5	1	4	1	5	2	5	1	**92.5**
p3	5	1	5	1	4	1	5	1	4	1	**95.0**
p4	5	1	5	1	4	1	5	1	5	1	**97.5**
p5	4	1	5	1	4	1	5	1	5	1	**95.0**
p6	5	1	5	1	5	1	4	1	4	1	**95.0**
p7	5	1	4	1	5	4	5	1	5	1	**90.0**

The consistent results in all sessions highlight a general consensus amongst participants that they highly rate the usability of the BCG app. It also evidences that changes made for the second prototype have either maintained or increased usability. This was also reflected in the positive comments/feedback discussed in the think aloud sessions. A comparison of the first and second prototype is provided in Figure 64 and highlights the differences for each question of the SUS for each of the two prototypes.

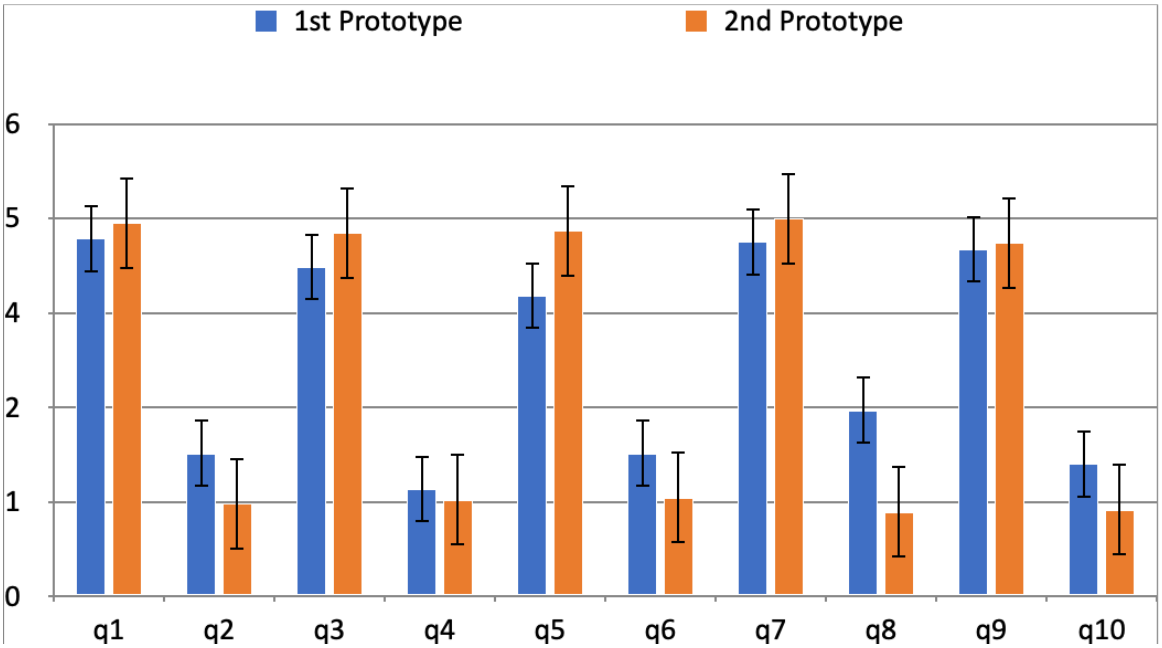


Figure 64 - A comparison of SUS results for the 1st and 2nd prototype

The overall SUS scores for each question is presented in Figure 64. For each, the mean (93.6), standard deviation (5.41) and standard error of the mean (0.85). The overall SUS score for the 1st prototype was 81, the second prototype was 93.58. An independent t-test was used to compare these results. The results show a significant difference p-value of < 0.05. For each question the mean was calculated (shown in figure 64). On analysis, it is evident that the 2nd prototype had the greatest impact on questions 5 and 8. Question 5 refers to 'if the various functions in this feature were well integrated'. This could be due to the decision algorithm design and integration. Question 8 asks if the user 'if features

are very cumbersome to use' which has reduced. This could again be due to the decision algorithms within the application.

6.4. Idea Writing session for the second prototype BCG app

To further evaluate the 2nd prototype of the BCG app, an 'idea writing' session was conducted using the same methods discussed in section 4.4.1. This session was conducted at the Wythenshawe Hospital, part of the Manchester University NHS foundation Trust. The session was conducted with four (n=4) participants, three registrar (n=3) clinicians and one clinical fellow (n=1). Participants were selected using the convenience sampling method. No remuneration was offered to participate in the sessions. A full set of results for this session are provided below:

6.4.1. Results

Feedback provided during the idea writing session was largely positive. Specifically, participants used words such as "very useful" and "good" to positively describe the 2nd prototype of the BCG app. Feedback was analysed and the following comments have been extracted as examples:

- *simplify the content as too wordy to be used in emergency although info all good - my suggestion is to use flowcharts as much as possible as first thing you see then have the fuller content below or linked to separate page*

Although this is related the authoring of the guidelines (discussed in subsequent chapters), this does specifically mention the need for succinct information delivery in an emergency, specifically delivery utilising the decision algorithm discussed in section 5.4.5. Another comment refers to guideline titles:

- *simplify and lose acute from the section titles as it makes it harder to search for subjects*

Although this has only been mentioned by one participant during the focus groups and think aloud sessions an interesting point was raised regarding succinct information and how it is displayed in the content pages. It also has similarities to a usability issue which occurred during the think aloud sessions (section …) where a user was unable to locate the Acute Heart Failure guidelines because it was superseded by the word acute. Another comment also referenced the layout of guidelines, specific to warnings contained within the guideline:

- *warnings at top of pages*

This was in contrast to feedback received during other focus groups and think aloud sessions. However, it does highlight that individual preference may be a key factor in delivering clinical information and this requires further investigation.

6.4.2. Overview of results

Table 21 provides an overview of the main findings presented in previous sections. Each finding is presented with the method utilised and how it has affected the recommendations presented in the introduction of this chapter.

Table 21: Overview of method findings and outcomes

#	Finding	Method	Outcome
1	*Inline decision tools caused less errors*	*Think aloud and video analysis*	***Adapting** existing recommendations to include inline activation*

#	Finding	Method	Outcome
2	*Warning design should be more explicit and salient*	*Think aloud and Idea Writing*	***Adapting** existing recommendations to include explicit, salient warnings*
3	*Warning text be repeated to avoid missing critical information*	*Think aloud*	*Adding a new recommendations based on repeat warning text.*
4	*Easier to find guidelines if unnecessary wording is removed*	*Think aloud and idea writing*	*Adding a new recommendations based on removing wording from titles in content pages*

6.4.3. Discussion of results for the think-aloud and idea writing sessions

This study utilised a mixed-method triangulation approach to inform the improvement of a mobile application for delivering bedside clinical guidelines. The use of the think-aloud technique with clinical scenarios and the 'idea writing' focus group, as well as the SUS methodology produced data which has informed on the impact of implementing recommendations and identified clear usability issues (i.e. decision algorithm activation). Despite the overlap in the findings of these methods, unique insights were elicited from participants. Both methods also enabled evaluation of a clinical application where access to relevant users (clinicians) is extremely limited and restricted in terms of time. They also offer a unique insight into the use of these techniques as no studies that have combined these techniques to inform the delivery of bedside clinical guidelines could be found.

The evaluation has provided a number of specific and general findings relevant to the development of the BCG app. In terms of layout, some participants referred to the order of content and specified alternative ordering. This is indicative of how preferences differ between individuals. Similar findings were also discussed in the survey (chapter 3), where personal preference has contributed to a large amount of variation in the apps clinicians

utilise. This is further impacted by the requirements of the delivered information in terms of educational use as opposed to clinical use. Participants conveyed the need for a more in-depth delivery of information when learning. This is highlighted in Karen Davies's review on the information-seeking behaviour of doctors, which states two main behaviours when clinicians are seeking information, one seeking facts and another seeking literature (Davies, 2007). This also reflects the findings of the observational study discussed in chapter 3, which found that Junior clinicians appear to use technology to establish knowledge which requires more information. Senior clinicians utilise technology for knowledge affirmation. The use of acronyms also suggests there are differences in the needs of individual clinicians from a knowledge perspective. Interestingly, the topic of warnings generated much discussion in terms of the information they contain. Specifically, the use of acronyms was expected by participants which is in direct contrast to feedback received during previous sessions. This may be due to the subject matter utilised within the warning. The scenarios utilised echocardiograms, a subject the participants were familiar with. It remains to be seen if other more complex subjects and less used acronyms would highlight knowledge gaps. However, previous findings highlighted the need to provide both acronyms and explications (Chapter 5, section 5.4.6).

6.5. Limitations

It is worth note that the higher score during the SUS (section 6.3.7) could be attributed to the fact that clinical students were utilised for this part of the study, a group that are familiar with mobile devices and clinical application use (Wynter et al., 2019; Boruff, 2014; Mather, Cummings and Allen, 2014). However, the group of students selected (year four) already participate in clinical practice through their university course, a requirement for all student clinicians in their final years of study. It is suspected that although this may have some

effect on the results, it would not have a considerable impact as student and junior clinicians were utilised in the earlier SUS sessions and focus groups.

6.6. Conclusions

Previous chapters introduced a set of recommendation (Chapter 3 and 4). Implementing these recommendations has informed the changes in the development of the 2nd prototype (discussed in chapter 5 and evaluated in this chapter). The high usability scores and positive feedback received during the think aloud sessions and idea writing session suggest a high level of user satisfaction in terms of usability. This suggests the changes that were made during the development of the 2nd prototype (chapter 5) have either maintained or increased usability in terms of user perception. More importantly, all users were able to complete information retrieval scenarios with few errors across multiple sessions, this suggests the changes have not introduced any issues that prevent information retrieval, as evidenced in section 6.3.6 of this chapter. The findings of this chapter also discuss several further recommendations which inform the development of an app for the delivery of clinical information on mobile devices (presented in Table 21 in section 6.5. The findings have also informed the adaption of some of the recommendations from previous chapters, also presented in section 6.5. A total of thirteen (n=13) recommendations were developed. For ease, they are provided below:

1. Cross-Platform
2. List view with A to Z and Categories
3. Basic filter
4. Easy access menu (such as tabbed)
5. Minimise manual tasks (e.g. Manual calculations)

6. Minimise the requirement to use other systems (if possible), e.g. if a drug dosage calculation is required, this should be available to the clinician without the need to use another app or system. As mentioned in section 3.1.4, this may not be possible due to security, organisational governance or limitations of technology.
7. Decision algorithms to be displayed in-line with the guideline information
8. The original 'flowchart' decision algorithm is provided
9. Minimise the number of warnings/alerts to avoid 'alert fatigue'
10. Acronym use is prevalent in medicine, but not all clinicians have knowledge of acronyms. Methods to address both experts and novices should be adopted.
11. Warnings should be more explicit and adopt better salience for the user
12. Guideline sentences should be reduced.
13. Content Pages should utilise icons/images as well as headers

The evaluation of the thirteen recommendations during this chapter suggests that recommendations 7 and 11 be adapted as follows:

7. Decision algorithms/Calculation tools should be displayed in-line with the guideline information, clearly outlined to distinguish from the main content, and ready to be used (i.e., does not require activation).

11. Warnings should be succinct, explicit and adopt a salient design to ensure visibility.

The findings also suggest the addition of two new recommendations, they are as follows:

- Text contained in alerts or warnings should also be available within the text it refers to
- Remove unnecessary wording in titles e.g. Instead of ‘Acute Heart Failure’ use ‘Heart Failure’

The adaption of previous recommendations and the addition of new recommendations has culminated in the creation of 15 recommendations for developing clinical information delivery applications for mobile devices. The final set of recommendation is provided below and re-ordered for clarity. The recommendations suggest that any application should:

1. Be cross platform
2. Provide multiple methods of accessing content in list views (i.e., A to Z and Categories)
3. Minimise unnecessary wording in titles (i.e., ‘Acute heart failure’ should be presented as ‘heart failure’
4. Have a menu that can be easily accessed, preferably using a tabbed menu design
5. Utilise icons/images as well as headers
6. Provide a basic filter function to filter content in both menu and information sections
7. Minimise manual tasks (i.e., Drug dose calculations)
8. Provide as many tools and resources as possible to minimise the requirement to use other systems

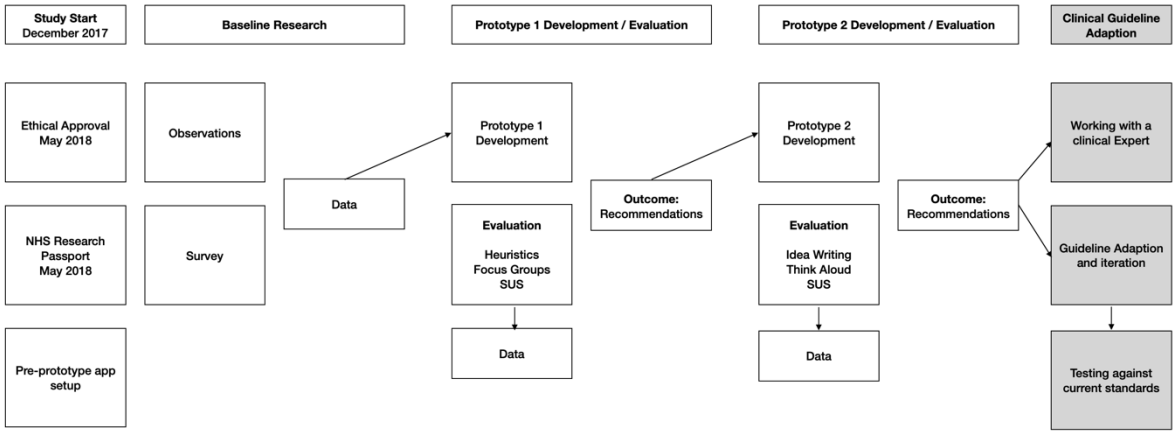
9. Provide clear decision algorithms and calculation tools in line with content, and ready to use (i.e., does not require activation)
10. Provide original content for any tools or decision algorithms (i.e. An original flow chart)
11. Utilise acronyms, but also provide a method of understanding acronyms where possible
12. Minimise the number of warnings/alerts to avoid 'alert fatigue'
13. Display warnings/alerts in line with content, ensuring they are salient in design and succinct and explicit in content
14. Repeat warning content within the main information
15. Reduce the use of long sentences and provide information as succinctly as possible

Aside from the recommendations elicited from feedback and evaluation, it is clear that further investigation into personalised delivery is required. Although a limited number of participants specifically mentioned layout, the feedback during the evaluation of both BCG app prototypes highlights the eclectic nature of information delivery that satisfies user preference. The evaluation of both prototypes has also highlighted that both system and information validation and verification is critical to both patient care and user confidence. This will be discussed in the following chapter (Chapter 7).

7. Chapter 7 – Working with clinical experts to adapt, verify and validate clinical information

Objectives:

- *Understand and evaluate the impact of guideline changes based on recommendations*
- *Discuss the impact of working with a clinical expert*
- *Discuss the validity and verification of information*
- *Compare the final BCG app with as set of app recommendations from the Royal College of Physicians*



The placement of this Chapter within the PhD study is highlighted (Grey)

7.1. Introduction

A recent study into the conformance of clinical guidelines app for Eczema treatment concluded the need for quality assurance (QA) mechanisms for health apps (Galen et al., 2020). Previous chapters discuss the evaluation of recommendations in terms of user interaction and usability. However, it is necessary to understand and evaluate the impact of these change. This chapter investigates the impact of those recommendations in terms of the quality, authoring and adaption of individual clinical guidelines. This chapter also describes the process of working with a clinical guideline expert to re-author clinical guidelines, ensure their validity, the verification of adapted clinical guideline, and the classification of clinical warnings using card sorting. Also discussed is the process and results of comparing the final BCG app prototype (discussed in Chapter 5 and 6) against recommendations developed by the Royal College of Physicians (Wyatt et al., 2015).

7.1.1. The BCG validation process

The BCG content has an existing validation process, outlined in Figure 65. For the medical guidelines utilised in this study, this would be a bi-annual process (unless critical evidence needed to be introduced). In terms of quality assurance, the current process of validating the BCG guidelines will need to be adapted to include the app version of the guidelines. The overall development of the prototype application has considered software quality characteristics such as those described by Cavano and McCall (Cavano and McCall, 1978) and Kitchenham (Kitchenham and Pfleeger, 1996). In terms of the BCG Application development, concepts such as reliability, Performance Efficiency, Security, Maintainability, Testability and Usability were considered to support the development of a reliable software system as they are also discussed by Kitchenham (Kitchenham and Pfleeger, 1996) . However, further validation in relation to quality assurance is necessary. This is in the form of validation for the medical information each guideline contains. As each guideline needs to be adapted based on the recommendations elicited and implemented in previous chapters, each guideline requires medical expert validation to ensure safety and validity.

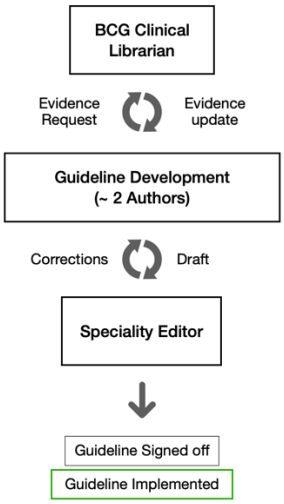


Figure 65 - BCG validation process (prior to app creation)

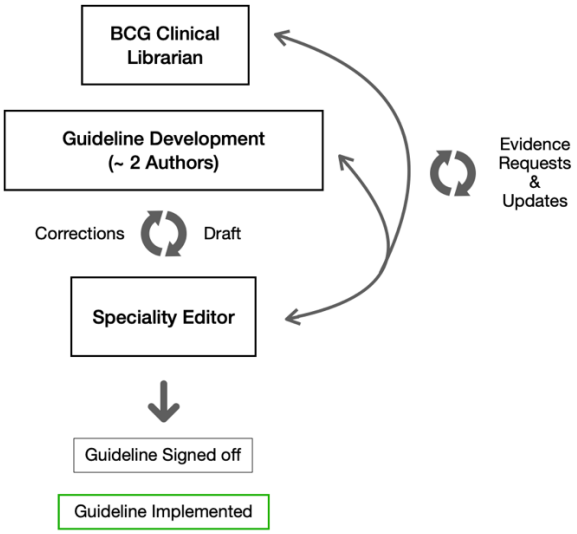


Figure 66 - Updated validation process for the BCGs

Figure 66 highlights the proposed BCG validation process adaptions. The BCG app allows for the updating of guidelines and evidence outside of the bi-annual process. This enables an improved workload management and enables more frequent updating of information. This has been evidenced to support clinical care (Petter and Fruhling, 2011). In later sections, the verification of the information is discussed separately (Section 7.3).

7.2. Working with a clinical guideline expert to re-author the BCGs

7.2.1. Introduction

Clinical knowledge is immensely complex (Gorry, Silverman and Pauker, 1978) and has a high rate of change (Wyatt and Spiegelhalter, 1991). Factors such as synonyms and abbreviations, as already discovered (section 5.3.6), can be ambiguous. The research discussed throughout this thesis has benefitted from the guidance and experience of clinicians. In particular, the reauthoring of complex medical guidelines made it necessary to involve a clinical expert. Typically, UCD methodology recommends multiple user input (Nielsen and Landauer, 1993; Maguire, 2001). However, limited access to clinicians and the need to have input from clinicians and clinical knowledge made it necessary to look at single person or expert studies (Yin, 2002). Razak, Hanis and Dix discusses the value of

single person studies where researchers can build up a relationship with a single user, leading to a deeper understanding of information or user needs that may otherwise appear relevant (Razak, Hanis and Dix, 2010). It also allows access to expertise that would otherwise require far more planning and availability. The BCGs delivers explicit knowledge to support the development of tacit knowledge, however the understanding of how this knowledge is applied and developed is a key aspect. The support of a clinical guidelines expert ensures that the guidelines can be reauthored to consider knowledge and clinical practice. The clinical guidelines expert was provided with the recommendations elicited during the UCD processes discussed in chapters 3 and 4. Each guideline contained in BCG Medical Guidelines were then subjected to a reauthoring process by the clinical guidelines expert and then converted for use in the BCG app. However, these did not include the further recommendations discussed in the section 6.8 conclusions. This section discusses the results of applying all of the recommendations and the overall impact on the BCGs and the BCG app.

7.2.2. The impact of applying the recommendations

In order to gain a better insight into the impact of working with a clinical guideline expert and applying the recommendations discussed in previous chapters, an analysis of these was undertaken. The following discusses the analysis of guidelines, specifically investigating the impact to the size of the guideline (word-count) and how the recommendation has impacted the components of the BCGs (i.e. Tables, Decision algorithms). Also discussed in this section is a single person study on the classification of warnings.

7.2.2.1. Methodology

To measure the impact the recommendations have had in authoring the guidelines, forty-six (n=46) clinical guidelines from the BCG medical guidelines were analysed pre and post re-authoring. The guidelines were originally written in Word (.docx) format by numerous clinical guideline authors and then re-authored with the clinical guideline expert, taking into account the recommendations identified in previous chapters (Chapter 4). The guidelines selected (n=46) were those that had been re-authored at the time of writing. It is worth noting that the remaining guidelines contained within the BCG medical guidelines are structured and written in similar ways. The selection however provides a broad range of guidelines.

The aim of this study was to:

- analyse the original word count
- Analyse the reduction of tables and flowcharts
- Analyse the introduction of the new decision algorithms in each guideline

These are useful to consider for a variety of reasons. As mentioned, tables can pose usability issues on mobile devices and presenting flowcharts or decision algorithms can be problematic in terms of mobile design constraints. The reduction of word count, or adapting the guidelines to be more succinct, has been evidenced to improve overall efficiency in terms of access to clinical information (Brumley et al., 2006).

7.2.2.2. Results

7.2.2.2.1. Word count reduction

The results of the word count analysis are presented in this section.

Table 22: Word count analysis after editing of guidelines

Guideline	Original Word Count	Word count after re-authoring	% Reduction
Respiratory failure	855	134	84.33
Screening for MRSA/SA and MGNB/ESBL/CPE	1105	184	83.35
Fluid deficit/maintenance management flowchart	1257	487	61.26
Clostridium difficile infection (CDI)	1230	534	56.59
Fluid resuscitation	1209	629	47.97
Delirium (acute confusional state) in older people	2250	1234	45.16
Community-acquired pneumonia	1811	1022	43.57
Infective endocarditis	1800	1022	43.22
Sepsis management	898	515	42.65
Acute heart failure	3020	1758	41.79
Hospital-acquired pneumonia	1343	796	40.73
Control of hyperglycaemia in the ill patient	1738	1034	40.51
Use of personal protective equipment	850	528	37.88
Spontaneous pneumothorax	511	347	32.09
Hand hygiene	741	525	29.15
Bleeding disorders in adults	1361	974	28.43
Management of falls in A&E and wards	1007	734	27.11
Cellulitis	904	688	23.89
Standard infection prevention measures	814	620	23.83
Acute hot joint, septic arthritis and gout	1182	908	23.18
Management of sickle cell disease	2182	1731	20.67
Spontaneous leucopenia or thrombocytopenia	496	410	17.34
Pleural infection and empyema	630	527	16.35
Maintenance fluid therapy	864	725	16.09
Exacerbation of chronic obstructive pulmonary disease (COPD)	872	765	12.27
HIV infection testing	1204	1059	12.04
Transient loss of consciousness (blackout/syncope)	883	781	11.55
Accelerated (malignant) hypertension	918	814	11.33
Hypothermia in older people	753	672	10.76
Neutropenic sepsis	1105	989	10.50
Fever in the returning traveller	989	919	7.08
Acute severe asthma in adults	1106	1035	6.42
Unstable angina	1077	1059	1.67
Management of hospitalised patients with MRSA	493	493	0.00
Management of patients with ESBL/MGNB	13	13	0.00
Triage of patients with hyperglycaemia	181	181	0.00

Cardiac arrhythmias	1442	1453	-0.76
Acute myocardial infarction	2002	2037	-1.75
Cardiac tamponade	324	333	-2.78
Diabetic ketoacidosis and hyperosmolar hyperglycaemic state	1277	1420	-11.20
Atrial fibrillation	1134	1300	-14.64
Thoracic aortic dissection	922	1111	-20.50
Community acquired meningitis	381	559	-46.72
Pleural effusion – investigation of	406	602	-48.28
Management of constipation in hospitalised elderly patients	325	532	-63.69
Management bleeding in patient on dabigatran or rivaroxaban	229	501	-118.78

Of the forty-six (n=46) guidelines analysed, nine (n=9) had an increased word count, the contributing factors to this are examined in the discussion section (6.3.4). Overall, the mean word count was reduced from 1045.52 to 797.7. This was an overall average reduction of 247.82, or 23%. In some guidelines (e.g. Control of hyperglycaemia in the ill patient) the word count was reduced by over 1000 words. It is important to note that the words or information reduced in each guideline were not deemed vital by the clinical expert. Each guidelines author is being consulted as part of the process to ensure robustness and quality. The word reduction is part of a mobile first approach in the design.

7.2.2.2.2. BCG Component analysis

Table 23: Component numbers in teh BCGs

Tables	42
Tables Removed	36
Remaining tables	6
New DAs	32
Flowcharts	15

There is also evidence of a substantial reduction in the number of tables (Table 23). The number of tables in the guidelines analysed was originally 42. After re-authoring, the number of tables was reduced by 36 to 6 tables, a reduction of 83%. Analysis shows that the original versions of the guidelines contained fifteen flowcharts or manual decision

algorithms, this was reduced to 0. In terms of the new decision algorithms (DAs) introduced in chapter 3, 32 were created in the guidelines analysed. These are comprised of either original decision algorithms being converted to the new format or text information that is not deemed to be required for immediate access (i.e. requires the clinician to complete steps).

Table 24: Warning numbers in the BCGs

# Warnings	130
# Warnings after re-authoring	28

As shown in Table 24, the original set of guidelines analyses contained warnings 130. After re-authoring, the number of warnings was reduced to 28. An example of a removed warning would be "***Please ensure you wash your hands***" from the hand hygiene guideline. Another example would be the "***If unfractionated heparin commenced – see*** **Heparin-induced thrombocytopenia** ***guideline***" from the Atrial Fibrillation guideline. These were deemed as obvious to the reader and therefore irrelevant as a warning, or more useful in context as it is not necessary to 'warn' the user. This resulted in a reduction of 78%. As already mentioned, these warnings were not deemed vital by the clinical expert.

These changes have been implemented based on following the recommendations set out in chapter 6 (section 6.8). The reduction in word count can be linked with the recommendations of reducing long sentences, providing information as succinctly as possible, and minimising the number of warnings/alerts to avoid 'alert fatigue'. Althought not a recommendation in terms of the 15 outlined in chapter 5, the reduction of tables is also a factor in the reduction of text. It is worth note that the word count reduction is despite the introduction of decision algorithms and calculation tools.

7.2.2.2.3. BCG Warning classification

Discussions were conducted with a single clinical expert on how warnings could be classified, the results of this are presented here. As mentioned in section 4.3.1.3 of chapter 4, it was evident that warnings needed to be reduced to avoid alert fatigue. It was also evident that warnings needed be classified in terms of hierarchy (i.e. importance and nature). This was discussed in the main results section of both focus groups, section 4.4.1 of Chapter 4. During the discussion it was determined that clinical information contained withing the warnings could be classified in terms of their relevant subject. To determine how they could be classified a card sort (Rugg and McGeorge, 1997) was conducted with a single clinical expert.

Methodology

A repeated single criterion card sort methodology (Rugg and McGeorge, 1997) was utilised as it provided a method of determining both the categories and how each warning could be categorised and sorted. The participant was provided with an overview of how card sorting is conducted and an example was provided using LEGO™ bricks. The participant was then asked to sort each brick into various categories (e.g. size, shape, colour). This gives the participant a foundation of understanding for how card sorting is conducted, as evidenced by Rugg and McGeorge as they suggest a 'toy example' for instructing participants (Rugg and McGeorge, 1997). An example of the LEGO™ bricks used is provided in Figure 67.

Figure 67 - Example of LEGO™ bricks used for instructing participants regarding Card Sorting

Card sort results

380 warnings were identified in an analysis of the BCG Medical Guidelines. The single expert was asked to sort a selection of 20 warnings selected at random from the BCG. Each of the warnings used are provided in Table 24. Warnings were tagged with an identifying number (i.e. which warning it was from the 380 identified), the warning text, which section of the medical guidelines it is taken from and the page number. These allowed each to be identified in terms of classification after the card-sorting session.

Table 25 - Card Sorting cards provided to the participant for single criterion card sorting

5	Date (day, month, year) and time (using 24 hr clock) each entry, sign it, print your name and GMC number legibly with a contact bleep number or, if no bleep, telephone number and your grade	*Medical Records*	*9*
12	Expressed consent must be recorded in patient's clinical records	*Consent*	*13*
26	If any lesions or recurrent skin infections, or if any decontamination product causes skin irritation, contact occupational health	*Hand Hygiene*	*34*

39	IV adrenaline is hazardous, use only with extreme care, and under critical care supervision, for those in profound shock that is immediately life-threatening	*Acute Anaphylaxis*	*57*
45	Immediate treatment and investigations must run simultaneously	*Hypotention*	*65*
51	In the elderly, confusion can occur as the only symptom of meningitis in the absence of meningism or even of fever	*Community-Aquired Meningitis*	*70*
69	If Gram-negative bacilli grown in blood of patient returning from a typhoid endemic area (e.g. Indian sub-continent), give ceftriaxone 2 g IV by infusion daily; do not use ciprofloxacin as many strains of Salmonella typhi are resistant.	*Fever in a returning traveller*	*81*
85	Administer insulin and glucose infusions via same cannula using anti-siphon and anti-reflux valves (e.g. Vygon Protect-A-Line 2 extension set) through a large peripheral vein or central line – see Administration of IV insulin infusions and fluid infusions guideline	*Diabetic Ketoacidosis and Hyperosmolar Hyperglycaemic state.*	*102*
87	Blood glucose may rise as a result. Do not revert to sodium chloride 0.9%	*Diabetic Ketoacidosis and Hyperosmolar Hyperglycaemic state.*	*103*
91	Further information available from clinical biochemistry or from renal or endocrine teams	*Electrolyte Disturbances*	*108*
96	If cause not obvious, refer to renal or endocrine team for further evaluation	*Hypercalcaemia*	*111*

160	Gentamicin and vancomycin require careful monitoring, especially in patients with renal impairment. Monitor for signs of deafness and balance problems which may occur at normal levels	*INFECTIVE ENDOCARDITIS*	*166*
179	BEWARE: suspected basal pneumothorax usually implies a bulla. CT scan and previous chest X-rays will differentiate bullae from pneumothorax	*SPONTANEOUS PNEUMOTHORAX*	*189*
184	En-route to CCU, ensure patient is accompanied by a doctor (usually an anaesthetist) prepared to intubate if patient's clinical condition requires it	*ACUTE SEVERE ASTHMA IN ADULTS*	*192*
210	Check on Clinical information system (CIS) whether patient tagged for extended spectrum beta-lactamase-producing Gram-negative bacilli (ESBL), methicillin-resistant Staphylococcus aureus (MRSA), multi-resistant Gram-negative bacilli (MGNB) or Carbapenemase-producing Gram-negative bacilli (CARB)	*PLEURAL INFECTION AND EMPYEMA*	*209*
223	Manage patients with antiphospholipid syndrome who have an acute ischaemic stroke in the same way as patients with acute ischaemic stroke without antiphospholipid syndrome	*ACUTE STROKE*	*225*
227	Consider all patients with TIA who are in atrial fibrillation (AF) as high risk TIA irrespective of whatever the ABCD2 score is	*TRANSIENT ISCHAEMIC ATTACK (TIA)*	*228*
235	Patients whose renal function continues to decline (even if creatinine <300 µmol/L) despite initial resuscitation – refer to renal team within 48 hr of diagnosing ARF/AKI	*ACUTE KIDNEY INJURY (acute renal failure)*	*241*
287	Above weights should be used to calculate both maintenance and loading dose (if appropriate)	*AMINOPHYLLINE*	*304*

347	All pleural procedures should be performed under ultrasound guidance by a trained operator or under the supervision of a fully competent individual	*INTERCOSTAL TUBE DRAINAGE*	*355*

The results of the card sorting produced several categories. The clinical expert suggested to sort into Risk, workflow, and finally subject. The initial card sort produced two categories (n=2). The second card sort expanded these to three categories (n=3). The fourth card sort produced four new categories (n=4). Finally, the fourth card sort produced six categories (n=6), although not all cards could be sorted into these categories.

Table 26 - Card sort 1 - 4, categories created

Card Sort 1 Categories
High Risk
Low Risk

Card Sort 2 Categories
High Risk
Intermediate Risk
Low Risk

Card Sort 3 Categories
Background/Info for Patient Management
Referal
Admin
General Guidance

Card Sort 4 Categories
Management
Investigations
Diagnosis
Drug
Info
Biology (Bio)

Each of the card sorting rounds were recorded. The results are provided in Tables 27 to 30. Images of the original sorting sessions can be found in appendix 6.

Table 27 - Card sort 1 categories and cards

High Risk	**Low Risk**
12	45
85	287
227	91
39	87

210	51
184	223
347	96
235	26
160	5
179	89

Table 28 - Card sort 2 categories and cards

High Risk	Intermediate Risk	Low Risk
85	12	91
227	45	87
39	287	223
210	51	96
184	69	5
179	347	
	235	
	160	
	26	

Table 29 - Card sort 3 categories and cards

Background	Referral	Admin	General Guidance
223	235	12	187
210	347	5	85
69	26		45
287	96		160
51	91		
227	184		
179	39		

Table 30 - Card sort 4 categories and cards

Management	Investigations	Diagnosis	Drug	Info	Bio (Biology)
184		91	85	12	87
12		69		91	
85					
45					

Application of the card sorting categories to all warnings

This aspect of the research was designed with the aim to pilot if card sorting would be a useful tool in providing categories and hierarchy to the 380 warnings contained within the BCG Medical Guidelines. The single repeated criterion card sorting method produced criterion such as ‘risk level’, ‘management’ or ‘diagnosis’. In further sessions conducted as part of a single person study with a clinical expert, these criteria were applied to clinical warnings contained within the BCG guidelines. During these sessions the clinical expert

categorised 100 warnings over three sessions. The warnings were categorised based on the card sorting categories produced in sort 2, shown in Table 28, as this seemed to be the most relevant to implement. During this session, it was suggested by the clinical expert that some warnings should also be contained in a further 'VERY HIGH RISK' category and as such the coding session was adapted to include this. Each warning was also coded based on the categories derived during the 4th card sort, shown in Table 30.

Table 31 shows the results of the initial analysis of the 100 coded warnings. The majority (n=43) were coded as Intermediate level, with 25 and 20 warnings coded as high and low respectively. Few warnings were classified as VERY HIGH (n=5).

Table 31 - Clinical warning hierachy classification based on risk

V. High	High	Int	Low
5	25	43	20

Of the 100 coded warnings (#1-100 of 380 warnings in the BCG Medical Guidelines), 7 were deemed inappropriate and therefore not categorised. On attempting to categorise warnings in terms of the categories presented in Table 31, it was apparent that the time required would be unsuitable for the limited availability of the clinical expert. At this stage, the clinical expert categorised the warnings over a longer period of time (~3 weeks). During this category analysis, it was evident further categories of analysis were required. The clinical expert also classified each of the warnings (if possible) in terms of their likelihood of occurrence, in terms of illness or diagnosis, and the severity. The clinical expert provided an analysis of method and process:

Risk

Problem: If we classify risk, will people ignore lower level? A risk of 100 chance of occurring will still means 1 in 100 patients will be harmed.

A risk ranking of a warning box might be classified in two parts:

1. *If clinician does not follow advice in the box, likelihood of event happening*
2. *Severity of event*

These could be classified by analysis looking at the evidence. At the very least, speciality authors must classify risk for warning boxes-authoring tool

For each warning box, we need to record:

- *Event trying to avoid*
- *Likelihood*
- *Severity*

The clinical expert also classified each warning in terms of the following:

1 = swift action

2 = Stop hasty/over zealous action/drug interactions /point to which of two or more paths in guideline to take

3 = Referral

4 = When not to use this guideline/ Use appropriate guideline

5 = Order of action/ use appropriate equipment/ correct doses calculations

6 = Important statement applying whenever guideline is implemented

9 = Inappropriate

However, after the clinical expert had classified 380 warnings in terms of appropriateness, risk, and adding further comments in terms of context and analysis, it was determined that warning classification was extremely complex and would require dedicated research in terms of repeated studies and further analysis, all of which were outside the scope of this study. The full results of the 380 warnings analysis are provided in appendix 7. Warnings were therefore classified in terms of severity (Red, Amber and Blue), as discussed in section 5.4.7 of Chapter 5.

7.2.3. Discussion

Section 6.3.2 presents the impact of applying the recommendations discussed in previous chapters (3 and 4). It is evident that the recommendations have enabled more succinct guidelines to be authored. The overall word count reduction of 23% evidences the reduction and therefore a more efficient set of guidelines (in line with efficiency proven through usability testing, see Chapter 6). The reduction in word count, tables and flowcharts contributes to a more usable system on mobile devices, as discussed in other chapters 3, 4 and 6. In some cases (see Table 22), the word count increased. This was due to several factors, the amalgamation of tables and flowcharts into the main text or where guidelines have been merged. Another factor of increased wordcount is the repetition of warning text within each guideline. Although, the results do highlight the number of warnings contained within each guideline were reduced significantly.

Reading rate was considered as a method of measuring efficiency. However, with limited access to clinicians and a dichotomy between readability for the general population and experts, it would be extremely difficult to accurately measure reading rate for each

guideline - this is evidenced in a study by Bruce et al. (Bruce, Rubin and Starr, 1981). The reading ease of the guidelines has an average score of 29.5 on the Flesch reading ease scale (Flesch, 1948), meaning complex language is used (as expected) and therefore would be difficult to test without clinical knowledge.

Warnings are clearly complex in terms of simplifying their presentation through categorisation and risk factors. It is difficult to determine how to present such information from the results obtained during the card sorting study. It does however highlight the need in working with a clinical expert. The card sorting pilot highlighted the complexity of clinical warnings at an early stage and therefore reduced the risk of conducting research that would not have been beneficial with other clinicians who have extremely limited access.

7.3. Information verification

7.3.1. The need for information verification

As the guidelines are adapted to conform to the recommendations set out in previous chapters, it is imperative the information is validated (Ventola, 2014b). This will ensure patient safety and validate the correctness of the guideline information, necessary for CE certification and clinical user trust (Shekelle et al., 2001; Wyatt and Lewis, 2014). To this end, a verification process was established to ensure the information being converted from the re-authored .docx files to the BCG app format was correct, this was highlighted in section 6.2.2. The following sections describe the development of the verification process.

7.3.2. Guideline comparison tool development

A simple text comparison tool was utilised to highlight inconsistencies in the two versions of text. As the process of converting the .docx files to a format compatible with the BCG app is manual, a simple verification stage was added to ensure correctness.

The tool was developed using HTML, CSS and JavaScript. The tool predominantly utilises jsdiff, a JavaScript tool based on the O(ND) Difference Algorithm and its variations (Myers, 1986).

A

```
FLUID RESUSCITATION
INITIAL MANAGEMENT
•       Use ABCDE approach
•       Treat cause of fluid deficit
•       All resuscitation treatment is given as boluses of fluid in addition to, or before starting, maintence fluids
•       Continue prescribed maintenance fluid therapy concurrently with resuscitation therapy
•       Use clinical assessment rather than cumulative maintenance volumes administered when predicting required
resuscitation volume




Volume of initial fluid
In patients at risk of pulmonary oedema because of heart failure, reduce fluid bolus volume by half
Fluid deficit none/mild
•       Encourage patient to drink and/or give patient fluids enterally – see Practice and ethics of nutritional support
in medical patients guideline especially if any complex fluid or electrolyte problems. Otherwise move to IV MAINTENANCE
FLUIDS guideline
```

B

```
FLUID RESUSCITATION
Search to filter sections
INITIAL MANAGEMENT
Use ABCDE approach
Treat the cause of fluid deficit
All resuscitation treatment is given as boluses of fluid in addition to, or before starting, maintenance fluids
Continue prescribed maintenance fluid therapy concurrently with resuscitation therapy
Use clinical assessment rather than cumulative maintenance volumes administered when predicting required resuscitation
volume
Hypotonic or potassium-rich maintenance fluid is inappropriate/dangerous when given in large volumes required for
resuscitation
Volume of initial fluid
In patients at risk of pulmonary oedema because of heart failure, reduce fluid bolus volume by half

Fluid deficit none/mild

Encourage patient to drink and/or give patient fluids enterally – see Practice and ethics of nutritional support in
medical patients guideline especially if any complex fluid or electrolyte problems. Otherwise, move to IV MAINTENANCE
FLUIDS guideline
```

C

```
FLUID RESUSCITATION
Search to filter sections
INITIAL MANAGEMENT
•       Use ABCDE approach
•       Treat the cause of fluid deficit
•       All resuscitation treatment is given as boluses of fluid in addition to, or before starting, maintenance fluids
•       Continue prescribed maintenance fluid therapy concurrently with resuscitation therapy
•       Use clinical assessment rather than cumulative maintenance volumes administered when predicting required
resuscitation volume
Hypotonic or potassium-rich maintenance fluid is inappropriate/dangerous when given in large volumes required for
resuscitation




Volume of initial fluid
In patients at risk of pulmonary oedema because of heart failure, reduce fluid bolus volume by half

Fluid deficit none/mild
•
Encourage patient to drink and/or give patient fluids enterally – see Practice and ethics of nutritional support in
medical patients guideline especially if any complex fluid or electrolyte problems. Otherwise, move to IV MAINTENANCE
FLUIDS guideline
```

*Figure 68 - Guideline Comparison tool output - **A**, App version of the Guideline. **B**, Original Guideline Text extracted from an MS Word file. **C**, Comparison output*

As highlighted in Figure 68, the jsdiff tool allows comparison of the original document and the converted version of each guideline. This enabled inconsistencies to be highlighted to ensure no errors have been induced.

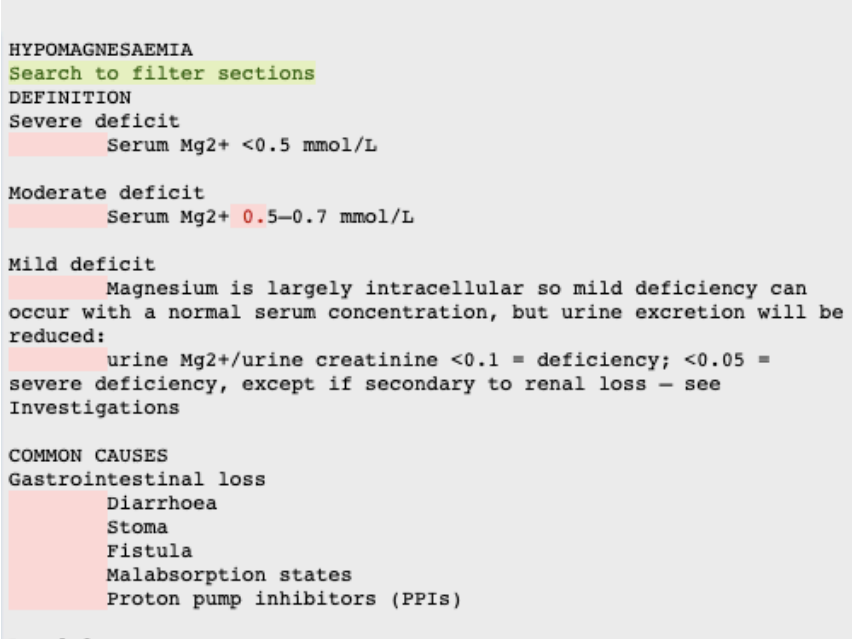


Figure 69 - JavaScript Comparison tool highlighting an error with a decimal point missing from the converted guideline

Figure 69 shows how the tool highlight inconsistencies in text. Yellow highlighting signifies text not in the original version, red highlighting signifies text that differs from the original version. In the example highlighted (Figure 69), an error had occurred where a decimal point was missed, this would have caused a potential dosage error possibly leading to clinical error. This highlights the need for such a tool when information is changed from its original format. It also provides an excellent initial verification process which saves time during manual verification.

7.3.3. Manual verification (Data validation)

The main method of assessing the accuracy of the BCGs converted for us in the BCG app was using manual validation. A proof-reading method is utilised to verify each guideline.

The method requires the researcher to read original documents as the clinical guideline expert checks the software system version. Automated methods could be investigated for future work but are out of scope for this project. Figure 70 shows an overview of the process used.

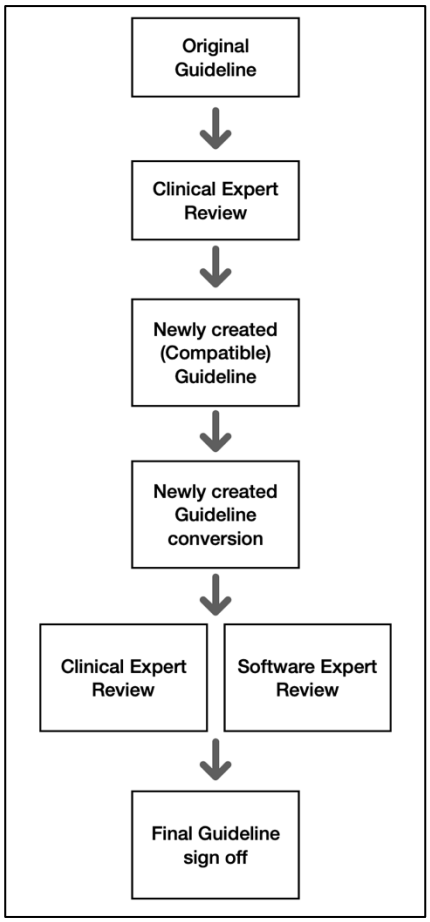


Figure 70 - Overview of the manual adaption and verification process involving a clinical expert

7.4. Further aspects impacted by the use of clinical guideline experts

7.4.1. Guideline evidence

Another expert utilised during the development of the BCG app was the clinical guidelines Librarian. The BCG Librarian workflow was provided during the initial stages of the project in order to establish an understanding of how the BCGs are created and maintained. The librarian's goals are as follows:

- Track and record up-to-date research on all guidelines.

- Share research with authors for inclusions in amendments/updates of each guideline.
- Answer and evidence questions from authors.
- Maintain a 'supporting information' document for each guideline.
- Updates/Checks - completed bi-monthly.

Figure 71 shows the BCG Librarian's process of collecting evidence for each guideline and dealing with queries during and after guideline updates.

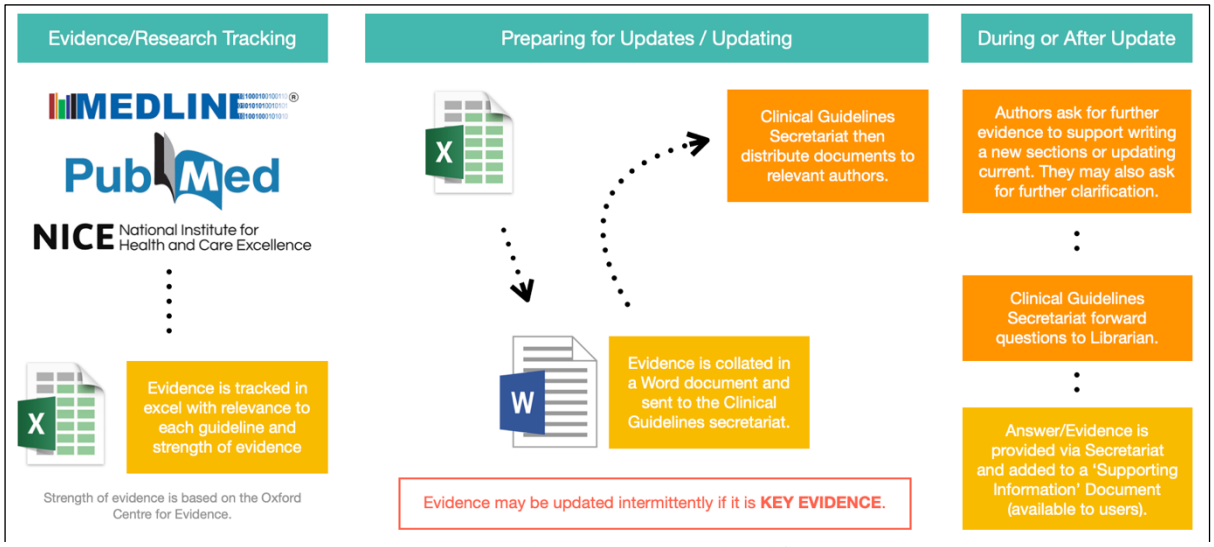


Figure 71 - BCG Librarian process and workflow

Each guideline is based on clinical evidence. The evidence is graded from 1-5, depending on the source or process the information is derived. This grading is provided by NICE (https://www.nice.org.uk/process/pmg6/chapter/reviewing-the-evidence). Although grading does not impact the development of the clinical guidelines, the use of evidence to develop and update the guidelines needs to be considered. It is evident through the numerous queries from clinicians that information regarding evidence should be provided to clinicians (e.g. in the form of external sources). Recent research does suggest that access to evidence and further information can impact learning and understanding (Daei et al., 2020; Gallagher-Ford et al., 2020). As mentioned in the literature review in Chapter 2,

research that reviewed several applications designed for hospital or clinical use, stated that the applications lacked evidenced based content (Boulos et al., 2014). A method of accessing evidence for each guideline was implemented into the BCG app, as shown in Figure 72.

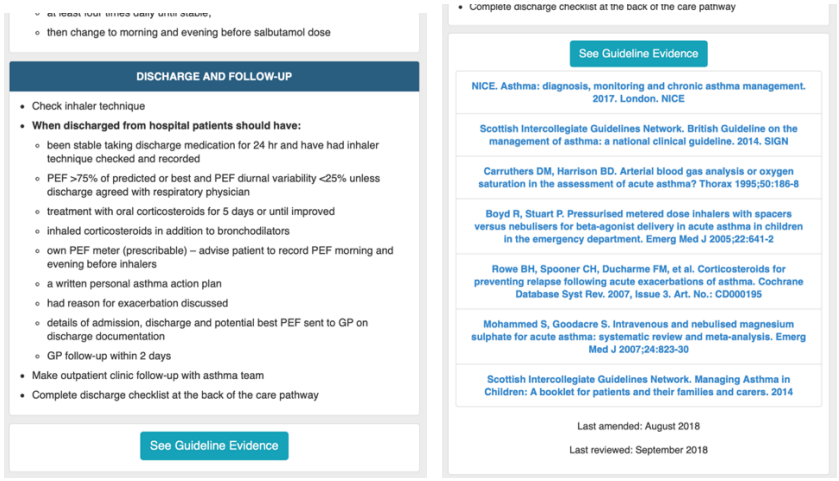
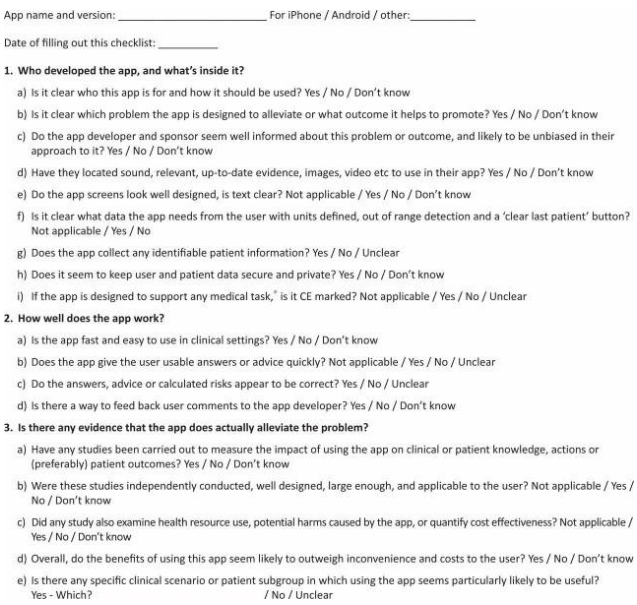


Figure 72 - Guideline evidence presented in an accordion view for clinicians to access

7.5. Comparing the BCG app with current recommendations

As mentioned in the above summary, the need for validation and information verification is an important aspect of clinical software. Wyatt et al. state the vast majority of medical apps remain without any form of regulation or safety check, and some of these may present a patient safety or other risk (Wyatt et al., 2015). In this 2015 paper Wyatt et al. introduced the Royal College of Physicians (RCP) Health Informatics Unit checklist . The study developed and piloted an 18-item checklist to help clinicians assess the structure, functions, and impact of medical apps. The checklist assess the app internals in terms of development, the apps functionality, and if the app alleviates a problem.

The checklist is outlined below:



App name and version: _____ For iPhone / Android / other:_____

Date of filling out this checklist: _____

1. **Who developed the app, and what's inside it?**
   a) Is it clear who this app is for and how it should be used? Yes / No / Don't know
   b) Is it clear which problem the app is designed to alleviate or what outcome it helps to promote? Yes / No / Don't know
   c) Do the app developer and sponsor seem well informed about this problem or outcome, and likely to be unbiased in their approach to it? Yes / No / Don't know
   d) Have they located sound, relevant, up-to-date evidence, images, video etc to use in their app? Yes / No / Don't know
   e) Do the app screens look well designed, is text clear? Not applicable / Yes / No / Don't know
   f) Is it clear what data the app needs from the user with units defined, out of range detection and a 'clear last patient' button? Not applicable / Yes / No
   g) Does the app collect any identifiable patient information? Yes / No / Unclear
   h) Does it seem to keep user and patient data secure and private? Yes / No / Don't know
   i) If the app is designed to support any medical task,* is it CE marked? Not applicable / Yes / No / Unclear
2. **How well does the app work?**
   a) Is the app fast and easy to use in clinical settings? Yes / No / Don't know
   b) Does the app give the user usable answers or advice quickly? Not applicable / Yes / No / Unclear
   c) Do the answers, advice or calculated risks appear to be correct? Yes / No / Unclear
   d) Is there a way to feed back user comments to the app developer? Yes / No / Don't know
3. **Is there any evidence that the app does actually alleviate the problem?**
   a) Have any studies been carried out to measure the impact of using the app on clinical or patient knowledge, actions or (preferably) patient outcomes? Yes / No / Don't know
   b) Were these studies independently conducted, well designed, large enough, and applicable to the user? Not applicable / Yes / No / Don't know
   c) Did any study also examine health resource use, potential harms caused by the app, or quantify cost effectiveness? Not applicable / Yes / No / Don't know
   d) Overall, do the benefits of using this app seem likely to outweigh inconvenience and costs to the user? Yes / No / Don't know
   e) Is there any specific clinical scenario or patient subgroup in which using the app seems particularly likely to be useful? Yes - Which? / No / Unclear

Table 32 shows the analysis of the BCG app against the Wyatt et al. checklist and discusses how each criteria has/has not been met.

Table 32: Comparison of the BCG app with the RCP Checklist

Criteria	Criteria Met	Evidence
Who developed the app, and what's inside it?		
a) Is it clear who this app is for and how it should be used?	Y	Observations, Survey, User Testing
b) Is it clear which problem the app is designed to alleviate or what outcome it helps to promote?	Y	UCD Methods, previous use of the Bedside Clinical Guidelines
c) Do the app developer and sponsor seem well informed about this problem or outcome, and likely to be unbiased in their approach to it?	Y	UCD Methods, previous use of the Bedside Clinical Guidelines, Working with a clinical expert
d) Have they located sound, relevant, up-to-date evidence, images, video etc to use in their app?	Y	Updated by the Clinical Guidelines Librarian and provided in app
e) Do the app screens look well designed, is text clear?	Y	Designed with best practice and iterations based on feedback
f) Is it clear what data the app needs from the user with units defined, out of range detection and a 'clear last patient' button?	Y	Units are clear with examples, clear boundaries have been set in terms of calculation data, and each calculation tool or decision algorithm has a reset button
g) Does the app collect any identifiable patient information?	N	No identifiable patient data is collected
h) Does it seem to keep user and patient data secure and private?	N/A	-
i) If the app is designed to support any medical task,* is it CE marked?	N/A	This is currently in progress
2. How well does the app work?		
a) Is the app fast and easy to use in clinical settings?	Y	Using clinical scenarios during the think-aloud sessions evidenced that users can accurately and rapidly assimilate the information

Criteria	Criteria Met	Evidence
b) Does the app give the user usable answers or advice quickly?	Y	As above
c) Do the answers, advice or calculated risks appear to be correct?	Y	Information has been validated working with a clinical expert
d) Is there a way to feed back user comments to the app developer?	Y	This will be provided in app as part of the next stage of pilot testing
3. Is there any evidence that the app does actually alleviate the problem?		
a) Have any studies been carried out to measure the impact of using the app on clinical or patient knowledge, actions or (preferably) patient outcomes?	N	This is planned for the next stages of the study
b) Were these studies independently conducted, well designed, large enough, and applicable to the user?	N/A	-
c) Did any study also examine health resource use, potential harms caused by the app, or quantify cost effectiveness?	N	This is planned for the next stages of the study
d) Overall, do the benefits of using this app seem likely to outweigh inconvenience and costs to the user?	Y	There is very little cost to the user as the BCGs are already utilised as part of clinical workflow
e) Is there any specific clinical scenario or patient subgroup in which using the app seems particularly likely to be useful?	Y	Bedside information retrieval

As evidenced in Table 32, the majority of the checklist criteria is met by the BCG app. This is especially true for sections 1 and 2 (The app functionality/development and usability). In terms of section 3 there are several criteria that have not been met as these require further study. Measuring the impact on aspect such as clinical knowledge, actions and patient outcomes requires longitudinal studies for accurate and relevant data. However, it is worth noting that the BCGs have been in use for over 20 years and as the app utilises the BCGs, it could be summised that these criteria will be met without issue once the app has been piloted and released. The app should also be approved for use as a *Class 1* Medical Device, as per the MHRA UKCA mark criteria (formally CE mark) (MHRA, 2021).

7.6. Summary

This chapter has highlighted the impact the recommendations have had on the content of the BCGs. The application of the recommendations has had a significant impact on how the BCGs are authored and presented. By reducing the word count, tables and manual decision algorithms (flowcharts), the guidelines conform to a set of usability

expectations/recommendations that benefit clinical users. Evidence provided in usability testing throughout the development of the prototype BCG app highlights the high usability rating and therefore the positive impact of applying these recommendations.

Also highlighted is the necessity of working with a clinical expert to ensure the medical information contained within the BCG app remains valid and can be verified through simple checking processes. This study suggests that validation of information should be completed at all stages. At present BCG clinical guidelines do not have a validation process after the initial authoring and conversion for use in mobile device applications will require changes, as discussed, in the process of how they are designed, validated, and verified. The guidelines also need to present evidence to allow for an overview of how they are created. This can contribute to trust and learning. The outcome of the card sort and verification process highlights the complexity of clinical information, both in terms of knowledge requirement and methods of categorising the information.

8. Chapter 8 – Synthesis

This synthesis chapter discusses the findings of this thesis in relation to the research aims outlined in the introduction of this work. The overall aims are as follows:

- Utilise UCD to elicit data from clinicians that informs the development of a clinical guidelines mobile applications
- Develop a novel set of recommendations for the delivery of clinical guidelines on mobile devices
- Measure the impact of these recommendations on clinical guidelines (utilising a clinical expert)

8.1. Introduction

This research aimed to investigate and develop efficient methods for presenting and authoring clinical guidelines for use on mobile devices. A prototype mobile application was developed using best practice and heuristic evaluation. The results contributed to a set of recommendations for presenting clinical guidelines on mobile devices (Chapter 6). The results are indicative that a user centred design approach can be utilised to investigate methods of presenting and authoring clinical guidelines for mobile devices. Figures 73 and 74 are an example of how the guidelines have been adapted for mobile. These aspects are discussed in the following sections.

A

ACUTE SEVERE ASTHMA IN ADULTS • 1/3

RECOGNITION AND ASSESSMENT

- Complete the asthma pathway for **ALL patients** attending emergency portals with an asthma exacerbation

Symptoms and signs

- Cannot complete sentences in one breath
- Respiration ≥25 breaths/min
- Pulse ≥110 beats/min
- Use of accessory muscles
- Peak expiratory flow (PEF) <50% of predicted (**Figure 1**) or best (if known)

Life-threatening features

- PEF <33% of predicted (**Figure 1**) or best (if known)
- SpO_2 <92%
- Silent chest, cyanosis, or feeble respiratory effort
- Bradycardia or hypotension
- Exhaustion, confusion or coma

Patients with severe or life-threatening attacks may not be distressed and may not have all these abnormalities. The presence of any one of these should alert the clinical team

Investigations

The only investigations needed before **immediate treatment** are:

- PEF
- Oximetry

If SpO_2 <92% or patient has any life-threatening features or not responding to treatment, measure arterial blood gases (ABG)

ABG markers of a life-threatening attack

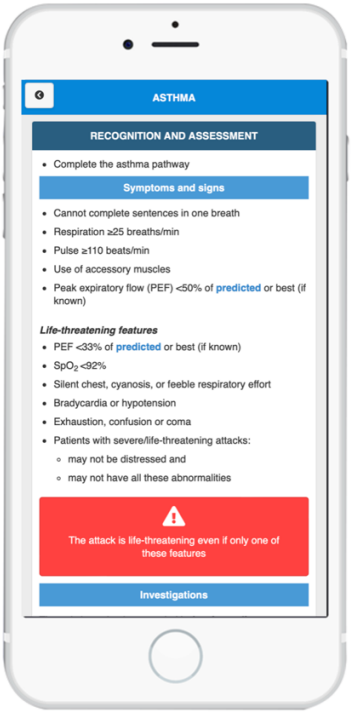
- Normal or high $PaCO_2$ (>4.6 kPa)
- Severe hypoxia: PaO_2 <8 kPa irrespective of treatment with oxygen
- Low pH (or high H^+)

IMMEDIATE TREATMENT

- Oxygen: follow **Oxygen therapy in acutely hypoxaemic patients** guideline (CO_2 retention not usually aggravated by oxygen therapy in asthma)
- Terbutaline 10 mg or salbutamol 5 mg plus ipratropium 500 microgram via oxygen-driven nebuliser 6–8 L/min oxygen
- Prednisolone tablets 40 mg (if taking maintenance prednisolone, increase daily dose by 40 mg; maximum 60 mg) or hydrocortisone (preferably as sodium succinate) 100 mg slow IV bolus, or both if very ill
- No sedatives of any kind
- If patient has coincident chronic bronchitis (regularly produces sputum), consider antimicrobial treatment
- Chest physiotherapy **not** indicated
- Assess and treat hypovolaemia and electrolyte imbalance – see **Fluid resuscitation** guideline, **Maintenance fluid therapy** guideline and **Electrolyte disturbances** guidelines

Further investigations

- Chest X-ray
  - if not responding to treatment or to exclude pneumothorax, consolidation or life-threatening exacerbation
- U&E (use green top bottle for accurate K^+ level)
- FBC
- If patient on maintenance theophyllines – take bloods for therapeutic levels



B

ACUTE SEVERE ASTHMA IN ADULTS • 2/3

Patients with life-threatening features

DO NOT LEAVE THE PATIENT. Ask medical SpR, staff physician or consultant physician, ideally respiratory, to review urgently

- Give magnesium sulphate 2 g made up to 50 mL with sodium chloride 0.9% by IV infusion over 20 min if not already given earlier (e.g. in ambulance). Ensure cardiac monitoring and oximetry *in situ*. Never give a second dose of magnesium sulphate without discussion with consultant respiratory physician
- **Speak to critical care unit (CCU) and transfer patient urgently if continues to deteriorate with:**
  - falling PEF, worsening or persisting hypoxia, or hypercapnia
  - exhaustion, feeble respirations, confusion, or drowsiness
  - coma or respiratory arrest

En-route to CCU, ensure patient is accompanied by a doctor (usually an anaesthetist) prepared to intubate if patient's clinical condition requires it

SUBSEQUENT MANAGEMENT

- Admit to a respiratory ward
  - lower threshold for admission in patients attending with history of non-adherence, lives alone, mental health issues, learning difficulties, previous near fatal attack, presenting at night, pregnancy, difficult asthma
- Correct disturbances in fluid and electrolyte balance, especially potassium (K^+)

If patient requires IV fluid with potassium, always use commercially produced pre-mixed bags of sodium chloride 0.9% and potassium chloride. NEVER add potassium chloride to infusion bags

If patient improving

- Continue oxygen – to maintain SpO_2 >94% (see **Oxygen therapy in acutely hypoxaemic patients** guideline)
- Prednisolone daily at dose in **Immediate treatment** section, or hydrocortisone 100 mg 6-hrly as slow IV bolus over 1 min if unable to tolerate oral medication
- Nebulised salbutamol 2.5 mg plus ipratropium 250 microgram 6-hrly
- Continue regular inhaled/oral preventer medication

Fax referral to clinical nurse specialist in asthma on 74072 or call 74068 to review patient

- Change to discharge medication 24 hr before discharge and check inhaler technique

If patient not improving after 15–30 min

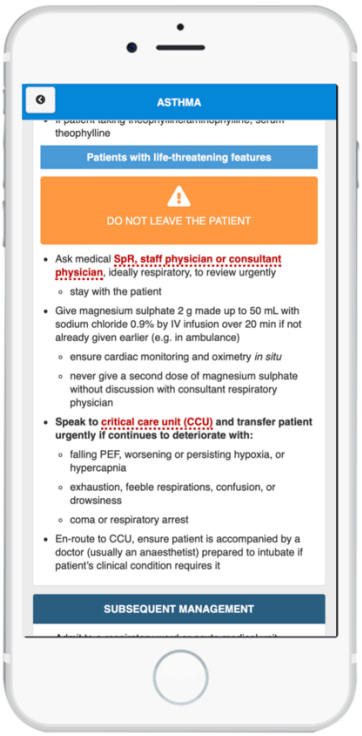
- Continue oxygen to maintain SpO_2 >94%
- Give nebulised salbutamol 5 mg more frequently, up to every **15–30 min** – see **Monitoring treatment**
- Give ipratropium 500 microgram 4-hrly until patient improving
- Once patient improving, reduce nebulised salbutamol to 2.5 mg and ipratropium to 250 microgram 6-hrly

If patient still not improving

Ask medical SpR, staff physician or consultant physician, ideally respiratory, to review urgently

- Give magnesium sulphate 2 g made up to 50 mL with sodium chloride 0.9% by IV infusion over 20 min if not already given earlier (e.g. in ambulance). Never give a second dose of magnesium sulphate without discussion with consultant respiratory physician
- Senior clinician to consider use of aminophylline or salbutamol by infusion – see **Aminophylline** guideline and **Salbutamol** guideline for doses. If patient already taking oral theophylline **DO NOT** give loading dose IV aminophylline
- **If any life-threatening features present (see above), transfer to CCU and refer to respiratory physician**

En-route to CCU, ensure patient is accompanied by a doctor (usually an anaesthetist) prepared to intubate if patient's clinical condition requires it



C

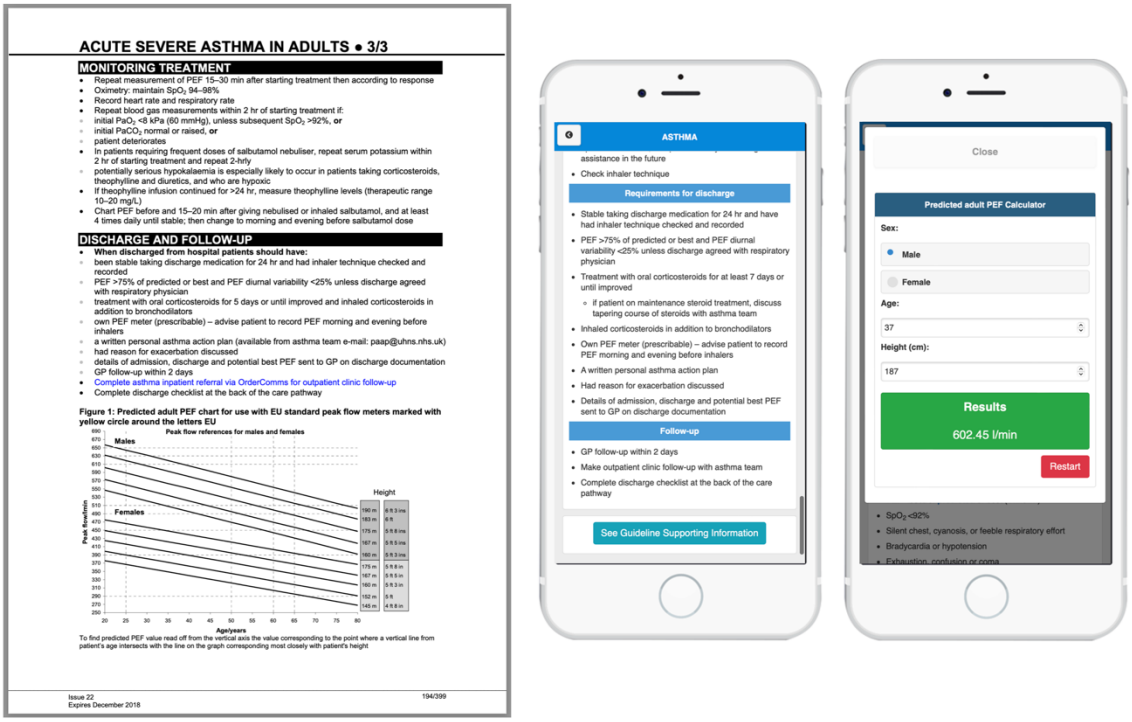


Figure 73 – Example of how a medical guideline (Asthma) has been adapted based on the recommendations

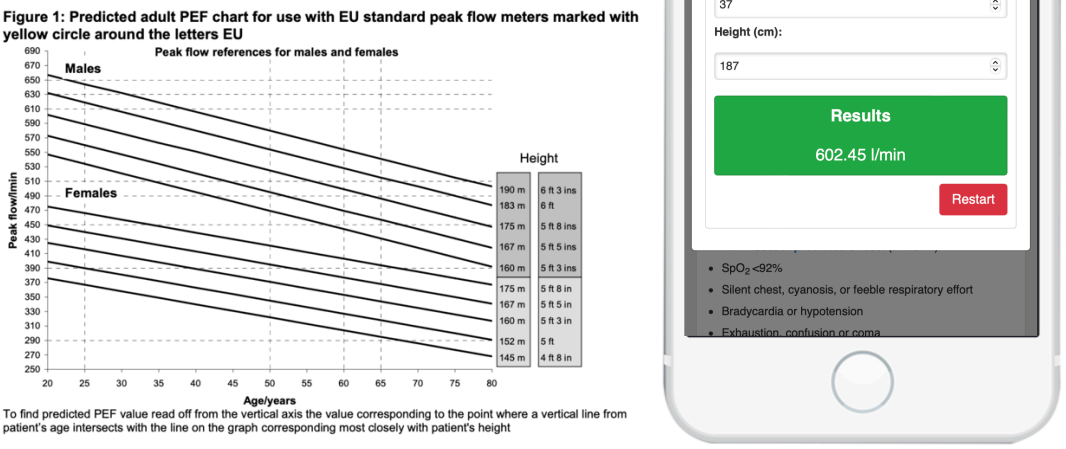


Figure 74 - PEF calculation changes (book - left, App - right)

Image *A* in Figure 73 shows the changes to the warnings and layouts. Blue inline links to the calculation tool (PEF) can also been seen. Image *B* shows the amber warning in line with the guideline, clearly more salient in comparison to the original. Image *B* also shows red text which in future iterations will contain local information i.e. specific forms the clinician is required to complete. Image *C* shows the discharge changes and the graph to calculation tool conversion, this is shown in more detail in Figure 74.

8.2. **Presenting clinical guidelines**

Observations were conducted to establish an understanding of clinical technology use and the use of clinical information (specifically clinical guidelines) in an acute hospital environment. The observations highlighted several behaviours in relation to technology use and interaction with clinical information.

The impact of clinical interruptions has long been established (Westbrook et al., 2018) and this study echoes these findings. The use of clinical technology in terms of junior and senior clinicians is also established. A recent study by Patel et al. (Patel et al., 2015) highlighted both use and perceptions of clinicians with varying roles and experience. In terms of mixed technology use, studies by Payne, et al. (Payne, Wharrad and Watts, 2012), Mobasheri, et al. (Mobasheri et al., 2015) and O'Connor and Andrews (O'Connor and Andrews, 2016), all found an inconsistent and mixed-use of technology within clinical environments. It was very clear during observations that the mixed use of technology was evident throughout. A contributing factor is the inconsistent implementation of clinical technology. This could be linked to the fact that clinicians appeared to utilise personal technology for knowledge retrieval and only utilised hospital provided technology where system access is limited (e.g. Health Data). It was interesting to find that dedicated apps appeared to be the preferred method, however this should be investigated further utilising surveys and interviews to

establish a deeper understanding of these behaviours. It does offer a key insight into the use of technology in a clinical environment.

A survey was conducted inline with the observation study. The survey was developed with the aim of understanding current smartphone and application usage amongst clinicians and medical students. The survey section (Chapter 3, section 3.2) highlights several studies which have conducted similar surveys in other UK NHS trust (Payne, Wharrad and Watts, 2012; Mobasheri et al., 2015; O'Connor and Andrews, 2016). All of these studies has consistent findings in smartphone preference and ownership. The limitations of these studies were also discussed (Chapter 3). The survey conducted as part of this research highlighted several factors that clearly showed a mixed use of clinical applications outside of a core set (BNF, MDCalc, MicroGuide). As discussed, (chapter 3), this variation in app use could have several contributing factors (age, role, personal preference). The observations and survey studies contributed to an initial set of recommendations; these were then utilised along with best practice to produce a prototype BCG application. The results also highlight to need to investigate specific application use in terms of patient treatment and consistency.

Using the prototype designed in Chapter 4, focus groups were conducted to identify the perceptions of clinicians and highlight general and usability errors. This builds upon studies by Payne et al and Kwa (Payne, Weeks and Dunning, 2014; Kwa et al., 2015). However, the focus of this research was to investigate how clinical information could be displayed and not just accessed. Surprisingly, the initial focus group proved to be difficult in terms of gathering relevant information. At this stage, further focus groups utlised the 'idea writing' method. Results show that this method provided several consistent points in terms of usability and design for the BCG application. It also highlighted the need to change

methodology to ensure relevant information is collected. Previous studies (Payne, Wharrad and Watts, 2012; Kwa et al., 2015) do not highlight any difficulties in utilising UCD methods; however it could be argued that the majority of studies fail to highlight methods that fail to produce results. This research highlights the need to report failures in UCD methods and the necessity to utilise alternative methods in order to elicit feedback, especially with groups that have limited access. As part of this study stage an SUS was conducted to gather quantified feedback in terms of usability. It highlighted that developing an application based on best practice can lead to rapid deployment of a prototype and this can lead to high usability scores (in this case 80+). It also highlights that the SUS method alone does not provide sufficient feedback in terms of usability and should be combined with other methods to elicit specific feedback. A key finding of this study was further recommendations on how different aspects of BCGs can be presented inline. It also contributed to a novel method of presenting decision algorithms in line with clinical information.

Based on the findings of the initial prototype (prototype 1 – Chapter 3) study, a further prototype (prototype 2 – Chapter 5) was developed. The initial part of the study utilised the 'think aloud' methodology to conduct clinical information retrieval scenarios in order to test the BCG prototype and to establish the impact of iterative development and applying recommendations. The 'think aloud' method was combined with a further SUS study to compare changes made from the previous version. As with the previous prototype, this prototype achieved high usability scores (90+). This evidenced that adapting software based on initial feedback leads to better perceived usability, this is highlighted in other studies that also implemented UCD methods to provide iterative feedback (Ghazali, Ariffin and Omar, 2014). It also highlighted the novel use of the 'idea writing' method can assist

in eliciting specific feedback, again this is important when access to clinicians is extremely limited.

The ‘think aloud’ sessions enabled both feedback elicitation and usability evaluation. Other studies have utilised the ‘think aloud’ method to evaluate clinical applications (Kushniruk, 2002; Li et al., 2012), but to the authors knowledge this is the first time it has been used to test and evaluate an application designed to deliver clinical guidelines at the bedside. As a UCD method, it enabled recommendations to be adapted or provided new recommendations based on the findings. This included methods of displaying clinical warnings inline with clinical information and displaying more succinct titles for ease of navigation. Similar studies have established methods of displaying clinical warnings (Bates et al., 2001; Scott et al., 2011; Coleman et al., 2013). However, this research has established that repeating warning text within the main guideline information could assist in locating the correct information.

8.3. Utilising UCD

As discussed in the previous section and throughout this work, various UCD methods were utilised in order to co-design a clinical guidelines application. An aim of this research was to evaluate if UCD methods can be utilised to design, develop, and adapt how bedside clinical guidelines are authored and delivered. Similar studies (Payne, Wharrad and Watts, 2012; Kwa et al., 2015) have utilised UCD methods, however they fail to establish if these methods do not work or if other methods could provide more relevant results. This research established that methods such as ‘idea writing’ and ‘think alouds’ can be used to elicit feedback from clinicians when access is extremely limited. The impracticality of UCD in the ‘real-world’ was highlighted in the work of Vrendenburg (Vredenburg et al., 2002), as mentioned in the literature review (Chapter 2). For example, think-aloud sessions can be unnatural. A key factor of UCD is access to and feedback from ‘users’ throughout the

process of designing and developing an application. In the case of this research, access to 'users' was extremely limited due to time constraints; research governance including ethics and research passport/access approval; and a variety of other factors which makes accessing clinical users limited. A major limiting factor was the SARS-CoV-2 global pandemic, which started at a key point of this research. This further limited access to the clinical environment and time with clinicians. Despite these limitations, this study has shown that UCD methods can be adapted to fit the constraints of a study and still produce accurate and relevant results.

Another benefit that this research presents is the benefits of building a close working relationship with an expert and utilising them throughout the study to ensure accurate and validated information. Working with a clinical expert was a crucial factor in recognising the importance and complexity of the information contained within the BCGs and highlights that any software application development process for clinical use must utilise clinical expertise. These processes have culminated in the production of a BCG app that meets the necessary criteria of trust and evidence in terms of development and information, as highlighted by the adherence to the RCP checklist.

8.4. Strengths

This work has several strengths. The outcome of which has culminated in a mobile device application that supports 154 clinical guidelines, this is the first time (to the authors knowledge) that such a rigorous process in terms of UCD has been followed with a large number of implemented guidelines. The thesis provides a comprehensive UCD mixed-method investigation into delivering clinical information on mobile devices. This includes detailed analysis and evaluation of UCD processes that have involved 201 participants, plus an additional 146 respondents of the survey. Another aspect which can often be absent from

such work is the discussion of failure and adaptions of UCD. This is especially true in terms of the focus groups and aspects such as card-sorts.

8.5. Limitations

There are several limitations to this work. Clinicians can be extremely positive about the introduction of technology; this can cause bias in terms of feedback. However, this was limited by utlising mixed methods and a mixture of experience in terms of clinical practice. Another limitation is that the majority of this research utilisied expertise in a single NHS trust, further work will need to be conducted in other trusts to ensure the results can be transferred. Although this may be a limitation, the fact that the BCGs have been utlised in multiple NHS trusts for over 20 years suggests this will not be a limitation in future work. This research also utilised a single expert which could have limitations. However, steps were taken to ensure the input was related to clinical expertise alone.

The single biggest limitation was access to the clinical environment and clinicians. This was discussed in the introduction to this thesis. However, methods to mitigate against this were utilised such as using student clinicians. This ensured feedback was still possible and elicited from the correct subject group. This access limitation also impacted planned testing in a live clinical environment. This will have to be conducted in further studies. At the time of writing, research access to hospitals is still limited. Despite these limitations, the results are nonetheless valid for the purpose of answering the research questions.

8.6. Challenges of the study

This study had several challenges to overcome. Unsurprisingly, access to a clinical environment is not easy. However, it proved far more difficult than originally anticipated. Underpinning this challenge was the requirement to have ethical approval for a study involving not only human subjects, but human subjects in a clinical environment. This

meant that other considerations such as patient confidentiality, observation of clinical care, and the impact researching in a clinical environment could have. This study has been subject to numerous approval panels (both university and NHS related), which had an impact in starting the initial research. Another challenge was having access to clinicians once ethical approval and an NHS research passport were obtained. Studies such as observations proved far simpler to organise, but throughout this study it was necessary to adapt the approach to collect the data needed to inform the outcomes. It is worth highlighting that it is, and was, extremely difficult to encourage clinicians to participate in focus groups, surveys or many other user centred design methodologies and in some cases within this study, final year medical students were utilised due to this limitation. It is also worth note that despite these challenges, the studies described in this thesis involved over 200 clinicians and medical students.

8.7. Recommendations and further work

For this section, it is necessary to set out the consequences for research, policy and practice based on the findings of this thesis. Future research can now be completed utilising a basis for building quick mobile application prototypes. This will enable faster production of clinical guidelines applications that will enable more accurate data collection for studies utilising these tools. It will also enable further research studies to mitigate against usibility issues without having to conduct time consuming usability studies. The recommendations provided in this thesis are by no means exhaustive. However, they provide an evidence based starting point for further work.

In terms of further work, there are many avenues that could be explored beyond the work set out in the thesis. Some of this potential further work is discussed in the following sections.

8.7.1. Scalability

One aspect of further work that could be conducted is investigating how scalable the recommendations and findings in this study are. The recommendations can be applied to clinical guidelines for mobile, however it remains to be seen what the impact of these are for larger devices, integration into other clinical systems or the additional of multiple sets of guidelines beyond medical.

8.7.2. Cloud based System Updates

Cloud based system updates would add an additional dimension to the app created in this thesis. However, research is required to investigate methods of implementing these updates and how they can contribute to a usable system. Factors such as user notification, the impact of up-to-date information on trust, and how changes impact the user of the app.

8.7.3. Search Term analysis

The BCG app implements a filter function that allows users to filter aspects of the guideline and menu. Analysis could be conducted on these ‘filter’ or ‘search’ terms to determine how users filter medical information.

8.7.4. Personalisation

There are a number of factors throughout this research that suggest the user of personalisation could lead to a more satisfying and efficient system. The implementation of user modelling, adaption and personalisation may contribute to ensuring the guidelines are utilised more often and it would be interesting to study how use data could be analysed to implement a system of presenting information to clinicians depending on their individual preferences. There is research to suggest that users do not utilise personalisation when it is offered (Zheng et al., 2019). However, automatic personalisation would not require to user to manually adjust settings and therefore offer users the personalisation they desire. In this

case adaptive/intelligent UIs utilising AI or recommender systems could be implemented to automatically adapt the interface based on the user type and user behaviour.

8.7.5. Learning and Development

An interesting aspect of further research would be to investigate how the guidelines are used beyond clinical practice. App use data could enable the analysis of how users utilise the guidelines for learning and development.

8.7.6. Alert/Warning type, hierarchy, and salience

It was clear during this research that clinical warnings/alerts are a complex subject. However, there is an opportunity to investigate this further and this is especially true for mobile apps that support clinical practice. Not only could warnings have different designs in terms of type, as demonstrated within this thesis, but other aspects such as hierarchy and salience need to be investigated. Icon testing would also be required in future work to ensure they offer relevance in terms of enabling users to locate the correct sections more efficiently. Visual hierarchy can also be tested using Gaussian blurring and user testing. A button audit could also be completed to ensure button design is optimal.

8.7.7. Security and Trust

Security and trust are intertwined in terms of clinical software delivery. Research suggested that clinicians are asking for system delivery, however they fail to utilise it once implemented (Richardson et al., 2020). It remains to be seen how trust can be established, although some research by Jones et al. (Jones, Thornton and Wyatt, 2021) suggests a potential solution in bridging the gap between a usable system and a system which is trusted by the clinician. How the outcomes of this research impacts security could be investigated. This can contribute to building a framework of trust for implementing usable and secure mobile apps for use in clinical information delivery.

8.7.8. Other

Other work could include speech i.e Siri integration to allow 'hands-free' access to guidelines in emergency situations or medical procedures; Data structure of how the guidelines are written; Accessibility; Comparison of Manual v's Digital Calculations; and history tracking including attachment to learning and development. Further work could also utilise methods such as the Delphi method which has been used with experts (Dalkey and Helmer, 1963) to adapt how the guidelines are implemented. This would result in rapid changes until the feedback is saturated in terms of new findings. This was utlised in a study using User-Cantered Design in Gamification Design Guideline Development with interesting results (Chen, 2018).

8.8. Contributions to Knowledge

- Affirmations of clinical technology use, including device use and reasons for using technology. This work builds upon the existing literature. (Chapter 3)
- Insights into the cross-platform device requirements of clinicians. (Chapter 3)
- Insights into clinicians' behaviour in terms of app use, and specifically the diverse nature of utilised apps. (Chapter 3)
- Insights into the necessity of limiting manual tasks in clinical workflows, this includes limiting the requirement of multiple systems to complete a task. (Chapter 3 and 4)
- Mobile display methods and usability of decision algorithms/clinical workflow charts. (Chapters 4-6)
- Insights into methods of displaying clinical warnings for bedside clinical guidelines. (Chapter 7)

- Insights into the reduction of sentences for easier information assimilation. (Chapter 7)
- Suggestions for novel methods of eliciting feedback from time constrained and dominant subject groups utilising 'Idea writing'. (Chapter 6)
- A readily applicable list of 15 evidence-based recommendations for delivering clinical guidelines on mobile devices which will provide an easy-to-follow method for further studies to utilise and build upon. (Chapter 6)
- Insights into methods of replacing elements such as nomograms with inline calculation tools (Chapter 4, 5 and 6)
- Insights in clinicians' preferences for information, particularly in terms of having a 'bigger picture' of clinical workflows for knowledge. (Chapter 4, 5 and 6)
- Insights into use of icons for quicker access to guidelines information (Chapter 5)
- An overview of the benefits of working with a single clinical expert to adapt and change clinical information (Chapter 7)
- A proposed model for guideline verification. (Chapter 7)
- The first mobile app that has delivered over 150 medical guidelines inline with calculation tools and decision algorithms for use at the bedside constructed via UCD methods. (Chapter 4, 5, 6, and 7)
- The first study investigating the delivery of bedside clinical guidelines utilising UCD methods. (All Chapters)

Figure 74 highlights the contributions in each study stage, presented on the thesis map. Overall, the contributions have the potential to impact health and care in terms of delivering a usable system for clinicians to utilise at the bedside. Importantly, this research could have wide stretching implications in terms of positive patient outcomes and clinical workflow.

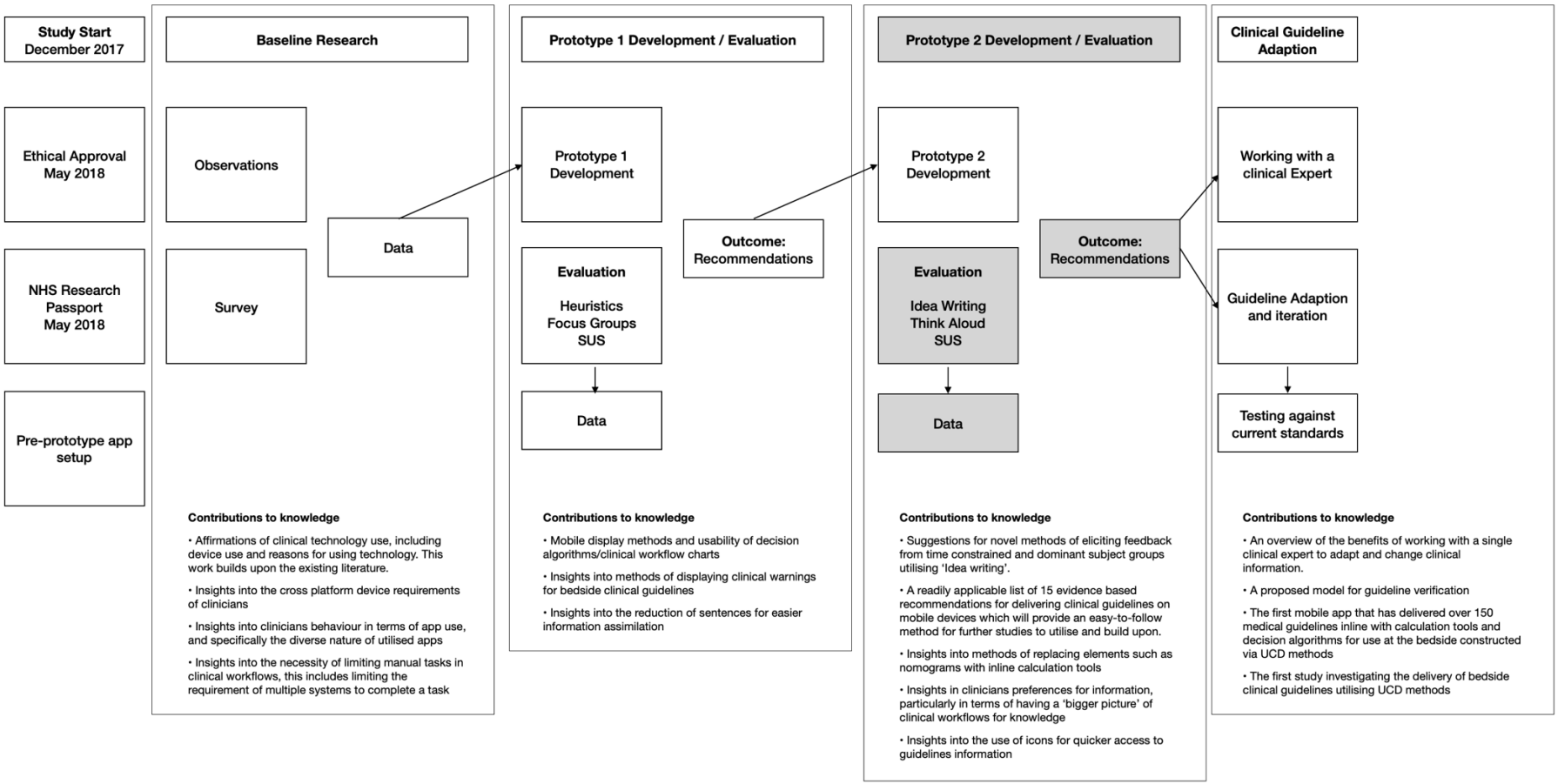


Figure 75 - Thesis map and overview of contributions to knowledge

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Appendices

Appendix 1: An example of a full medical guideline – Acute Myocardial Infarction, Ideal body weight, and Asthma

ACUTE MYOCARDIAL INFARCTION ● 1/5

RECOGNITION AND ASSESSMENT

Symptoms and signs

- Severe, persistent chest pain
- Dyspnoea
- Fear
- Pallor
- Sweating
- Anxiety
- Peripheral vasoconstriction
- Shock

Investigations

- ECG (see below)
- Locally available cardiac biomarkers of myocardial injury
- Acute coronary artery syndromes comprise myocardial infarction and unstable angina, and are currently distinguished by history, ECG and presence or absence of cardiac biomarkers of myocardial injury
- Raised cardiac biomarkers signify myocardial infarction, not unstable angina
- A raised troponin I concentration can suggest myocardial necrosis but can also occur in a number of other conditions:
  - auto-immune disease
  - congestive cardiac failure
  - critical illness
  - dilated cardiomyopathy
  - extreme physical effort
  - hypertension
  - hypothyroidism
  - multiple injury
  - myocarditis
  - pericarditis
  - pneumonia
  - pulmonary embolism
  - renal failure
  - sepsis/septic shock
  - subarachnoid haemorrhage
  - tachyarrythmias
  - vasculitis
- Plasma cholesterol (within 12 hr of onset of symptoms; otherwise leave for at least 6 weeks)
- Venous blood glucose and HbA_{1c}
- FBC, INR, APTT

IMMEDIATE TREATMENT

- Aspirin 300 mg (chew and swallow)
- Diamorphine 1 mg/min IV until pain relieved, up to maximum 10 mg (5 mg in elderly or frail patients)
- Metoclopramide 10 mg IV over 1–2 min (5 mg in young adults 15–19 yr <60 kg) with ≥8 hr before repeating
- Oxygen – see **Oxygen therapy in acutely hypoxaemic patients** guideline
- Atenolol 5 mg IV (over 5 min) or 50 mg oral daily, **unless contraindicated** – see BNF
- Atorvastatin 80 mg once daily for all acute coronary syndromes, unless history of CKD present. Start with atorvastatin 20 mg once daily if history of CKD
- **Admit** all patients with **acute myocardial infarction (MI)**, or **unstable angina with acute ST depression and/or raised troponin I** to CCU under the care of duty consultant cardiologist
- If ECG shows **ST elevation MI (STEMI)**, follow **MANAGEMENT OF STEMI**
- If patient has a **Non-ST elevation MI (NSTEMI)**, follow **MANAGEMENT OF NSTEMI**

MANAGEMENT OF STEMI

- Default strategy for STEMI management for patients presenting within UHNM is primary angioplasty (pPCI)
- Contact on-call cardiology SpR **immediately** for immediate transfer and treatment
- Administer loading dose of aspirin (300 mg oral) if not already given, and either clopidogrel [600 mg oral (unlicensed dose)] or prasugrel (60 mg oral) immediately
  - prasugrel if age <75 yr, weight >60 kg, and no previous TIA/stroke or severe liver impairment
  - clopidogrel if age >75 yr, weight <60 kg or previous stroke or TIA
  - if decision is **not** for primary angioplasty, only give thrombolytic therapy if directed by on-call cardiology service – then follow **Thrombolytic therapy (STEMI)**. Usually a contraindication for primary angioplasty is a contraindication for thrombolysis
- If thrombolysis is to be administered, contact on-call cardiology SpR **immediately** for transfer to ward/CCU

Primary PCI

- Ensure patient loaded with appropriate antiplatelet agents; aspirin 300 mg oral plus prasugrel 60 mg oral **or** clopidogrel 600 mg. Contact on-call cardiology team
- Transfer patient directly to catheterisation laboratory or CCU, after discussion with cardiology SpR

Thrombolytic therapy (STEMI)

Indications

- Presentation within 12 hr of onset of symptoms
- Typical cardiac chest pain persisting for >30 min
- >1 mm ST segment elevation in 2 or more precordial leads or 2 or more bipolar leads OR >1 mm ST segment depression in leads V1–V3 (suggesting acute posterior infarction) OR LBBB with any of the following in leads V1–V3:
  - >1 mm ST segment depression
  - >1 mm ST segment elevation where QRS complex positive
  - >5 mm ST segment elevation where QRS complex negative

Contraindications

- **Absolute:**
  - active bleeding
- **Relative:**
  - major trauma/major surgery within previous 4 weeks
  - stroke/TIA within previous 3 months
  - confirmed subarachnoid haemorrhage at any time
  - traumatic cardiac massage or intracardiac injection
  - known bleeding disorder
  - active dyspepsia or history of GI haemorrhage
  - sustained systolic BP ≥180 mmHg
  - proliferative retinopathy
  - recent head injury
  - pericarditis
  - INR >2.0

Cardiogenic shock and ventricular arrhythmias are not contraindications to thrombolysis. There is no upper age limit for this treatment

Choice of agent

- Standard agent is tenecteplase (Metalyse). Tenecteplase should be administered on the basis of body weight, with a maximum dose of 10,000 units (50 mg tenecteplase) according to the table below

Body weight (kg)	Tenecteplase (Units)	Tenecteplase (mg)	Corresponding volume of reconstituted solution (mL)
<60	6,000	30	6
≥60 to <70	7,000	35	7
≥70 to <80	8,000	40	8
≥80 to <90	9,000	45	9
≥90	10,000	50	10

- Administer by giving unfractionated heparin 5000 units by IV bolus, followed by tenecteplase administered as a single IV bolus over approximately 10 seconds, then give unfractionated heparin 1000 units/hr via infusion pump for 48 hr, adjust dose to maintain APTT ratio 1.5–2.0
- In the elderly (>75 yr) not already given thrombolysis, give streptokinase 1.5 million units in 100 mL of sodium chloride 0.9% by IV infusion over 1 hr
  Streptokinase can be re-administered within 3 days of first administration but, after 5 days, the likely presence of streptokinase antibodies precludes its further use for at least 12 months

Complications

- Hypotension – if occurs *de novo*, review for cardiogenic shock, mitral regurgitation or tamponade. If streptokinase being administered, stop IV infusion and recommence at a slower rate after BP has recovered
- Bradycardia – usually responds to atropine 300 microgram IV
- Ventricular tachycardia or idioventricular rhythm – usually self-limiting and requires no therapy. If sustained – see **Cardiac arrhythmias** guideline
- Avoid arterial puncture, central venous cannulation and IM injections in patients undergoing thrombolytic therapy, unless essential to patient care

MANAGEMENT OF NSTEMI

Treatment of choice for most patients for NSTEMI is inpatient cardiac catheterisation with early revascularisation, either by percutaneous intervention (PCI) or CABG. For patients unlikely to be suitable for an early invasive strategy because of frailty or multiple co-morbidities should have that decision made early and by an experienced clinician Refer to on-call cardiology SpR (07936 182946)

- Prescribe fondaparinux 2.5 mg once daily by SC injection
- Give clopidogrel loading dose 300 mg oral [(600 mg (unlicensed dose) in those who are unstable and likely to require catheter lab management within 24 hr)]

Risk of bleeding is increased in patients with low body weight (<50 kg), physiological frailty, severe liver or renal failure (eGFR <20 mL/min), thrombocytopenia or defective platelet function and following surgery, trauma or haemorrhagic stroke. Seek advice from appropriate team e.g. cardiology, renal, liver or haematology

NON-DIABETIC PATIENTS WITH BLOOD GLUCOSE >11 mmol/L AND ALL PATIENTS WITH DIABETES MELLITUS

- On admission, check blood glucose/HbA1c and, if blood glucose is >11 mmol/L, refer to locally approved guidance for management of hyperglycaemia in ACS patients
- In patients with diabetes/raised blood glucose, seek advice from endocrinologist/diabetes nurses early

SUBSEQUENT MANAGEMENT

- Aspirin 75 mg oral daily (to be continued indefinitely) plus:
  - if STEMI and treated by pPCI with no history of CVA or TIA or cerebral bleed and age <75 yr and weight >60 kg, prasugrel 10 mg daily for 12 months
  - otherwise clopidogrel 75 mg oral daily for 1 year
- Bisoprolol 2.5 mg oral daily, or atenolol 25 mg 12-hrly (to be titrated to maximum tolerated dosage and continued indefinitely)
- If no clinical suspicion of significant mitral/aortic stenosis or hypertrophic cardiomyopathy, plasma creatinine <300 µmol/L and there is no other contraindication to using ACE inhibitor, start ramipril – see **Introduction of an angiotensin-converting enzyme (ACE) inhibitor** guideline. Check electrolytes on day 3–5. Increase titration rapidly to achieve a dose on discharge as near to 10 mg as achievable
- Check statin (atorvastatin) has been prescribed, subject to renal function (see above)
  - give patient information sheet
- If pain persistent, consider glyceryl trinitrate (GTN) infusion – see **Glyceryl trinitrate** guideline, or further dose atenolol 5 mg IV if heart rate >70 beats/min and systolic BP >100 mmHg
- If pain persists, contact duty cardiology team to facilitate transfer to ward/CCU
- Unless complications ensue, recommend early return to physical activity:
  - mobilisation depends on revascularisation strategy, with early mobilisation and discharge by day 3 the norm post STEMI managed with an early invasive strategy

ACUTE MYOCARDIAL INFARCTION ● 4/5

- **Refer all patients to rehabilitation co-ordinator,** who will arrange for **all** suitable patients for assessment by cardiac rehabilitation team as soon as practically possible before discharge
- patients not wishing to join rehabilitation programme – provide appropriate dietary advice
- Refer all patients treated with glucose and insulin infusions to diabetes nurse specialist to confirm presence of diabetes vs stress-induced hyperglycaemia

MONITORING TREATMENT

- Continuous ECG monitoring for 24–48 hr (longer if continuing instability or arrhythmia)
- Measure BP 4-hrly for 24 hr, then twice daily
- Daily 12-lead ECG. Plasma CK and AST on 2 consecutive days, unless troponin I already positive. If troponin is positive, no further cardiac enzyme assessments are warranted
- Observe for specific complications (more likely to occur if patient not re-perfused)

Arrhythmias

- See **Cardiac arrhythmias** guideline (seek further cardiological input)

Cardiac failure

See **algorithm** (seek further cardiological input)

- In patients with left ventricular failure (LVF) or impaired LV function, introduce an ACE inhibitor as soon as this is practical – see **Acute heart failure** guideline
- In patients with significant LVF and/or anterior Q wave infarct, arrange echocardiogram as outpatient, to document LV function and exclude LV aneurysm and/or thrombus

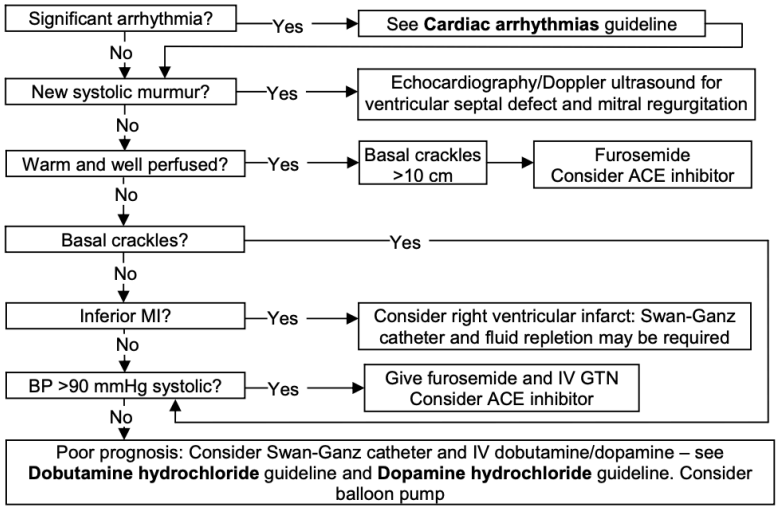
Pericarditis

- More likely after large infarcts (seek further cardiological input)
- Pain with persistent/intermittent pericardial rub 2–5 days after infarction
- Adequate analgesia (may need diamorphine). Give indometacin 25 mg oral 8-hrly if no contraindication (beware fluid retention and antagonism of loop diuretic)

Recurrent ischaemic pain (seek further cardiological input)

- Isosorbide mononitrate SR oral (GTN infusion if necessary – see **Glyceryl trinitrate** guideline)
- If persistent chest pain occurs, refer to duty cardiology team for consideration of inpatient stress testing, coronary angiography and possible inpatient revascularisation
- If re-infarction occurs during admission, contact duty cardiology team immediately

Management of cardiac failure after acute MI



Dopamine must only be used in critical care and in the coronary care unit and administered preferably via a central line

ACUTE MYOCARDIAL INFARCTION ● 5/5

DISCHARGE AND FOLLOW-UP

- If no complications, discharge home on day 3–7
- Check risk factors for recurrent MI (e.g. smoking, hyperlipidaemia, hypertension, obesity) and advise or treat accordingly (mortality in first 2 years is doubled in those who continue to smoke and is 3.5-times greater if total cholesterol >6.5 mmol/L)
- Explain graded return to full activity (see advice booklet)
- Where appropriate, ensure patient has climbed stairs to assess for chest pain/shortness of breath
- Ensure advice booklet and chest pain alert card have been issued
- If taking atorvastatin, ensure GP letter regarding intensive statin therapy accompanies patient on discharge
- Warn about post-infarct angina
- Ensure GTN 400 microgram spray for sublingual use has been prescribed TTO and patient has been counselled on use
- Advise not to drive as per DVLA rules and check with insurer (Group 2 drivers must notify DVLA, taxi drivers must notify local council)
- Ensure referral has been made to cardiac rehabilitation team
- Check that rehabilitation plan has been made
- Middle grade in cardiology will be able to review patients who attend as an outpatient at cardiac rehabilitation. Rehabilitation co-ordinator will arrange
- If patient declines cardiac rehabilitation or is unsuitable for programme, refer to cardiology follow-up clinic
- Check that follow-up has been arranged in diabetic clinic for all patients treated with glucose and insulin infusions

Follow-up clinic visit

- Ask about smoking, exercise and weight reduction
- Ask about angina – if occurring, consider referral for angiography
- Look for signs of heart failure and measure BP
- Check cholesterol
- If patient has not been to catheter laboratory, consider treadmill exercise
- Encourage return to work 1–3 months after infarction
- Resume driving 1 month after infarction (except Group 2 drivers)
- Unless there are contraindications, all patients should be taking the following treatment

STEMI

- ACE inhibitor (target dose ramipril 10 mg or equivalent)
- Statin therapy (target dose atorvastatin 80 mg or equivalent, unless history of CKD)
- Beta-blocker (target dose to achieve heart rate of 60 bpm at rest)
- Aspirin (75 mg) indefinitely
- If STEMI and treated by pPCI with no history of CVA or TIA or cerebral bleed and age <75 yr and weight >60 kg, prasugrel 10 mg daily for 12 months
- otherwise clopidogrel 75 mg oral daily **for 1 yr**

NSTEMI

- ACE inhibitor (target dose ramipril 10 mg or equivalent)
- Statin therapy (target dose atorvastatin 80 mg or equivalent, unless history of CKD)
- Beta-blocker (target dose to achieve heart rate of 60 bpm at rest)
- Aspirin (75 mg) indefinitely
- Clopidogrel 75 mg oral daily **for 1 yr**

IDEAL BODY WEIGHT • 1/1

Use this guideline for drug dose calculations. Do not use as a dietary advice guideline

CALCULATION

- Calculate ideal body weight (IBW) from height/length, using formula:
- 1 cm = 0.394 inch and 1 foot = 12 inches

Males

IBW (kg) = 50 + [2.3 × (height in inches − 60)]

Females

IBW (kg) = 45 + [2.3 × (height in inches − 60)]

TABLES

- Read ideal body weight from tables below for heights in feet and inches or centimetres

MALE		
Height (feet and inches)	**Height (cm)**	**Ideal body weight (kg)**
5' 0"	152	50.0
5' 1"	155	52.3
5' 2"	157	54.6
5' 3"	160	56.9
5' 4"	163	59.2
5' 5"	165	61.5
5' 6"	168	63.8
5' 7"	170	66.1
5' 8"	173	68.4
5' 9"	175	70.7
5' 10"	178	73.0
5' 11"	180	75.3
6'	183	77.6
6' 1"	185	79.9
6' 2"	188	82.2
6' 3"	191	84.5
6' 4"	193	86.8
6' 5"	196	89.1
6' 6"	198	91.4
6' 7"	201	93.7
6' 8"	203	96.0
6' 9"	206	98.3

FEMALE		
Height (feet and inches)	**Height (cm)**	**Ideal body weight (kg)**
4' 10"	147	40.4
4' 11"	150	42.7
5' 0"	152	45.0
5' 1"	155	47.3
5' 2"	157	49.6
5' 3"	160	51.9
5' 4"	163	54.2
5' 5"	165	56.5
5' 6"	168	58.8
5' 7"	170	61.1
5' 8"	173	63.4
5' 9"	175	65.7
5' 10"	178	68.0
5' 11"	180	70.3
6'	183	72.6
6' 1"	185	74.9
6' 2"	188	77.2
6' 3"	191	79.5

ACUTE SEVERE ASTHMA IN ADULTS ● 1/3

RECOGNITION AND ASSESSMENT

- Complete the asthma pathway for **ALL patients** attending emergency portals with an asthma exacerbation

Symptoms and signs

- Cannot complete sentences in one breath
- Respiration ≥25 breaths/min
- Pulse ≥110 beats/min
- Use of accessory muscles
- Peak expiratory flow (PEF) <50% of predicted (**Figure 1**) or best (if known)

Life-threatening features

- PEF <33% of predicted (**Figure 1**) or best (if known)
- SpO_2 <92%
- Silent chest, cyanosis, or feeble respiratory effort
- Bradycardia or hypotension
- Exhaustion, confusion or coma

Patients with severe or life-threatening attacks may not be distressed and may not have all these abnormalities. The presence of any one of these should alert the clinical team

Investigations

The only investigations needed before **immediate treatment** are:

- PEF
- Oximetry

If SpO_2 <92% or patient has any life-threatening features or not responding to treatment, measure arterial blood gases (ABG)

ABG markers of a life-threatening attack

- Normal or high $PaCO_2$ (>4.6 kPa)
- Severe hypoxia: PaO_2 <8 kPa irrespective of treatment with oxygen
- Low pH (or high H^+)

IMMEDIATE TREATMENT

- Oxygen: follow **Oxygen therapy in acutely hypoxaemic patients** guideline (CO_2 retention not usually aggravated by oxygen therapy in asthma)
- Terbutaline 10 mg or salbutamol 5 mg plus ipratropium 500 microgram via oxygen-driven nebuliser 6–8 L/min oxygen
- Prednisolone tablets 40 mg (if taking maintenance prednisolone, increase daily dose by 40 mg; maximum 60 mg) or hydrocortisone (preferably as sodium succinate) 100 mg slow IV bolus, or both if very ill
- No sedatives of any kind
- If patient has coincident chronic bronchitis (regularly produces sputum), consider antimicrobial treatment
- Chest physiotherapy **not** indicated
- Assess and treat hypovolaemia and electrolyte imbalance – see **Fluid resuscitation** guideline, **Maintenance fluid therapy** guideline and **Electrolyte disturbances** guidelines

Further investigations

- Chest X-ray
- if not responding to treatment or to exclude pneumothorax, consolidation or life-threatening exacerbation
- U&E (use green top bottle for accurate K^+ level)
- FBC
- If patient on maintenance theophyllines – take bloods for therapeutic levels

ACUTE SEVERE ASTHMA IN ADULTS ● 2/3

Patients with life-threatening features

DO NOT LEAVE THE PATIENT. Ask medical SpR, staff physician or consultant physician, ideally respiratory, to review urgently

- Give magnesium sulphate 2 g made up to 50 mL with sodium chloride 0.9% by IV infusion over 20 min if not already given earlier (e.g. in ambulance). Ensure cardiac monitoring and oximetry *in situ*. Never give a second dose of magnesium sulphate without discussion with consultant respiratory physician
- **Speak to critical care unit (CCU) and transfer patient urgently if continues to deteriorate with:**
  - falling PEF, worsening or persisting hypoxia, or hypercapnia
  - exhaustion, feeble respirations, confusion, or drowsiness
  - coma or respiratory arrest

En-route to CCU, ensure patient is accompanied by a doctor (usually an anaesthetist) prepared to intubate if patient's clinical condition requires it

SUBSEQUENT MANAGEMENT

- Admit to a respiratory ward
  - lower threshold for admission in patients attending with history of non-adherence, lives alone, mental health issues, learning difficulties, previous near fatal attack, presenting at night, pregnancy, difficult asthma
- Correct disturbances in fluid and electrolyte balance, especially potassium (K^+)

If patient requires IV fluid with potassium, always use commercially produced pre-mixed bags of sodium chloride 0.9% and potassium chloride. NEVER add potassium chloride to infusion bags

If patient improving

- Continue oxygen – to maintain SpO_2 >94% (see **Oxygen therapy in acutely hypoxaemic patients** guideline)
- Prednisolone daily at dose in **Immediate treatment** section, or hydrocortisone 100 mg 6-hrly as slow IV bolus over 1 min if unable to tolerate oral medication
- Nebulised salbutamol 2.5 mg plus ipratropium 250 microgram 6-hrly
- Continue regular inhaled/oral preventer medication

Fax referral to clinical nurse specialist in asthma on 74072 or call 74068 to review patient

- Change to discharge medication 24 hr before discharge and check inhaler technique

If patient not improving after 15–30 min

- Continue oxygen to maintain SpO_2 >94%
- Give nebulised salbutamol 5 mg more frequently, up to every **15–30 min** – see **Monitoring treatment**
- Give ipratropium 500 microgram 4-hrly until patient improving
- Once patient improving, reduce nebulised salbutamol to 2.5 mg and ipratropium to 250 microgram 6-hrly

If patient still not improving

Ask medical SpR, staff physician or consultant physician, ideally respiratory, to review urgently

- Give magnesium sulphate 2 g made up to 50 mL with sodium chloride 0.9% by IV infusion over 20 min if not already given earlier (e.g. in ambulance). Never give a second dose of magnesium sulphate without discussion with consultant respiratory physician
- Senior clinician to consider use of aminophylline or salbutamol by infusion – see **Aminophylline** guideline and **Salbutamol** guideline for doses. If patient already taking oral theophylline **DO NOT** give loading dose IV aminophylline
- **If any life-threatening features present (see above), transfer to CCU and refer to respiratory physician**

En-route to CCU, ensure patient is accompanied by a doctor (usually an anaesthetist) prepared to intubate if patient's clinical condition requires it

ACUTE SEVERE ASTHMA IN ADULTS ● 3/3

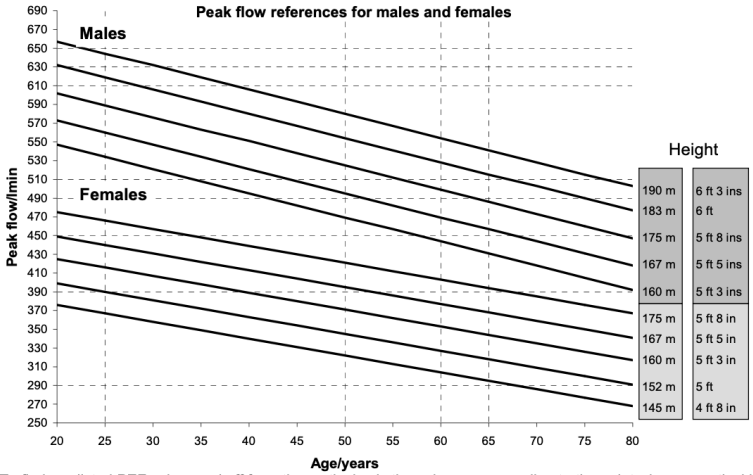
MONITORING TREATMENT

- Repeat measurement of PEF 15–30 min after starting treatment then according to response
- Oximetry: maintain SpO_2 94–98%
- Record heart rate and respiratory rate
- Repeat blood gas measurements within 2 hr of starting treatment if:
  - initial PaO_2 <8 kPa (60 mmHg), unless subsequent SpO_2 >92%, **or**
  - initial $PaCO_2$ normal or raised, **or**
  - patient deteriorates
- In patients requiring frequent doses of salbutamol nebuliser, repeat serum potassium within 2 hr of starting treatment and repeat 2-hrly
  - potentially serious hypokalaemia is especially likely to occur in patients taking corticosteroids, theophylline and diuretics, and who are hypoxic
- If theophylline infusion continued for >24 hr, measure theophylline levels (therapeutic range 10–20 mg/L)
- Chart PEF before and 15–20 min after giving nebulised or inhaled salbutamol, and at least 4 times daily until stable; then change to morning and evening before salbutamol dose

DISCHARGE AND FOLLOW-UP

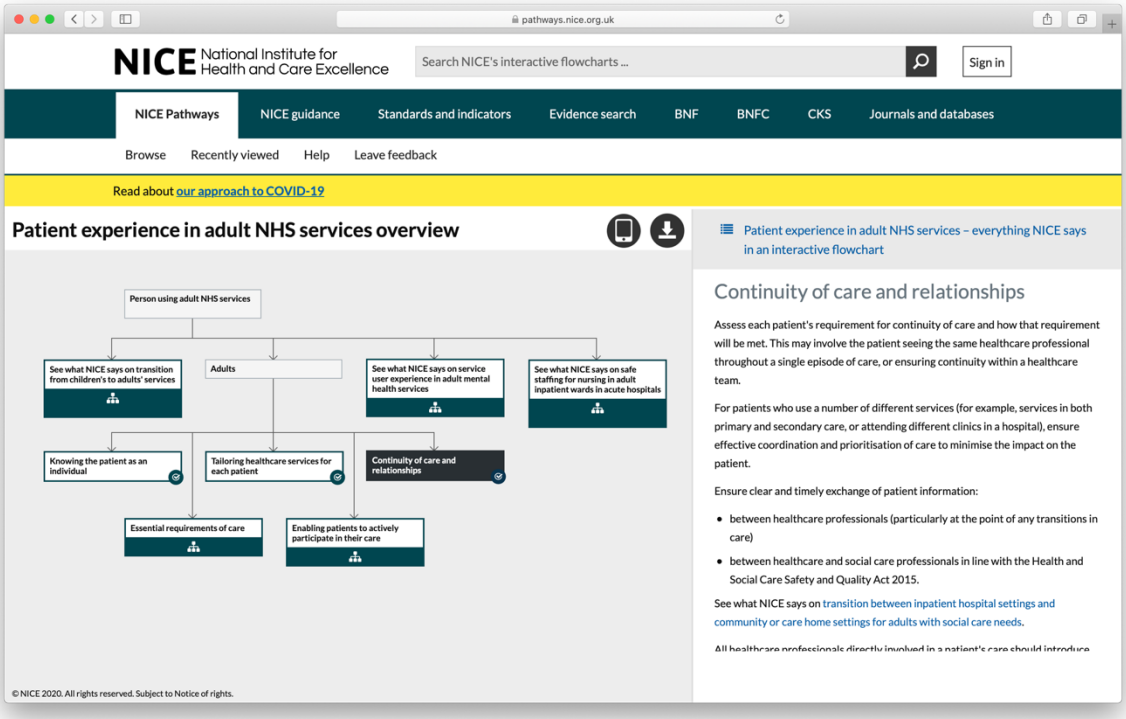
- **When discharged from hospital patients should have:**
  - been stable taking discharge medication for 24 hr and had inhaler technique checked and recorded
  - PEF >75% of predicted or best and PEF diurnal variability <25% unless discharge agreed with respiratory physician
  - treatment with oral corticosteroids for 5 days or until improved and inhaled corticosteroids in addition to bronchodilators
  - own PEF meter (prescribable) – advise patient to record PEF morning and evening before inhalers
  - a written personal asthma action plan (available from asthma team e-mail: paap@uhns.nhs.uk)
  - had reason for exacerbation discussed
  - details of admission, discharge and potential best PEF sent to GP on discharge documentation
  - GP follow-up within 2 days
- Complete asthma inpatient referral via OrderComms for outpatient clinic follow-up
- Complete discharge checklist at the back of the care pathway

Figure 1: Predicted adult PEF chart for use with EU standard peak flow meters marked with yellow circle around the letters EU

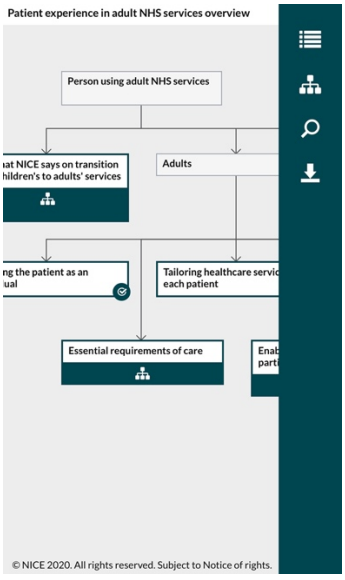


To find predicted PEF value read off from the vertical axis the value corresponding to the point where a vertical line from patient's age intersects with the line on the graph corresponding most closely with patient's height

Appendix 2 - NICE Pathways tool example (Accessed with Safari Version 13.1.2 and Safari for iOS 13.7)

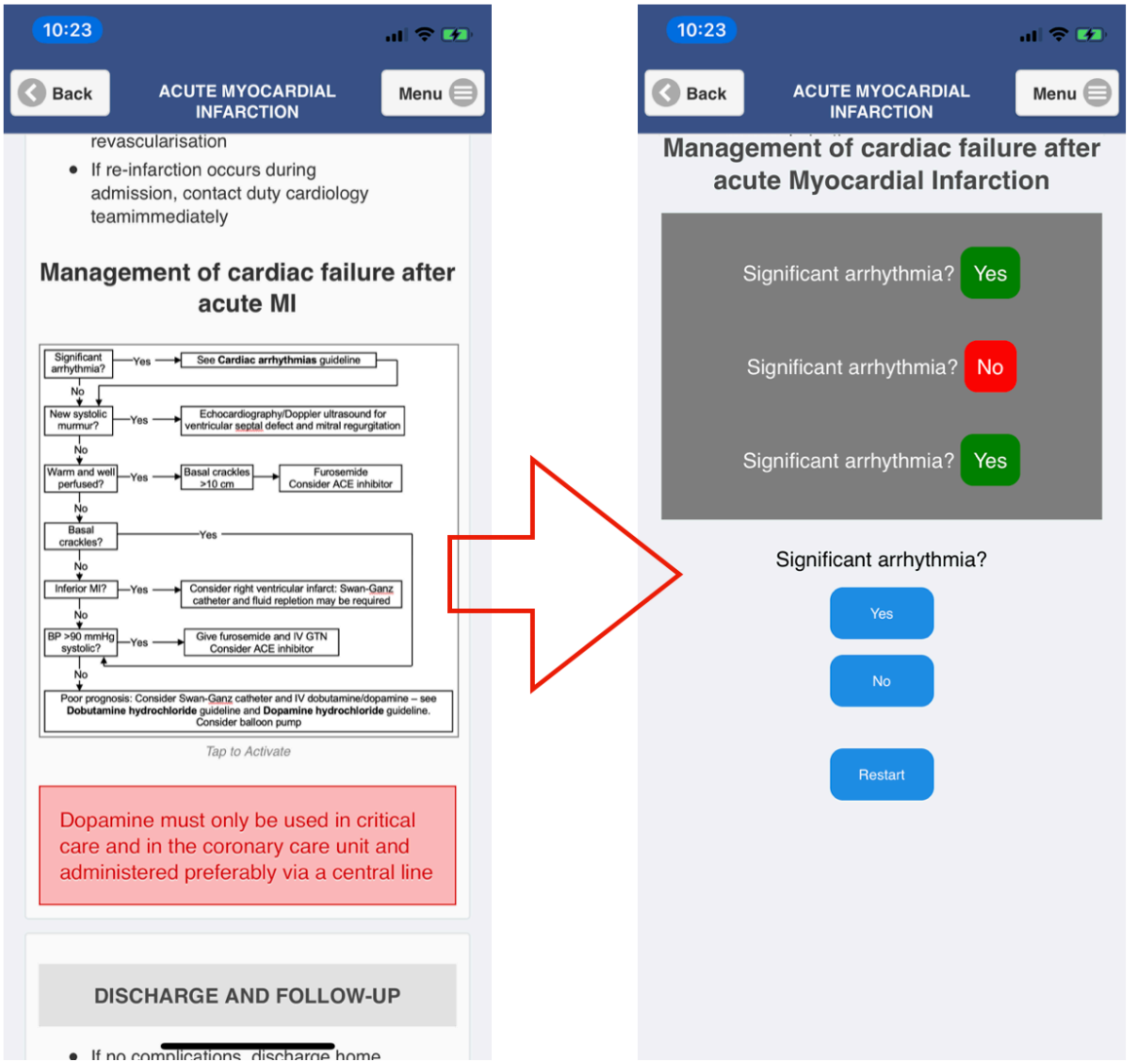


Desktop version



Mobile Version

Appendix 3 - Screenshots of the mobile device decision algorithm activation



Appendix 4 - JavaScript for the Peak Expiratory Flow PEF calculation tool

```
<script>


            //JS for Asthma Calculation
            $(document).ready(function(){

                var calcButton = document.getElementById('calculate');
                var female = document.getElementById("female");
                var male = document.getElementById("male");
                var age = document.getElementById("age");
                var height = document.getElementById("height");
                var restartButton = document.getElementById("restart")

                restartButton.style.visibility = 'hidden';
                restartButton.style.height = '0px';
                restartButton.style.padding = '0px';
                restartButton.style.margin = '0px';


                calcButton.onclick = function () {

                    // form validation stage


                    if(parseInt(age.value) < 16 || parseInt(age.value) > 100) {
                        alert("Stop! Age must be greater than 16 or less than 100 years")
                    }

                    else if(parseInt(height.value) < 100 || parseInt(height.value) > 210) {
                        alert("Stop! Height must be greater than 100cm or less than 210cm")
                    }

                    else {
                        calculate();
                    }

                };

                function calculate() {



                    if(male.checked) {
                        //window.alert("MALE"); //For testing
                        //Calculation
                        console.log(age.value);
                        console.log(height.value);
                        var agem = parseInt(age.value);
                        var heightm = parseInt(height.value);
                        var calculation = (((0.0614 heightm) (0.043 agem) 0.15) 60);
                        console.log(calculation);
                        calcButton.style.visibility = 'hidden';
                        calcButton.style.height = '0px';
                        calcButton.style.padding = '0px';
                        calcButton.style.margin = '0px';
                        restartButton.style.visibility = 'visible';
                        restartButton.style.height = '';
```

Appendix 5 - Think aloud session data

Usability
Visibility
Clinical workflow
BCG Content

Session 1, 23rd January 2020.

So I want to get to scenario one . It's about unstable angina, so thats cardiovascular. You've got two headings which I like, so I want to go to unstable angina, and that comes in, what is the recommended dose, I'm going to go down, not to investigations but all the way to treatment and immediate treatment. And then you just have to Aspen 300 milligram oral chew and swallow.

So it's quite nice to scroll up and down.

That's it. And then now I'm on scenario two. immediate treatment in acute heart failures. So I'm going to go back, the second one in cardiovascular and that immediate treatment and the ECG. So I want to go down to treatment again. So you've got echocardiogram under investigations, but not under immediate treatment.

So I'm gonna scroll down. It doesn't really have so I have to scroll back up. And the industry, the echocardiogram one, which is requesting patient echocardiogram unless for the last six months, I'm guessing that this is the immediate treatment, but because the heading is further down, I'm not sure if that has immediate treatment or whether that's just under investigations, but scrolling through it looks like it as, because let's go right to the bottom.

No, nothing about immediate treatment and negative. I'm going to go guess. With that one, but perhaps the headings can be a bit more clear. But other than that, it's fine. And then the third scenario is the management of patient acute myocardial infarction. So I'm going to get back to cardiovascular.

So it's got acute heart failure and sip angina doesn't have acute myocardial infarction, so I'm just going to search. It doesn't comes up.

It's not there in the search function, so I'm going to go to cardiovascular. I'm going to go to probably unstable angina because my cousin props and can follow that.

Okay.

Yeah, that's what that's, I'm going to go back and try looking at your, keep talking though.

with management.

I haven't found anything about acute myocardial , but I want to get it back and just type it in.

oops, sorry.

No.

Maybe search for that one there.

I'm going to go back to unstable Angina that.

Oh, there it is. So acute coronary syndrome talks about myocardial infarction here, and It says about BP. And so it's to do with the BP and arrhythmias. Yeah. Finished

the search for the BP.

It's a bit difficult because there is so much information, but obviously the guidelines are huge. They're like a thousand pages, so I'm not surprised.

Okay. I found nothing on the BP, nor for acute myocardial infarction.

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	No	
Did they use the filter function in the guideline?	No	
Did they make any errors?	Yes	Error related to incorrect section for information (not immediate treatment). In this case the user did not find the correct section and made an educated guess (confirmation bias?), there seems to be an issue where users are unwilling to say they cannot find the information requested (what bias is this??)
Other notes	Acute MI guideline was not in the list (error) and therefore caused some confusion near the end of the session.	

Session 2, 23rd January 2020.

Um, so the first thing I'm gonna do, is find unstable angina kinda like, um, how it's that, but I think maybe it'd be nicer if it was just the big blue header and then you can open and close.

So you mean it almost closed or like opens up like, cause if not, it's like a lot to scroll through. But I like how you have a search bar as well, just in case.

So let's do Angina. So I'm going to open that up.

That's quite nice to have like a big warning to make sure that you do what you need to do.

That's pretty good. Yeah. I like how there's like different section for what it is and the symptoms and investigations. I think this could be closed to maybe cause I feel like it's a bit like a lot of texts. This one was recognition main section of that guideline.

Um you can also maybe have like, instead of having to scroll through everything, just have like a little drop down, right that he press and then it can come out. Okay. (Accordion)

so I'm looking through, I'm looking, scrolling down to the treatment. So again, I think the drop downs would be great as well. So subsequent management. So I've got aspirin 75 milligrams oral daily. Yeah. I'm going to go back for Acute heart failure again, I really like that as well, and it was like, makes you look at it and make sure that you don't kind of miss the point.

Mmm.

Yeah. I think it's a bit long to like scroll down and so I think just separating it a bit and bit might be a bit useful.

So that's the answer to question two I guess. Is that right? Um, what would it be done in an immediate treatment?

Cause it kind of, it's a bit like unsure with them looking for investigations or immediate treatment. But I think that's fine. This might just be, *and then management of acute myocardial infarction. What is the*

Do I start this? You can start the app with, yeah. Yeah. There we go. It's a bit. I think it's a bit confusing where it's like. See it cause I was looking here. *Which part is confusing?* Is the part where you see the complications in monitoring treatment? Yeah, so I think when I was looking for it, I was looking at with mass instead of trying to start awkward.

So when it said cardiac failure, I thought it meant just the algorithm for cardiac failure, which I think have been a bit confusing for me
present. So I'm just pressing no. There's no systolic murmers. So pretty, no, I'm not warming up to, so no basal presence, not saying yes. Uh, and more than 90. Yes. So I like, I really like that actually. That's pretty good just to have to make sure that everything's like checked off. Um, you don't have to like read through everything to get a recommendation.

So I think that's very helpful. Like guideline evidence, which is great. *Yes. There's just examples in there at the moment, but the evidence will be provided to it. Yeah.*

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	No	
Did they use the filter function in the guideline?	No	
Did they make any errors?	Yes	Error related to incorrect section for information and not guideline - ECG in warning not located. User could not find algorithm decision tool.
Other notes		Liked Guidelines evidence section but none was provided in example.

Session 3, 23rd January 2020.

Um, unstable angina ended dosing method of aspirin, unstable angina that filter to aspirin and then immediate treatment, 200 mg. She was swelling. Subsequent management. Okay. It's going to be 300 mg or, um, dosing method of aspirin.

Yeah. And I'm not even following up with GTN, spray and beta blocker. So some protocol. Okay. *Are there any other areas or the guidelines that mentioned it?* What do you mean? *Are there any other parts of the guideline in there that mentioned aspirin?* Um, sort of subsequent management? Yeah. So continue to be the beta blocker, like.

filter and highlights?
Um, yeah, it was good. It's really good. Um, it narrows it down and it makes quite clear. Um, I don't know if there's a part that makes it go down automatically. I don't know. So you mean like on the PDFs when you see it? *Yeah, on to the next one.*

So doing immediate treatment and acute heart failure that

So if you get acute heart failure,

So when should it be sought? So you request an inpatient echocardiogram unless it's performed in the last six months, or there's no on, you know, new or worsening symptoms since the last cycle, um, by the other mentions of it. Yeah. So you do the BMP before it, um, and at the BNP screening, 400 less than 400, but greater than a hundred and with less than 400, then heart failure as possible.

So then you proceed to echocardiogram. Under the BMPs lesson in hundred, then unlikely for heart failure

and fluid management as well. So if you want to arrange an immediate a cardiogram, we seek advice from the cardiology team, which is quite boldly highlighted as well. That's how it's highlighted. Yeah. I mean the really important parts in there. You want to. Uh, avoid the fluid of the station and pulmonary edema, hypertension, worsening symptoms…

And then in the management of the patient, actually my club fashion was the recommends….

it's a horrible word.

So if you go back to the search field form and just remove the text just to eat, to from there. Um,

so if you can just activate the algorithm there for me and just talk through that and stuff as part of this.

Yeah. So if it's significant right there. Yeah. That's not when they started. Nope. Well, my peers that not being in the classrooms. Yep.

So it gives you a reason, lots of the loop, diuretic and TTS. *So what are your thoughts on how that's presented?* And that was a lot easier than searching a hundred times easier. Cause it would nine times out of 10, they do have the murma or they do have, um, some sort of complication like that. We're saying it gives an idea of management, but that was good because this complication, which tells you what to do.

So yeah. Thoughts on that? Well laid out, um, justified best same as earlier. Just end to fact though, when you pass down down. Yeah. But it's clear, concise.

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	Yes	
Did they use the filter function in the guideline?	Yes	
Did they make any errors?	Yes	Searching for information related to wrong section, but correct information User could not find algorithm decision tool.
Other notes		

Inline decision algorithm tool was used from here, more GLs were present in main menu:

Session 4, 23rd January 2020.

I'm just looking to find something to do with subsequent management, say immediate treatment. So it's not immediate. I'm guessing you need a subsequent management. Um, what is it recommended because of cases like the first thing is 75 mg oral daily, that's it.

So it's 75 oral all day. Well, it's just reading what is below it to say if it responds or if it doesn't, but yeah, during fluid management…

so acute heart failure, I think I prefer it like that than scrolling and finding the name of the topics, I guess. Yeah. That is easier. Um,

So I'm going to search again just because I can imagine on the ward that I don't have time to scroll. And so useful for dynamic heart abnormalities, but them, the monitors.

it says investigation.

Yeah. So you had this one doesn't have ECG. So it says echocardiogram, that's not what I.need. I should have had that chronic part maybe. And I request inpatient ECG on this, easy to go from the last six months. So yeah, it gives you the answer.

Oops. That's good. Just type, kind of came up. Um,

okay.

management then I'll go. Okay. So it's got the flow chart. Mmm.

So what was your thinking on finding that then?

I mean,

not really sure. Cause I was looking at this sign of symptoms and it does mention potassium both there, and then you've got a bit of potassium investigation and then you put in management. So, I mean, Normal, but it's just because I'm not familiar with it potentially. So, and then it says, so that's one of the five, I think I like it because it's quite straightforward and it gives you an option.

So it's six two, but in real life, is that necessarily I think, yeah, I guess it tastes so less than, but then what if, what if it's less than 5.5?

Well, if it's a little straightforward, but they're the standard. So in the original flowchart, which you'll see here, The difference now is that you would have had, so this is just a different way of presenting that digital flow chart.

I think I liked the other because this is too complicated. And I think when we need it quickly on the ward and you want to say something that probably not the best way. Okay. So if you want to activate that from, from this and then follow the recommendations. So are acute ECG are present here.

Oh, right. So it give you information, in particular calcium.

So then what's your thinking in the feedback? Um,

I think I'm like it's short and sweet. Um, yeah. I don't have much clinical knowledge to say how concise it is, but I think it's good. Quick quick reads.

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	Yes	
Did they use the filter function in the guideline?	Yes	Wrong information found for ECG scenario as navigated to incorrect section "but it's just because I'm not familiar with it potentially."
Did they make any errors?	No	
Other notes		

Expected acronym for echocardiogram, Found tool without prompting.

Session 5, 23rd January 2020.

Okay. So subsequent management of unstable angina, what is the recommended dosing method of administering aspirin?

So if you could just talk to me what you're thinking.

Okay. So, uh, under, I'm just checking where I think unstable angina would be for kind of these first seen here now. Um, so I'm going to click it. Yeah. What does it recommend? Dosing methods. So I want subsequent manage management. Okay. So I'm going to check if there is a, usually there'd be a management section, so that's immediate management or treatment.

So I'm guessing yet subsequent management. Okay. But in the essay of some surprise, don't say management, but immediate treatment actually makes sense. Yeah. Maybe that's more clear. It's more clear. Yeah. Um, so subsequent management. So what is the recommended dose and method of administering aspirin?

So recommended dose is 75 milligrams oral. Uh, I assume once daily, it doesn't say how many times, but you'd assume, um,

Okay, so you can move on to the second scenario yet.

during fluid management and acute heart failure, when should an echocardiogram be sought? So we go to acute heart failure and under cardiovascular, um, Okay. When shouldn't echocardiogram say during fluid management. So again, we want to go down to the management section, I would have thought, um, so the all fluid management section, so that's quite clear, uh, when she echocardiogram be sought.

So, so now I'm basically just looking for the word echocardiogram.

I'm querying if I've gone past it, um, may have done

Oh, okay. So it was in the red. Um, so when should an ECG be sought, uh, she could last from the cardiology team. *So what made you avoid that?* Well, I'll just skip past it. Yeah. Uh, I kind of read the first line and then I was like, I was also looking for ECG and big. Bold capital letters. Yes. Rather than just cause it's written by that here.

Echocardiogram, brackets, like, I thought it might say that there, and that's kind of what you like, like here, it says ECG in big letters and stuff. And I don't know what empirical food assistant patients, parent team hypertension, even after I've interconnected..

in the measurement of measurement flow chart.

Of hyperkalemia. What is the recommended action by plasma? Potassium is a 66.4 on a case D changed the present. So we look for hypokalemia. So

section where the recommended action were. So, okay. So that's quite nice, quite bright, um, and obvious. And I dunno if whatever is, and having used phones a lot, it's very obvious that if like click these or click these, then it will, it'll something will happen. Yeah. Um, whereas the duller color you wouldn't yeah. Nothing happens as you'd expect. That's kind of intuitive too. I think so plasma potassium is six to 6.4. Uh, so it's that middle ones from clicking that are acute ECE changes, present pink T waves. So they are present. Yes. So what is the recommended action? Uh, protect the heart. Calcium. Just these three points?

what about how this is presented in? Oh, how, how this was? Yes. Um,

protect the heart. Continue to share information. I mean, it looks good to me to be fair. What's the original, Oh,, okay. This is new. Okay. Oh, this is where this is based on. Oh, I see. Okay. Alright. That's nice. It might even just be an option to yeah.

Instead of having that option, just have it there anyway, but maybe you're adding more. You don't want to make it more complicated looking into it. I don't know, but I'm okay. Yeah. Cause I might not have clicked that. Out of curiosity, I'd click that. Yes. But I wouldn't necessarily automatically go to it and have a look. But if it was just there, then you can't, it's not really, um, I don't know how to phrase it, but if it was there, I wouldn't look at it.

Yeah. Yeah. You don't know what's there, if you don't know it's there, if it makes sense.

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	No	
Did they use the filter function in the guideline?	No	
Did they make any errors?	No	

Other notes		

Immediately understood the layout of the GL - subsequent after initial management
Probably wouldn't use original flowchart

Session 6, 23rd January 2020.

Um, so subsequent management recommend dose and method. Um, probably start by looking at unstable angina and see if I can find anything that just gives me like an overview, if any management or anything. Is that how you search? Yes. Oh, okay.

That's good that it comes straight up and it also tells you like the kind of heading of like, what would angina would be under. Okay. That is nice. So it's nice that it comes up with something that's kind of like gives you a kind of a brief overview of what it is. I think that it's really clear when it just says unstable.

I would. Almost rather than the, it says the unstable angina is as the first bit. *Okay. It was in the blue, dark blue header at the top*, just as like a very first thing. Um, also I think with the big chunk of writing, I looked for the smaller bullet points. Okay. Fast. Um, but that's yeah. I will always go for the least amount of information first and then build up.

Um, I just like to be able to get quick information, to build a picture better, and then I'll read. Cause it just takes, like I can read these three bullet points pretty quickly and I get it very quick, understanding of that. And then later on, and then I'll go back and read it or here, um, at the top. Cause it just takes a bit longer.

Um, Okay, so then I'll scroll down. I really like how it's methodical. It's similar to how I would lay my notes out. I know it's out. And I'm like, yeah, because we have literally, almost exactly the same thing. Um, like the way you have to learn. So yeah. Symptoms and signs, then we do our investigation. So I'm assuming results would be stuff from results will be on that.

And then something about management. Yeah.

So my recommended dose would be 75 milligrams.

Okay. So I'll get back. Um, all that was really handy that you didn't have to go back through everything that you could just, yeah, that was good. Um, so probably to see the same thing. Okay. Acute heart failure. Um, I think the search bar is really easy to use.

It's really handy when it comes up with things as you're going, rather than you have to type all of it out and then sift through everything.

symptoms and signs, does that make sense…

It's just a request, inpatient echocardiogram, unless… and your last six months.

Oh, okay. So it'd be further….

Um, can you, if I such, um, like fluid management in heart failure, doesn't matter. *It's a filtering system.* Yes. You have to go on. *Is that something that you would like in there or.* Um, what might be good as like, so if you put in half acute heart failure, Oh, you have already got that. So you've got a section, so then I could go fluid management and then it should tell me in this, but I think.

So it's a fluid management section. Yeah. Oh, okay so its in the big red bit. *So you think the reason was that you avoid that?* You didn't say it in the first place. So you think that it being big red, whether they felt like, I mean, I think it might just be the way that I read information. I'll usually go for things, but it's also, I think partly that's how I set up my notes.

Okay. So that's what I. I like things that are bullet pointed and then inset bullet point, and then the detailing.

What do you think would have helped for you to notice the information in there if the too much text in there is, or is it, cause I know you mentioned earlier about having the small amounts of texts and then you go back to the larger amounts.

Yeah. See, I thought, I didn't think that's particularly anything that's wrong with that. I think most people would read that as a big, as the. As the first thing, but I immediately went down. I didn't know. I guess I expected the details on why you would arrange or if an echocardiogram to be more down here rather than, so that was more, maybe my like ideas of it.

I think I would maybe have two, like in capitals capital site, like avoid and then like, Uh, like colon and then put what you'd avoid and then maybe like a next steps.dot dot that. Or like, I dunno, just to kind of, I think I definitely respond more to things that are like,

like put like that or like yeah, like kind of signpost a little bit more. Yeah. That's okay.

~~so are these ones that you've already searched will recently, are they just, so these ones, this is a test application at the moment where we're going through a verification process to sign off the guidelines, or these are the ones that have been signed off with. Okay. Oh, okay. So by the end of it, you'll have, okay.~~

Oh, that's nice actually that you have at the beginning so that you could flick through and see like, just an overview of all the things that you have on it. Um, okay. — — **LAYOUT OF CONTENT PAGE**

So we're down to management, click on flow chart. How do you. **Does it, well, that's not a button.** That's just a, well, it's just a header, original flow chart. And then this is the programmatic one. Okay. Alright. So

it's six to 6.4. So. And acute ECG changes. Yes. I think that would be really good when you're actually in the hospital. I did not be so handy because that took me two seconds to work out exactly what to do rather than having to go along here and read all that, that also for me as someone who likes to have constant information quicker and less. That would save so much time. I really like that. Yeah. Um, so recommended option. Yeah. Yeah.

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	Yes	
Did they use the filter function in the guideline?	Yes	
Did they make any errors?	Yes	Thought section header was an activation button
Other notes		

Thought header was button

Session 7, 23rd January 2020.

Okay, sorry, I I'm looking for unstable angina on this medical guidelines and I can see that it's over here. And then next I'm looking for the, in the subsequent management. So that's recognition and management sometimes in science investigations, um, differential diagnosis, immediate treatment, subsequent management.

So that's here. Um, the recommended dose and method of administrating aspirin. So it says aspirin 75 milligrams, oral daily. *Okay. And what do you think of the layout and things like that though?* I think it's very nice and well done. Like, um, I like that it's all bullet pointed and it's not, you know, like quite wordy.

It's very like, to the, it seems like it's quite to the point. And, um, I liked the, I liked that the co like the headings are coloured and in bold and all caps. Um, and it seems nice, like**, this is much nicer than a book or going to a post, like, if I could just find this that's amazing.** Okay. Yeah.

Great. So during fluid management and acute heart failure, so acute heart failure, why don't you then there'll be sought. So fluid management I'll look for that investigations. There's an echo here. Um, but I'll just check for fluid management. I hear that. Okay. Mmm, arrange echocardiogram and seek advice from the cardiology team.

Perfect. So did you notice that straight away then? Did you with the, yeah. I definitely saw like the red warning thing, so I guess that is quite, it shows that it's important. I guess if it's immediate, that means that you probably want to put at the top, which you guys did and. This pops out because you don't see this kind of thing on the other, on the other one that I saw.

Okay. And the management flow chart of hyperkalemia. Oh, we get to use the flow chart. Now. What is the recommended action or a plasm? Um, I hear some natural colored chart, right? Um, classmate K plus 6.0 to 6.4. It's that one? And the acute ECG changes are present are a ECG with just present.

Yeah. So for example, there might be like PT waves. Yeah. And then, and we already have the recommendations of protect the heart and we'll yeah. The calcium gluconate and, um, yeah, that seems good. Like, yeah, you want to use. I think this is what I've learned too. **I've seen before in other textbooks. So this, and it's very nice and short** and I like to protect the heart cause that's what they always say.

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	No	
Did they use the filter function in the guideline?	No	

Did they make any errors?	No	
Other notes		

Session 8, 23rd January 2020.

So I think the interface is really good. Um,

yeah. *Why is that, is it with the only reason why* I feel like it's laid out really well and it makes things easier to find. And I liked the search bars right at the top. *Okay.* Um, cause usually, sometimes it can be hidden. Like you have to click extra stuff to find it, but it's right there. Yeah. Um,

and it's got good subtype, good headings. *Is there anything in particular like about headings?* Um, I think just how it's laid out signs and symptoms and then investigations and then differential diagnosis. I feel like it's laid out in a good order and there's not too much text as well. Cause I find that when I'm using nice and stuff like that, there's so much text.

Whereas here it's like laid out in such a good. So could wait. Um, and I feel that the, the investigations are in order as well. Websites I use, they don't put the investigations in order. Just got a list of them. And differential diagnoses are always really good to have on the website as well. Cause sometimes you'd be using somewhere, but you would have to go somewhere else for it, but a little bit, same, you get treatment.

Subsequent treatment. So it would be, yeah, I spend 75 mg oral daily.

It's easy to go back to the main menu, which is good.

And it's fast. Yeah. Some apps really lag, but this is really fast. So the signs and symptoms investigation.

So you would do an ECG right after you do the chest x-ray. Is that what it means? Oh no, during fluid management.

With management

immediately. Yeah. Yeah. I didn't even recognise that that initially. Or *do you think it was, what do you think that we're using this?* Um, I dont know?

I'm so used to just looking straight at the text rather than in boxes. Um, and usually I go back to boxes to see if things are important. Yeah. Um, but I'm usually, yeah, that's hard to get straight to text, so that's why I missed it. Okay.

So, *what do you think of that?* How that, um, I like it. I prefer it to a flow chart. *Okay. For what reason?* Um, because it helps you follow. In your head. Like, I find that flowcharts can be a bit much sometimes following it. And yeah. Whereas this specifically just gives you the answer you need rather than every on stuff. So it makes it a bit easier to follow and easy to get the information you need.

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	Yes	
Did they use the filter function in the guideline?	No	
Did they make any errors?	No	
Other notes		

Session 8, 23rd January 2020.

Session 9, 23rd January 2020.

Okay. Let's just start searching for unstable angina. Which was found very easily. And now going to subsequent management.

Okay. So they were lower down and it clearly States how to use aspirin. Um, yeah. So 75 milligrams, it says orally. *Yeah. So it's a fairly straightforward one.*

Acute heart failure when shouldn't, such an acute heart failure. I really like how it just pops up with the main ones as well. And they have an alert thing. Heart failure is not a diagnosis in itself. Okay. When should ECG be sorts? Yeah. See what I get if I search ECG and it says it's useful for re rhythm or dynamic.

So that's probably a lot easier to search than to search through where the times he ECG is mentioned. Um, alright, so that was in fluid management though,

maybe.

Big sectional, fluid management. Okay. Um, search two things at once. Um,

What is it you're looking for at the moment? so under fluid management where, I mean, I know when he said you should be used, but not if I'm meant to be searching specifically for fluid management, like, um, almost to go back to school

and maybe it's fluid management. Here

All right. So during fluid management,

So put you up as your misery, but, um, if you read the warning So why do you think you might have missed that? Um, cause I always think like, um, uh, it's like a background information or something critical to you act heart failure and maybe not something specific about a management technique.

Okay. So do you think that alert is too specific? Um, I guess it's more about the fluid management?

Um, no, it was probably me just not being bothered enough to read. Something that I thought was going to be relevant, but that is actually very relevant. I also, **when I think of ECG, I think of the letters**. So I've probably yeah.

What is the recommended action by plasma cells? …and your acute ECG changes are present. Let's go to

See if you're going to find you see management and we easily see management flowchart, right? **That is not, that's not a button**. Um, what is the recommended action plasma? That is six to 6.4 and acute ECG changes, uh, present, uh, Yes. So recommendations is calcium gluconate 10% that out and the following.

Okay. So I know it's you, um, there's other people that have done that today with regards to the, where it says the management flow chart, would you prefer a button to activate it? So at the moment it's a, it's laid out like this. It's just a bit, I mean, I guess it works. It makes sense. It's just, it's not that obvious that that's not a button that these are a button.

Okay. But I guess once you've just done it once, then he will. Mmm. Mmm.

Okay. But, yeah. So you've got the, you've done the thing you on there, so that's pretty much it. Is there any, anything else you would like to feedback on with the app?

Just really, quite clearly out. And like, I was just one colour scheme. That's very want to say like a simple layout, like. It's not trying to be overcomplicated. So it was nice and organized, which I think medics, like, um, there's not too much text in one area, checked out. It's just painful to read as too much. Um, yeah, a bit of sub headings, always easier to read through things. Um, yeah. Um, yeah the search things really helpful.

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	Yes	
Did they use the filter function in the guideline?	Yes	
Did they make any errors?	Yes	Thought section header was an activation button
Other notes		

Session 2, 30th January 2020.

So scenario one is about the management of unstable angina, say cardiovascular guidelines at the head of the unstable angina. So click on that and so scrolling down to find what to administer aspirin. So it kind of defines what unstable angina actually is first, which is good. So you make sure you got the right thing and like the chest, the symptoms, investigations, uniform, and so set out pretty logically.

Okay. Then down at the bottom and the immediate treatment section says you give 300 milligrams or get him to chew and swallow it. Think that. And then it says later on in subsequent management, it gets into 75 milligrams oral daily.

Okay. So getting back onto like the main section for the guidelines and that's the acute heart failure say it's got the warning again right at the top, which is very good.

And all of the symptoms. And in the investigations section, it kind of defines what you need to do before your echocardiogram. And it says you would request an inpatient one unless it was before and in the last six months. *Okay. Is there anywhere else in the guideline that has mentioned?* Um, yeah, it'd be BNP that the full hundred.

Okay. And it's possible. Heart failure

anywhere else.

I have not come across it. *Yeah. Just scroll this way for you for a moment. So, yes. What do you think the reason is that you might have missed that?* I think, cause it said that it was about fluid management. I just was like, Oh, that's not what I'm looking for. But yeah. I'm actually really surprised. Sorry.

Yeah, no, no. That's okay. It's it happens to everyone pretty much. Everyone's done that. So, um, if you can work on scenario three B for me,

~~They keep the light ones right at the top is good. That's what you guys say there, you can just dismiss that calendar thing, sorry.~~

And so like the other ones, they are set out exactly the same, which is good. And they're really similar to the like ones in the book/online at the moment, which is good. Um, and next can I make me, is not present.

Well, that's really good. Okay. W*hat reasons do you do you like that?* Cause it's kind of easier than following it through. If you're in like a really big rush and like, I don't have time to scan it all through you just go right to bottom. I think if you look it up, but I guess then if you had something wrong, then maybe you might get down the wrong line.

But that was actually really very good. I, if 50 we're having it, like above all the rest of the text though. Cause I'm not. If I didn't know that it was there. Just go down to, I don't think I would have looked for it.

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	No	
Did they use the filter function in the guideline?	No	
Did they make any errors?	Yes	Did not locate information in warning box until prompted.
Other notes		

Used ACUTE MI again and user struggled to locate the decision tool

Session 3, 30th January 2020.

so just as I would probably go for it. Absolutely. Uh, so I'm gonna use the search bar. Okay. And I'm gonna search angina, unstable angina. That's what I want. And I want subsequent management. So raise just scrolling down. Trying to look for a heading that says subsequent management or management or something almost immediate treatment.

It's we have subsequent management. Um, what is your recommended dose and method? So aspirin for 75 milligrams or.. Yeah.

doing fluid management for acute heart failure, when should an ECG be sought? Okay. So I'm going to go back. I'm going to go back to search bar.

I'm gonna search for heart failure. Acute heart failure clicked on I'm looking for fluid management, ECG, potentially. Uh, no kind, nothing specifically about that. In fluid management

maybe . Yeah. So now just scanning for the word ECG.

Okay. So I don't see anything, all the same management, so I'm sure skim the rest of, and what I see? Because they have to make sure it's not Management

f you go back to the fluid management for me. Oh, can I search to fill out a section? So from there, can I just say a ECG and see what comes out? Yeah. Cool.

Anything else?. Which doesn't seem to have anything, but use a full word echocardiogram requesting patient echocardiogram in less six months specific, I guess, talking to her cardiogram

that's before BNP

Arrange. Oh, I must've just skimmed over it cause I was looking for it. So I think if I was going to get feedback that, no one calls it an echocardiogram the first time you use it, potentially ECG echocardiogram, ECG in brackets. And then after that, I'd refer to it as an ECG the whole way through. So, um, with regards to that, *then would you say that we should have ECG next to echocardiogram or only use ECG?*

I guess if you were to put ECG next, wherever echocardiogram every time, there's no confusion. And did you think you missed that because you were looking for . Okay. Perfect. Thank you. Um, right. Yeah. Mandarin plasma once a day, if you just tap on the screen as well, that bar will come back up.

Yeah, there you go. And then you can go back. Is it cheating. If I were to know the answer to this one, sorry, that. Although whatever happens, it's going to be easy and scored in the hyperkalemia guidelines. Um, what's short now I think you're right. Right. So we want a 6 6.4 and ECG changes are present six to 6.4.

Okay. Yes. A recommendation calcium taken eight, 10% over five to 10 minutes, although you'll find it on the less within the trust in A&E um, what's continuous pressure about yeah. As you're giving it a repeat ECG. Yeah. Uh, *so what do you think of the layout of that? Yeah. Yeah, that's fine. Okay. Is that better or worse than the original flow chart method?*

If you have a look, see the original flow chart it's in. I don't know where that is. So the original flowchart would also give you

if you were in the original flow chart, it's the next connecting part. Yeah. Yeah. So I'm much, much better like that. Um, I was, I don't know why, but I felt, I knew it was a link, if that makes sense. Okay. Um, but I wonder if other people might not know that you can click on it to get so when it was the yes-no thing, but, uh, I forgot to go back to restart, uh, and I go and find it again.

Oh, it does say select from the following. I didn't read that bit. Yeah. So, no, that's fine. Nothing. I don't know why it just made, I just looked back links.

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	Yes	
Did they use the filter function in the guideline?	Yes	
Did they make any errors?	No	
Other notes		

Session 4, 30th January 2020.

The subsequent management, unstable angina. What's the recommended dose method of administering aspirin. Okay. So I see a search bar. So I think I was just going to try and search unstable angina and see. Um, so I click on the first result. Um, so I want to administer aspirin, unstable angina. So scroll down to possibly the treatment.

I'm scrolling. Okay.

Okay. And it says aspirin 300 milligram or chew and swallow treatment immediately. *What about the subsequent treatment?* So for the subsequent treatment. Okay. Yeah. On it. So it's aspirin 75 milligram, oral, daily. Okay. And was that easy to find, do you think? Yeah, that was there. Wasn't too much scrolling and it was quite, quite straightforward.

So during fluid management, acute heart failure, Hen should, when should an echocardiogram be sought? Okay. So acute heart failure. Cute. So it's the first result there.

Um, Okay. And when should an echo be sought? So I'm scrolling to see investigations. Um, okay. *So what specifically are you looking for at the moment?* I'm looking for an echocardiogram or so possibly like complications or okay. In the investigations section. Okay. There's a section on echocardiogram. It says request in patient.

I could call you now unless I'm echocardiogram performed in last six months and no new or Westminster. Okay. *And, um, with regards to fluid managemen*t, um, during fluid management. So I'm going to have to. The management sort of Monitoring and management.

Um, I'm just looking for any like monitoring.

OH, there it is. Um, avoid empirical fluid resuscitation in patients with pulmonary edema hypertension. *So what, what do you think the reason is that you missed that?* The first time I was just looking at the text. Okay. The red boxes. So are you looking specifically for type of texts? So I was just looking so, cause throughout the whole screen, those like.

Black texts. I was looking for a black, anything in black text saying echocardiogram in fluid management. That's fine. ~~It's just a feedback to them. Some people have mentioned that they were looking specifically for ECG, for example, not echocardiogram. Okay. So that was one of the things we were just trying to assess if you could go into the suite before me.~~

Sure. So press back and cancel, uh, in the management flowchart of hyperkalemia was the recommended action where plasma. 6.0 to 6.4 millimoles per liter and acute ECG changes are present. So I'll look, I'll search up hyperkalemia, which is, I can see it's already an option first option there, so I don't need to search it.

Um, and it's defining, um, hyperkalemia is plasma potassium more than 5.5. Um, and I'm looking for what's the recommended action. So I'd look, I'd go on management, so, okay. It's got. potas values. What? Potassium is six to 6.4. Okay. I'll click that. Oh, acute ECG changes present. Yes. So it tells me calcium gluconate and watch continuously.

Okay. And what did you think of the layout there for the flow chart and how that works in comparison to obviously the, uh, the original one, which is there. Okay. Um, obviously this makes it a lot, lot easier in terms of visually and just instead of you having to follow each bit in the flow chart, you have to just click one button, that helps.

Um, and it just looks better, like in terms of the colors and like, And ease of reading. *So would you say that you prefer that?* Yeah. Um, is it the exact same like flow chart? Yeah. Yeah. Okay. Yeah, that, I think that works.

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	Yes	
Did they use the filter function in the guideline?	No	
Did they make any errors?	No	
Other notes		

Session 1, 13th February 2020.

Tapping the filter guidelines for unstable angina cases, I've selected the, um, option that came up unstable angina. So I'm looking for the recommended dose. I want to see if it can get to the management. So scrolling down and recommended.

So for immediate treatment, it says aspirin 300 milligrams orally. So thats the recommended day schedule milligrams. *Okay. And in subsequent management?* Yeah. Um, so there's the, glyceride try, I'm scrolling down to this little, I'll try nitrate spray to relieve the symptoms. So you'd give a dose of 400 micrograms per meter, dose rates, and one to two doses under the tongue.

Um, and bisoprolol 2.5 milligrams, or, *and is there a section in there that called subsequent management that you can find for me?* Yeah, there is so aspirin, aspirin, 75 milligrams. Okay. So giving back to the, to the main menu on it. Yeah. So it's really fluid management and acute failure.

So there's cardiovascular section. So it's acute. heart failure section to bring up the guidelines, um, so that I'm looking for investigations. So it says under investigations, ECG would be useful for rate rhythm and dynamic…. Okay. *And is there anywhere else that ECG is and mentioned*

scrolling down to see if I can find…
scrolling back up to

What is it in particular looking for what's your trigger for that?

So I want to see kind of the guidelines for the use of the ECG. Okay.

So he's going to search filter section at the top to see where ECG comes up to the ECG is highlighted in the investigations. Almost anywhere else. It can be. *Well, I'll just, um, I'll just ask you a question about this part here. So, um, there is a section for echocardiogram. So why do you think you want you to miss that part?*

Cause it wasn't easy to open. That's fine. Um, and then in that, *if you read the red warnings for me there. Um, is there anything in particular about an ECG?* So if you've got avoiding the perk of fluid resuscitation patients with pulmonary edema, hypertension, um, normal JVP, even after, right. *I know you're not the first person to miss this.*

Don't about what's, what's the reason that you think you might've missed that as well? It was more because I didn't see that it was anything to do with an echo. *So, um, do you tend to use acronyms quite often then?* Yeah, I think, I think maybe that was.

Im going back to the main menu, about to the main to put on hyperkalemia. Um, um, so I'm going to scroll down to see, so in the investigations, um, if an urgent 12 lead ECG is needed. If it's abnormal or a rapid rise in potassium levels. And then the patients with, uh, Plasma potassium with more than six point and there's a, *should be a management flow chart within the actual guideline that you can use as well.*

So, okay. So clicking on the option to the management flow chart, clicking on a hundred flight shot for six to 6.4, and then it asks other acute changes present. And we said, yeah. So it gives you the recommendation. So I've checked that it's a set of plasma. Calcium Tassimo 66.4, which is aligns with it. And there were acute ECG changes.

The recommendations are to protect the heart. So calcium gluconate, 10%, 30 millilliters, five to 10 minutes using central access. *If, and do you, um, have any thoughts on how that's presented and how that works compared to the, uh, original here? You can see, let's say original and that's how that presents.* I think it's a lot easier to follow.

Cause you can look on your, you'd be able to look on an ECG and you can follow, you can select what you want. So it's quite easy and it's like, it's, you're less likely to make mistakes. Whereas following a flow chart, you've got to kind of check back on yourself. I think that is really useful that you can collect and then you can reset it.

You can also compare what if I suppose if the potassium level change, then he could check back on information that differs

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	Yes	
Did they use the filter function in the guideline?	Yes	
Did they make any errors?	Yes	Located wrong section as looking for information on aspirin and did not navigate to subsequent management Could not find echocardiogram - looking for the acronym ECG
Other notes		

Session 2, 13th February 2020.

So I'm just going to have a quick look what's on the home page and then I'll just search for unstable angina

when it comes off as a dropdown. So I clicked that. Um, so recommend using unstable, uh, the management.

So I've gone to immediate treatment, just having a look. What else there is subsequent management as well. And so the dose is 75 milligrams of aspirin, oral, daily. Um, okay.

Okay. So I'm just pressing the back button, clearing the search and look what it is.

Acute heart failure. I think that's on the home page. Yeah. So I'll just click that and. And then scrolling down to see where it says I could have echocardiogram. Yeah. So I found this section and it says to request it, if

so. Yeah. So you should request an echocardio unless they've had one in the last six months. *Okay. And what about drawing and fluid management?*

Okay.

Okay. So I'm having a little bit of fluid management there.

So what was the question again? Sorry. Okay. So echos in fluid management. I didn't see the word echo anywhere else. I'm going to continue scrolling down in case there's another section on it.

I didn't see it if I scroll down. So I'll scroll back up to fluid management.

Oh, it's in the red. Okay. So arrange immediate echocardiogram and seek advice. *So why, why, why do you think you might have missed that, then?* What were you looking for in what I was actually looking for a bullet that said echocardiogram. Okay. Um, so perhaps you could include it as both. It's like in the red and as a bullet point.

I was also gonna say, perhaps like you could make some of the key words bold as all in. Cause I know it's all red, but some of the words are in bold. And then, so you may not see individual words that way. Okay. That's good because I do, yeah. Okay.

So I'll go back to the beginning. Hyperkalemia is on the page.

Okay. So I'm looking for when the plasma levels are between six and six 44.

Okay. So found that.

I said yes. Acute changes of present. So the recommendation is protects the heart and yeah. So there's three suggestions there. *Okay.*

What are your thoughts of how they're presented?
Yeah, I think it's fairly clear.

What about in comparison to the original flow chart?

Um, Actually I'm the type of person at first, the sort of original flowchart, just because I can see all three options and I know all the case, there's also an alternative there. Um, *is there any other reason why you prefer original flow charts?* Um, I think I can just see more of the picture, whereas once I've clicked on RQ, ECG changes present, I'd be slightly curious.

Oh, what if they weren't present? Is it. Just as serious or not. *So, um, what we're looking at is presenting both of those within the guidelines as they are now. Is that something that you would find useful to keep it as it is? So what would happen is you would have your options like this here, and then you would also have the option to see you original guideline.*

Yeah. Yeah. I think that'd be good when I first clicked on your flowchart. Yeah. I didn't realize it was. So I know that the heading says management flowchart, but I didn't realize it was going to like narrow it down if I answered the questions. Okay. So for a second then I got a little bit confused and thought.

Okay. *So what would you recommend as an option to present that differently? If anything,* maybe once you've used the app, you would realize, Oh, they've got lots of flowcharts. I just wasn't expecting a flow chart. And so I wasn't expecting to answer questions like that. But perhaps after I've used it once or twice, I sort of know that.

Yeah, the drill. Do you think maybe some introductory information in the app would help with that? Um, perhaps, but I think I personally would just skip the introductory cause I know I would be able to sort of figure it out eventually. Um, I guess it's nice to have some sort of like help section in case you do get stuck, but that would be my sort of last resort.

Any other thoughts on it? No, I think it's all looks quite nice actually.

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	Yes	
Did they use the filter function in the guideline?	No	
Did they make any errors?	No	
Other notes		

Session 3, 13th February 2020.

So I need to look at management of unstable angina, So cardiovascular it's quite clear. Okay. I need to find, so I'm going to go back. Okay. I choose it.

So what made you go back by then? No, I just wanted to make sure I clicked on an unstable angina because there's different types of them,. I was wondering, do you have different section or is it just the old part? Did you want? Okay, so you go up there separate section for each one of them. Its been divided into different sections which is quite clear
It's being separated into yeah. Symptoms or anything was to get patients, which is quite clear. So I need to go to just management, uh, okay. Subsequent management, which is a separate block. Good. And then I need to know what he's working on to dose escalate. That'd be a 75 milligram. Perfect. Yeah, it's quite straight forward.

During fluid management of acute heart failure. So I need to go into…, then I need to find some things during fluid management. There is a separate section.

Okay.

arrange immediate echocardiogram. *Yeah. So what'd you think the reason is that you missed that the first time?* Yeah. The reason probably being because the other…, I was looking at some of the fluid management. There will be a separate section.

rather than being in bold red. Yes. Maybe that's why maybe it's just me focusing on something else.

I need to find… investigation

six point six.

So if there's more than a six, you need to do a 12 lead ECG. Um, and on the flow chart.

Oh, there's it. Okay.

So when you look looking at peak T waves, book, Braod QRS bradycardia and all that on ECG, if we do them,

if I put a yes, will tell me or recommendation. Okay. Yeah. So if. If there's easy to present, then you will get . Yeah. *So what are your thoughts on how that's presented?* Um, I think it gets some of the, to get used to because it's a chunk of information top to bottom. Yeah, I liked the way how it's separated from symptoms, investigation and common causes and, you know, management, I think once you get more used to the app, it becomes a lot easier because I was looking at more like the investigation was assigned first and then I'm going to move onto that management kind of thing.

Yeah. Although the question asking for the flow chart. Yes. Good. But how it's. Maybe it's like how it's presented. It's really good. It goes step by step. It's printed. The whole thing's easy to follow through.. Anything you would recommend changes, anything like that?

Um, not necessarily, but I like how it's presented, you know, each condition is separates to do system wise, uh, components, which is really easy to get to the condition and all of that. Um, we can actually sign for the condition as well.

Okay. Okay. So you can still search while I've been going through it. That's fine. Um, so does this get updated as in when? Yeah.

And does it have, um, links to where you I'll see there will be a research.

Further Analysis		
Outcome	**Answer**	**Further Information**
Did they use the filter function on the menu?	No	
Did they use the filter function in the guideline?	No	
Did they make any errors?	No	
Other notes		

Session 4, 13th February 2020.

Okay. So scenario one says in the subsequent management of unstable angina was the recommended dose method of administering aspirin. I don't think I understand the question.

Cause it says subsequent management I'll go to the app and see if it has says a similar wording. Okay. So I'm on the app now. Um, and I'm looking at the. Categories, and I can see under cardiovascular there's unstable angina. So I'm clicking that. Um, I'm trying to have a look if there's something that sort of says subsequent to try and understand it.

Okay. So I can see immediate treatment and then I can see subsequent management, which is, I think what it's asking for. So the answer would be aspirin. 75 milligrams is the dose and the method of administering it would be oral once a day.

Okay. So scenario two says during fluid management and acute heart failure, when should an ECG be sought? So I'm going to try and go back. Um, I'm not actually used to using iPhone, so okay. Trying to figure out how to go back because I'm used to back button, um, *C seek out additives topic. Yeah. Yeah. Because it's at the bottom, isn't it?*

So you always know how to go back. Um, but yep. So if it's heart failure, then I'm going to look at the guidelines so I can see there's acute heart failure. So click on that and I'll look to see if there's anywhere that says fluid management. Um, yep. So there's fluid management. Um, and then I'm now just going to look to see if it says ECG anywhere.

Um

so it says arrange immediate echocardiogram and seek advice from cardiology team. So. Um, as soon as you have a fluid management problem, then you should do an ECG straight away. *Okay. And how do you think, uh, what you thought somehow it's presented is presented*

quite well Cause it's an, a red box with a warning and like, I think anyone would automatically look and make sure like, what's that warning about.

Okay. So in the management flow chart of hyperkalemia. What is the recommended action? Where plasma potassium 6.0 to 6.4. Uh, And acute ECG you've changed the presence. So this is management. Sorry. Um, so to do that, I'd go back. I'm now used to pressing back, so I know kind of where to go down hyperkalemia is there, so that's nice and easy.

Um, and I'm going to have a look and see what the action is. So, um, so this is when acute ECG changes of presence. So. I can see that there's three sections one, which is exactly matching what I have. So I'm going to click on that one, which is a management flow chart. It says our acute ECG changes present.

So I'm going to press. Yes. Um, and the recommendation is to protect the heart with calories simply you can eight, 10% female of a five to 10 minutes using central access to available watch continuously for extra visitation, which is very damaging to the tissues. Yeah…. is stopping fusion immediately and reset IvX to split.

Perfect. Yeah. Um, how, what your thoughts on how that's presented? I thought it was very easy to find. I don't know if the will always be like this, but it seems to match exactly what I'd look for. If I want it to find the solution, it's not like. I like that there's not too many sub menus. So once I click hyperkalemia, it's got exactly what I look for rather than having to go there, go to a sub menu to find what I'm looking for.

Okay. The less things I have to click to get there, the better! Yeah, definitely. Um, do you have any other thoughts on how else the F is presented in general? Um, no, I think it's very well laid out. If it stays like this, then I prefer it to the actual guidelines. Cause they're horrible to get through. What are the reasons for that at the moment, then they're hard to get through because everything is in a massive.

Big subsection. And it's not always like you can't, there's no hyperlinks or if there are they're very poor, so they don't take you to exactly what you're looking for. Whereas if you can split things into, okay, this is hyperkalemia and I can click and go there without having to go to guidelines, find the 2019, go to cardiovascular section, then go there.

Then it'll be much quicker. And if the, if the guidelines auto update themselves so that I never have to figure out if I'm looking at the latest guideline, that would be even better.

Further Analysis		
Outcome	**Answer**	**Further Information**
Did they use the filter function on the menu?	No	
Did they use the filter function in the guideline?	No	
Did they make any errors?	No	
Other notes		

Session 5, 13th February 2020.

you want me to explain what I'm doing? *Yes. All the way through. Yep.* Yep. So I'm typing into the search bar, unstable angina and it's come up. So I'm clicking on it. I like how it came up automatically as a list. Um, tell me a bit about what it is investigations I'm looking for.

I'm scrolling down because I assume that the body, so subsequent management, so. Recommended dose of aspirin is 75.

Okay. Okay. So, okay. Acute heart failure. That's kinda what I'm looking for.

Oh, echocardiogram.

Yeah.

So what is it you're looking for at the moment?

do an investigation during that? I'm not sure. Um,

Mmm.

See, I'm not sure if it's just this echo and it says request an echo unless it was done.

Okay. It does refer to the fluid management section.

Oh, it was right there. *So what do you think the reasons are that you might have missed that?* I think I just assumed. That, that wouldn't be. I didn't read that. I don't know why, although it looks like it's designed to be more important. I guess I assumed that an echo wouldn't be that important, so I didn't put it there, but that was so immediate echo.

Okay, hyperkalaemia then the management specifically. Okay. Oh, please select from the following. I like that. So six to 6.4. Oh, I bet you see vs. I liked this. I liked how it came up and was. Yeah, it helps rather than having to scroll through more stuff, which I don't know if that would. Yeah. *Well, the option is the original flow chart, so you can compare the both together.*

I prefer doing this, I find flow charts can be really nice to look at, but then at the same time when you're looking through it, I feel like things get easier in my opinion. Um, You found the right stuff anyway. So it's when you're overwhelmed, but you have with how the app is laid out and things.

And is there anything you would change? Anything that you liked? I really liked. This bit about the, instead of having seen a flow chart that was broken down into three sections and you could click on it. Yeah. Um, I think a flow chart is useful if you're looking for, like, if you studying an entire thing, but maybe if you just want one piece of information quickly, I think that's really effective.

Um, I like how the search bar worked as well. Um, and how stuff came up as you're typing it in, um, But it's good to also have like a scroll full of options in case you don't know what you're looking for. *Yeah. Is there anything you would change?* I don't think so. I struggled with the second one, but I think that was down.

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	Yes	
Did they use the filter function in the guideline?	No	
Did they make any errors?	No	
Other notes		

Session 5, 13th February 2020.

Session 6, 13th February 2020.

so I guess I'm searching for unstable angina.

Clicked in it, clicked on unstable angina

Search subsequent management

and it's already come up. So the recommended dose,

75 milligrams all day. *Perfect. Yeah.* What did you, uh, *what are your thoughts on how the filter works for this? When you searched?* Yeah, that was really easy. Cause it just came up once I typed the word basically subsequent. Um, yeah, that was good. I didn't treat the two steps, found it.

back to get rid of the search.

Um, so acute heart failure clicked on it.

Again, it came up easy. Um,

~~Gotcha. You have found a book, which is good. Can I borrow this for a moment? I'm just going to remove this because we'll move on to the next scenario now. But, um, the, the natural section on that, within this warning here, but what I've realized is the filter seems to have filtered out with the warning. So that's a good thing.~~

~~Oh. So can you see my screen? Yeah. So this is good because it means this is what these sessions are for both to find any issues that people have from a usability point of view, but also programmatically, something has gone wrong there with that particular guideline where that filter is decided to filter out that warning where the information that you were looking for was in that red warning.~~

~~Bug found - filter does not include warnings~~

Clicked on hyperkalemia.

so why is it a particular you're looking for that management's flow chart. Okay. I didn't realize I could tell Um, thats not…

Okay, acute. Changes are present.

Recommendation. *Perfect. Yeah. So what are your thoughts on how that is presented?*

Yeah, that was good. *And what about in comparison to how the original select shots?* Oh yeah, sure. *Do you prefer the new message, the original would you prefer both?* Is that. So the information is the same, but it just presents it in more of a it's cool that you can see or get that you can see the flow chart, because if, I mean, I'm obviously not familiar with this flow chart, but if you were familiar with it and how about how it, how it presents the same information in this form, that's much simpler.

Like one. *Do you prefer that?* Yeah, definitely.

Okay. And what about in, in a whole, how the app is sort of. Designed. Is there any feedback for that? I think it's really good. Yeah. Um, really easy to use. Um, so this is all the nice guidelines, isn't it?

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	Yes	
Did they use the filter function in the guideline?	Yes	
Did they make any errors?	No	
Other notes		

Filtered out warning, bug found

Session 1, 27th February 2020

Okay. So I'm going to search for unstable angina

actually clicking on . Um, and it's asking for recommended dose and method of administration. I'm scrolling. I try to use this treatment. So, uh, the first thing I can see that says aspirin 300 milligrams, a little brackets, chew and swallow. So that's the dosing method. Okay. And in the subsequent management section, you mind aspirin 75 milligrams daily.

Um, so it's kind of like a flow chart. Mmm Mmm. Yes. Simple. You don't need like, lots of, like, it doesn't need to be like, particularly in studies with information. So I think it's quite nice.

Okay. So I'm pressing back. Okay. And closing the, um, search bar during field management and acute heart failure.

When should an echocardiogram be sought? Okay. So I'm typing in acute heart failure and it comes up, clicked it, um, ECG. So investigations, um, It's the first, the first thing I'm going to question patient.

So yeah, on the echocardiogram specifically for investigations, it says requested unless it's being performed in six months. *Okay. And in fluid management, particularly.*

it was arranged an immediate epicardiogram and seek advice. Perfect. *And what, what, obviously what made that noticeable for you to see the red?* THE RED. Okay, that's fine.

in the management, flowchart of hyperkalemia was recommended action with plasma, the, okay.

So I'm going to press back on the app. I've clear the. Search bar. Oh, okay. Um, hypokalemia. Okay. So I'm going to click hypokalemia, the fluids and electrolytes. Um, so management officials scrolling down to management, speaking how she has no something's click, um,

So what made you think that was something to click there?

The management flow chart expecting it to actually be a visible, like diagram with information on it, but I can see from the bottom that it's just got the three things, three options, so that's fine. Um, okay. K plus six to 6.4

and acute ECG, whereas a person so. Yes. Recommendation is how do you protect the heart? So all of the information under that bracket. Okay. Yeah. *And what your thoughts on how that's presented, especially with regards to, um, the original flow chart being there.* Okay. Yeah, I think that's similar to what I was expecting, but obviously this is really bulky, so it's good that you've done like a click, the option for which the plasma, um, Potassium is.

And then yes, when I would say ECG changes. So it's walking you through the flow chart rather than, **cause I can imagine if it's a stressful situation, you wouldn't be wanting to like sift through this huge flowchart here shot**. So, um, yeah, I liked it. It was just, I think I just expected it to be like a button for some reason.

Yeah, it's fine. Um, and what your thoughts in general? Yes. How it's presented. Yeah. I think it's good. I think people would obviously need to get orientate oriented to it a bit. That's a, um, but it's got everything you'd need. So symptom, like all of the headings are clearly outlined.

Um, and there, there isn't like a lot of chunky text, um, from what I've read, it's also quite concise. Yeah. So we would need on an app for something like this with clinical guidelines.

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	Yes	
Did they use the filter function in the guideline?	No	
Did they make any errors?	Yes	Located wrong section as looking for information on aspirin and did not navigate to subsequent management Thought header was a button to activate tool
Other notes		

Session 2, 27th February 2020

So it's the management of unstable angina and dose for aspirin. So I'm just going to scroll down the home page and in the cardiovascular and the cardiovascular heading, I can see unstable angina. So I'm just going to click on unstable angina.

First section is recognition and assessment. And what unstable angina is signs and symptoms investigations, a differential diagnosis treatment. So aspirin is 300 milligrams, oral chew and swallow. Yup. Um, *and if you want to have a look in subsequent management for me*. Yeah. Subsequent management. So GTN spray.

A beta blockers, bisoprolol anticoagulants in their products and refer to cardiology. Subsequent mentioned aspirin daily at 75 milligrams. Perfect. *Yep. Um, and what are your thoughts on how it's presented?* Um, I think it's quite nicely presented. Um, I'm not sure how if aspirin is how long the aspirin, the initial aspirin treatment is for them.

It doesn't say how long the 300 milligram or is for. And then when do you swap to 75 milligrams

So joint fluid management and acute heart failure when shouldn't PCG be salt. So I'm just going to try and look under this cardiovascular heading.

There's no heart. Oh, Acute. *so were you looking then just for heart failure?* How feta initially. Okay. That's fine. That's good. Because you mentioned I'm just gonna try that first. Let's kind of go investigation

and investigation. There's ECG though. It doesn't mention when specifically, if it would be so

useful for rate rhythm or dynamics, clean it up, no harm and a joint fluid management

management. If a patient has congested symptoms or unresponsive to their condition, does of diuretics give the equivalent of 24 hours? So there's, there's congestive symptoms you get for reason might if you've never been on dialysis consider for us. So is there anything about ECG in that?

Not that I can see on this fluid management.

if you just read the bottom of that here, so what do you think, why do you think you might've missed that?

seek advice from cardiology team. I'm not sure as its bright red,

the management of flow chart of hyperkalemia. What's the recommendation action with plasma. Potassium six to 6.4 minerals, but Nita and acute issues that are present. So I'm just going to you find hyperkalemia and symptoms and muscular weakness may occur investigations. If serum potassium is more than six urgent, 12 VDCG Fiji of normal or rapid rising cause potassium levels. And in patient with that plasma potassium or the 6.5 minerals can be to continue 3d three cardiac imaging, ideally in high dependency setting, *you should be able to find, um, a management flow chart and somewhere* in the following, this is 6 6.4.

Acute changes, Peaked. Yeah, the recommendations protect constantly. You can. *Okay. So what did you think of how that was presented in comparison to, uh, the original sort of chart?* Uh, **um, it's easier because you can just click on it and it's quicker.** Um, and the original flow chart, I think you have to look through things.

Yeah. So it'd be quicker. Um, **but I guess the original flow chart be good for learning**. *Okay. Why is that?* Because slightly more detailed. And I think that this with hyperkalemia is an emergency, so I guess everyone knows it anyway. So I'm not sure how useful, how many people would go into this and click on in an emergency situation. That's because it's like common knowledge in.

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	No	
Did they use the filter function in the guideline?	No	
Did they make any errors?	Yes	Initially could not locate acute heart failure as looking for heart failure - corrected without prompting
Other notes		

Session 3, 27th February 2020

So I'm looking for the dose and the method of aspirin and unstable angina. So on the cardiovascular and unstable angina, that's what you look back on. And then, cause it's aspirin. It's probably going to go under management. So scroll down. It's 300 milligrams. *Okay. Is there anything in the subsequent management.*

Sometimes 75 milligrams, oral, daily. *Okay. And how, what your thoughts and how that's presented?*

It's quite easy. Yeah, quite easy. *What makes it easy?* Fact that it's under like unstable angina is under cardiovascular and then it's under management, you know?

Um, fluid management. So got in the acute heart failure, under cardiovascular. So again ECG. That's probably going to be under investigations. So it's useful for rate rhythm with them or a dynamic scheme. *It the, and is there anything on the buildmanagement within the, within an acute heart failure?*

So does it range immediate echocardiogram and seek advice from cardiology team.

And if it's plasma calcium six to 6.4, that's under that already, something could come up.

I keep ECG changes or presents it as a question. Yeah.

And then it says…. Perfect. Um, *what are your thoughts on how that's presented* this easy, easy, because it was phrased in a way that matches questions. Yes, I would agree. Um, is there anything with regards to how that's presented that you would change? Yes. So, or do you like how it's presented?

It's also about the original flow chart there as well. So you've got the option.

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	No	
Did they use the filter function in the guideline?	Yes	
Did they make any errors?	No	
Other notes		

Session 4, 27th February 2020

So unstable angina recommended dose administrative aspirin. Yeah. So I'm looking at the section from the unstable angina, and then it's talking about the dosage method phosphorus.

To treatment. Um, and then it's called section for immediate treatment aspirin 300 milligrams chew and swallow. Uh, okay. *And if you can just go through to, um, the subsequent management section.*. Yeah. Oh, and it's also got aspirin 75 milligrams or daily, *your thoughts on how that's presented?* Um, yeah,

I found it. Fairly quickly, um, quite well laid out. Um, does it clear heading for instance, when I'm trying to, and then for the immediate on subsequent management? So I'd say it's quite easy to use.

So again, cardiovascular, they've got acute heart failure. Um, and then I'm gonna look here. We've got an investigation section to do

Yeah. So they've got a section for echocardiogram or request inpatient echo, unless I cope with the last six months. And now the new almost in symptoms.

And is there any mention of, uh, fluid management?

Uh,

it just mentioned to measure the BNP before you do the echo and then yeah, there was a section for three months. I answer, I didn't see that, , so they will have a full section on two eight London trends. I mean, there is there anyone should have echocardiogram.

yes. It says to a region, immediate echocardiogram seek advice from a cardiology team. *What's your thoughts on how that's laid down?* Yeah, again, I'd say quite clearly labelled. I just didn't read the fluid management on the question. *that's okay*

what is recommended? Option six to seven, four to QVC for changes.

So in case of hyperkalemia, which is under electrolytes,

so that's

Yeah. I found the, um, the flow chart. Yep. Which recommending to start a calcium gluconate.... Repeat the ECG after five to 10 minutes. Um, that was quite well laid out to be fair. It gives you like options and you click on it that according to what you've selected, it gives you the management just to kind of saves you having the sift, through to solve like a long list of, you know, different scenarios that kind of just brings it up for you.

It was quite useful.

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	No	
Did they use the filter function in the guideline?	No	
Did they make any errors?	Yes	Initially selected wrong section of information (looking for aspirin rather than subsequent management)
Other notes		

Session 5, 27th February 2020

Okay. So I'm going to search for unstable angina. Okay. Just come up, just reading through it. Symptoms investigation from tools, immediate treatment. So aspirin is 300 milligrams oral. *And is there anything in subsequent management?*

And then 75 milligrams daily, early as well. Okay. And what are your thoughts on how that is laid out? Very easy. it's a good layout.

So I'm going to talk about acute heart failure. It's come up again, specifically for fluid management.

so I'm on the fluid management section.

So I can see the request for an echocardiogram. Yeah. But that doesn't seem to be linked to fluid management. It just seems to be as an investigation on that side. *If you want to read the bottom of the red box for me. Yeah. Okay. So what do you think you might've missed that?*

So I think the red box, yeah, it was like a warning.I wasn't thinking that that's going to be something that would be relevant in like an everyday scenario. I was expecting this to be quite a common thing when to do an ECG fluid management. So I was expecting it to be in the standard texts. Um, I normally have looked at that.

Perhaps a repeat of that. Okay. **So repeating me the warning, the information. Yeah. Okay. In text either that**, well, if the font was a bit bigger, so for example, because, because of the phones layout, yeah. I'm seeing fluid management, obviously it's the sites within, this text, I'm not looking at the warning, perhaps that's bad on my

So I was like, Scrolling multiple times to get past that. *So do you mean make it a more noticeable sense?* Right. Okay. That's fine.

-
I was typing hyperkalemia by that.

Yeah, that's quite clear. *And what are your thoughts on how that's laid out and presented good?* It was quite easy to follow found the management section clicked on my, when target frame. Yup. Range, target range. Yeah. And then it comes straight up with all the ECG changes present. Yeah. And then you get your recommendation.

That was quite clear.

Outcome	Answer	Further Information
Did they use the filter function on the menu?	Yes	
Did they use the filter function in the guideline?	No	
Did they make any errors?	Yes	Initially selected wrong section of information (looking for aspirin rather than subsequent management)
Other notes		

Session 6, 27th February 2020

Okay. So scroll down to the unstable angina, click on it, scrolling down to trying to find management differential diagnosis, immediate treatment, subsequent management.

Recommended those sprint. So 75 minute milligrams oral daily, okay. *Um, what are your thoughts on how that's laid out?* It's really good. So I like that it's a set up by sort of body system. Um, As opposed to anything else. I like that the search function as well. So if you wanna get something quickly, um, I imagine any actual thing we have, like more than just cardiovascular.

Okay. *Yeah. So it was cardiovascular and fluid and electrolytes. Obviously these are the medical guidelines or medical guidelines will be available*. Yeah. So I think I was like, as long as the search function will be, um, more useful, useful yet. It's I like that. Um, and yeah, really good, really good layout when you click on it as well.

Again, search function. Yeah. And then all the headings and stuff are consistent for everyone. fluid management for acute heart failure is click on a human heart failure. When should an ECG be sore, if your symptoms and signs investigation.

So it says here useful for rate rhythm or dynamic. abnormalities. Um, okay. And then I'm just scrolling down to this bit. So request inpatient echocardiogram, unless it was performed in the last six months with unknown new and worsening symptoms since the last echo. *Okay. Is there anything specific to flow with management during?*

Okay. I said really management business.

Okay. So I read echocardiogram and what your thoughts on the layout on there? Uh, yeah, it's good. Big confusing. That echocardiogram is already a section of there. Um, so maybe it's just me missing it. And then if we had, since it's about an echocardiogram, if we put that in the fluid management and then.

Just like another bullet point in the echocardiogram. Yeah. **So you mean repeat that in times? Not, not like a massive big, yeah. Yeah. That's good. If I look down, I might not scroll 40, right. I could call you again.**

three being in the management flow shop, hyperkalemia electrolytes.

Hyperkalemia. What was the recommended action with plasma case six to six 24 and the
So,

so like from . Okay. All right. Acute ECG change is present when, um, Recommendation per se the calcium gluconate 10%. Yep. Perfect. Continuously. And what you felt somehow that works. And in regards to there as well, having the original flow chart there as well. Yeah, I think it's good. Um, yeah. Then if guidelines change and stuff, they will also change it.

Yeah. Yeah. Cause then when you, when you categorise like, Sometimes cause it's like, clinic's not always X, Y, Z. Yeah. It is a bit out. And you still have to choose from one of the options. That's when it can get a bit. Cause that's how do you mean the past one or the line of it's like four or five or whatever situations like this, the patient 120 kg or 60 kg.

Yeah. In that case, is the potassium going to be 6.56? Yeah. So with all that context, **but then it's good that you've got the flow chart as well**. So we can. That helps with the context.

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	No	
Did they use the filter function in the guideline?	No	
Did they make any errors?	Yes	Wrong section for initial information regarding echocardiogram as it is a separate section. Repeat information
Other notes		

Session 7, 27th February 2020

So what you're currently doing? Typing in, unstable angina into the filter section. Okay. Um, recommended dose so we can just scroll down or investigation. Okay. Immediate treatment.

So aspirin 300 milligrams orally, and it says under the immediate treatment one, then subsequent management, which is what it's asked or some to 75 milligrams orally, daily. *What are your thoughts on the layout?* And that's quite good because it's clear under the management section and it's in order. So you go immediate first, then what you do need later on, which is quite handy.

It also tells you like monitoring. It was really easy to find on unstable angina, even if you didn't know, you could just get it. Cause it's a came with cardiology. I think it's, it came up with cardiology first in cardiovascular. Yeah. So that's quite handy because you can like altogether because the patient is not going to come and say I've got unstable angina.

Nope. Yeah. If you didn't know, you could type in potentially that the symptoms or to go into cardiac. Yeah. It's…

You're going to type in acute heart failure. Oh, it's come up when should an echocardiogram. So,

and so im going to type astute heart failure, it comes up. So requests the inpatient epicardial ground, unless it's the formula. *And is there anything in fluid management for echocardiogram?* Yes. So it's with like a big red box arrange immediate. I could call your ground and seek advice from quail. So what are your thoughts on what that red box is?

That's like, you can't miss it and yeah. Its a warning! Okay.

hyperkalemia.

Let's say was the recommended action. Okay.

So if ECG is abnormal, then continuous three lead cardiac monitoring, a decency setting. If it's above six. Okay. So if you want to keep scrolling down for me though, I'm in the here. Yup.

That's the management flow chart there.

So if they are present yes. So recommendation. Okay. So , *so what are your thoughts on how that is presented in comparison to normal flow?* Isn't it? Yes. That's correct. Yeah.

I think if you know how to click on it. So if we go back a bit, if you just went from there and you scroll down and select from the following, that's quite easy. So no one knows to do it. It's easier. If that makes sense than having to go and read it all. But I think if you don't know how to use it, that's quite easy because you can just see where you don't have anything.

Okay.

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	Yes	
Did they use the filter function in the guideline?	Yes	
Did they make any errors?	No	
Other notes		

Session 8, 27th February 2020

So in the subsequent management of unstable angina, what is the recommended dose and methods for administering aspirin?

Okay. So we're going to go on the phone and look up. Unstable angina, if they can find that off. Yeah. It's very clear and symptoms, investigations. It's very quick to scroll as well. *So what are you specifically looking for at the moment* I'm looking for the dose, um, the treatment, the treatment options, and yeah, it says you can get treatment when they those, okay.

Yeah. So then. Yeah, recommended doses aspirin 300 milligrams. And what about a subsequent management? Subsequent management is DTN spray, zipped portal. *Is that what he said about aspirin for subsequent management?*

oh subsequent management? **No, there is another type of that as well.** Um, yeah, it says aspirin 75 milligrams. *Okay. And what are your thoughts on how that's laid out?* Um, I think it's very, very clear because. And you've got a title for immediate treatment. So if you're in that acute scenario, you just know immediately what to do.

And then if you're like in the cardiology ward and after the patient is more stable, you know exactly what to look at and what to do. And it clearly says if responding, if not responding as well. So you need, you know, every single step that you can take afterwards. It's pretty good.

Okay. So scenario two is during fluid management of acute heart failure. When should an ECG be sought? So we're going to go back and go to acute heart failure, which is right at the top. And then the, um, well, I'm going to look at his fluid management and see if they've got a or look up ECG.

Fluid management. Yeah. Very clear. That's like red is well, so you need to know exactly found this right away. Um, so, um, yeah,

in the management of flow chart of hyperkalemia, what is the recommended action? K plus 6.02 6.4 and acute ECG. And the management of flow chart of hyperkalemia was the recommended action….

~~Okay. Pass is elevated and acute ECG changes are present.~~ Okay. So I'm going to go back and you've got a specific, okay. Fluid and electrolytes. So I'm going to click hyperkalemia and then specific to elevation plasma six to 6.0. So it's very, very clear what you can take the different levels as well. And then it says, recommended action is.

Um, if I can easily ECG changes are present, so they are present. Yes. And then it says recommendation is to protect the heart and then you get those three things. Yes. very clear.

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	No	
Did they use the filter function in the guideline?	No	
Did they make any errors?	Yes	Initially selected wrong section of information (looking for aspirin rather than subsequent management)
Other notes		

Session 1, 5th March 2020

Okay. So in the cardiovascular bit, scroll down to find unstable angina to press it and scroll down to

Immediate treatment. I think. Yeah. Subsequent. some little scrolling and it says the thing aspirin 75 milligram oral daily.. *I want your thoughts on how that's laid out.* Yeah, it makes sense. You go to like, it's exactly how I think we will do our notes as well. It starts with the conditioning and then work through like what to look for.

What's test how to manage and then having it split into like acute and subsequent management. Really nice. Right? So back to cardiovascular, heart failure, it's called suppose scroll scroll scroll scroll scroll and under investigations, ECG useful for right by them.

What's already known like ischemic up in the moment, too. *Is there anything specific to fluid management in there?*

Yeah, that's a great big red box. That's nice. Um,

it could just be me being thick. *So what specifically are you looking for?* Honestly, I'm just reading the fluid management because I got distracted. Oh its in the red box…

why is it you think you might've missed it in there? I think I was looking for, um, like the text below, because I think, um, Red box is because it's a clinical guidelines I'm seeing about, normally it doesn't apply to me.

Ooh, I like it. Um, alright, say six. *So what do you like there specifically*, um, that it's broken, up, sort of having a big, like just a flowchart that being able to select which bit, but, um, being able to answer questions. So it actually gives me exactly what I need,

why is it you prefer that?

Because honestly,, if I see a big flow chart im like…., ECG changes are present. Yeah.

So what your thoughts on how that's laid out? That's really nice. I like that. *What specifically do you like?* Um, you know, not having to scroll a load of stuff to find exactly what you need. So you just get down to the flow chart, press what you want and then it's there. So it's nice that it's saying like his is of plasma.
Potassium and then. Just the simple yes, no. Cause sometimes when it's like branching and you having to look everywhere to find exactly what you need, it's to the point. It's good, which is good. Cause I like to have clean.

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	No	
Did they use the filter function in the guideline?	No	
Did they make any errors?	Yes	Required prompting to find echocardiogram information in the warning box
Other notes		

Session 2, 5th March 2020

So I'm just looking for something it'll show me about angina. And I found it the, just that one dose does and method

investigation, maybe in treatment, ah here we go. So we've got immediate treatment is 300 milligrams. And that's, um, method is oral, chew swallowing. *What about in the subsequent management?* A subsequent management

Oh, here we go. It's not. Okay. Aspirin 75 milligrams oral daily

What are your thoughts on how that's laid out? Yeah. Yeah, that's good. I didn't think that it would be split up into immediate and subsequent. I thought we would all be in one play.

So during fluid management in acute heart failure, when should an echocardiogram or ECG be sought? Okay, acute. aCute heart failure here, then during fluid management. So maybe immediate management, fluid management. Okay.

Could be sought arrange, oh its in this red box. So in. In patients with pulmonary hypertension. *Okay. So what are your thoughts on how that's laid out and presented?* No, that's pretty good. It's right at the forefront.

Okay.

um, was there a point?

uh,, here's the management tool

I just want to select one of these, the ranges, six to six, one for…

acute ECG. Perfect. *What are your thoughts on how that's laid out?* Is pretty easy Its really good its really easy *Which parts of it? Do you find easy? What is it you like?* I like, oops, I like that. It's split up into the different intervals. And then when you. Click it, it breaks everything down probably to what you're thinking when you're looking for it.

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	No	
Did they use the filter function in the guideline?	No	
Did they make any errors?	No	
Other notes		

Session 3, 5th March 2020

I'm looking for the recommended dose and method of administering aspirin. So I'm going to look for unstable angina. I'm clicking on the unstable angina. Um, easy to find, um, You're scrolling through the page and looking at treatment

okay. So now I'm subsequent management, easy to find. Um, so there are bullet points. It clearly shows me, um, the dosages and the medications to use. Um, so the recommended dose is 75 milligrams oral daily. Perfect. *So what are your thoughts on how that's laid out?* It's sort of good. Um, yeah, it's good. **Maybe like at the top there could be like a mini, like contents where you could click on, for example, subsequent management and anything.**

Okay. Yeah. Like a shortcut. Yeah. Yeah. Okay. Excellent. So acute heart failure. Okay, so just kind of find it.

So when should an ECG be sought? So I'm just going down to see your medications. Um, so it tells me about ECG and then if I scroll down a bit more, it tells me

awesome.

Here we go. Um, so it should be sought. Uh, yeah.

Oh, I have a cardiogram. Okay. Sorry. Yeah, it should be. So I thought I was reading an ECG. Um,

After the BNP level, um, is shown to be about 100. *Is there anything specific for fluid management?*

Fluid management.

So what, what, what do you think the reason is that you skip that one? I just thought it wouldn't be relevant to what I was looking for, but I mean, obviously I probably should have read that first cause it was red. I think we gave, so arrange your media, echocardiography.

Um, what was the reason that you told me might not be relevant? Um, I thought it might be a warning about certain medications with something that would have it, uh, a specific effect that. What are your thoughts on how that's laid out though in general, in general? Um, I think it's good again, maybe like a shortcut at the start.

Yeah. Um, I think it's just me who didn't read the, we've done 30 of these now and *I think only two people have that in there.* Yeah. Um, maybe like on top of the warning box, they'd be just put something about

Mmm.

Just a little header to kind of, uh, proceed the information below kind of thing. Okay. Um, so like something, special circumstances or something, have a look. Yeah. *That's good feedback. Thank you.*

So just going to hyperkalemia.

Okay. So Plasmas. between six and 6.4. I'm just clicking on that box. Um, did acute ECG changes up present Ts?

So the, that it tells me the management. So calcium gluconate. That's really good. Yeah. I like that. Okay. *What is it you like about it?* The fact that there's like boxes, you can click and it easily takes you to the, um, the recommended treatment. And why is that useful? Um, it's kind of a logical and quick way of getting there other than looking through all the information, which I like.

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	No	
Did they use the filter function in the guideline?	No	
Did they make any errors?	Yes	Warning text ref echo required prompting
Other notes		

Session 4, 5th March 2020

I'm reading the prompts, subsequent management, let's say my job was recommended dose method of administering aspirin.

Well, I'm going to start with scrolling down. I'm going to think part of acids here. It's most squabble, quick little consent. They might be there. Amazing. Um, I'm on the screen. I'm looking for aspirin specifically. So I've looked around the screen to see if there's a quick search function. See when they're ready to except at the top here.

And I found it. Yeah.

Immediate treatments. What's the recommended dosing or immediate treatment that comes with 300 milligrams. Scroll through. See it pops up again. So subsequent management, I don't know, I found it a 75 milligrams, oral daily. *And what's your thoughts on how that's laid out?* I was fine less than easy. I think.

Once I found where the search bar was. We're just going to use it again, the next, um, I could get, and then it's highlighted that it's nice and I can scroll through it and I'd like, click, like to the next one. I can just rapidly scroll through and see how many times.

I'm going back to the homepage.

Cause I feel like that much fluid should.…

Yeah. So just so ECG generally is electrocardiogram. So it's like a different test. So like, if I was so do you want an echo or electrocardiogram echocardiogram? So I, when I see ECG, I'm thinking of electro electric trace one, rather than. The accurate cardiogram fleet is the heart ultrasound. So when I searched by way, it brings up the right rhythm and dynamic area.

I know that's not necessarily what I'm looking for. Um, so true echocardiogram. Before now cardiogram section here, of course, unless sacred performed in the last six months and no new or worsening symptoms since last echo, *anything specific to fluid management.*

Oh, fluid management. Yes. There we go. All right. I've only read half the thing.

It's not growth on fluid management. I got big box just telling me things.

device for cardiology team, for patients that have these symptoms, they pretty much found it in the web box. Um, *What are your thoughts on how that's laid out?* Um, well, I like a red box, cause it makes me read that even if I don't read anything else after that attention to it. I do like how it's, I mean, I mean, I'm not sure it's always gonna be that, but there's like a nice title at fluid management.

Are I know I'm at this section. I know that it's bounded by sort of here's the next one is how much I need to read from the quick, quick glance through it. measure the culture back to the front that worked last time. Hyperkalemic action. What is 6.64, try and search six.

That comes up, but it might not. I guess there we go. There's a management flow chart. I'll have a quick scroll through a case. There's a large flow chart. Mentions see original flow chart. Okay. So then the six, 6.4 range within the action. Im scrolling, um, 10% gain over 10 minutes.

Yeah. Perfect. Right. So if you can zoom back out again for me. Um, and then if you go back down to where that flow chart was, could you try using the, uh, the button just to see if, ah, yes. Oh, Oh, okay. Oh, to do that.

Yes. So what are your thoughts on how that's laid out? I like that, but as for me as a clinician, I would like to see the whole thing. Cause I like double checking it for myself, but I can see. That's user friendly, but I also don't trust my fat thumbs. So if I can trace from, start to finish where I need to go.

So I like having both options. Cause then I can also, I can do that and then I can double it. No, that's that's perfect. So what was the original, what did you miss that initially? Or was it just sort of flowchart and thought that's what I think. I saw see original flow chart. So I was like, I wanted to go there first.

You got to get an overview of everything. And it's when I get that narrow focus, you know, I can get to now knowing I can get in there if it cause that's fine. But I think I preferred sort of seeing overall what the whole thing is. Cause sometimes you get a little smaller aspect of the picture you don't understand, they know.

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	No	
Did they use the filter function in the guideline?	Yes	
Did they make any errors?	No	
Other notes		

User used the original flow chart, didn't originally see the flow chart tool.

Session 5, 5th March 2020

Okay. So I'm just gonna go to the search bar and put unstable angina. I came up straight away, which is good. And then just scrolling down to get to the dose. So going past symptoms, differential diagnosis, and it has immediate treatment here.

Um, so initially it does have aspirin that I'm getting is 300 milligrams oral, so that's clear. Um, so yeah, that's the initial dose and method of administering *that subsequent management, subsequent management.*

They have a labeled heading or subsequent management, which is aspirin 75 milligrams oral daily. *Perfect. And what your thoughts on how that's laid out?* Um, it was laid out quite well. Um, I don't know. It seems to be laid out in order of stages to do it as well, but she was quite good. And it does have the kind of background information at the top.

So you can kind of go through and signs that you see fast and then investigations that you do kind of like in a clinical setting. Um, and I do like the differential diagnosis as well, because that's the part that I personally struggled. Um, didn't seem to be quite clear.

So I've seen like that. Um,

So I'm gonna, again, type in acute heart failure, which comes up straight away and… I didn't fill it. So I know that it's supposed to be an investigation. Um, which it isn't it has a separate heading, um, so request inpatient echcardiogram, unless I could probably pull them last six months and then that's fine.

And can you find anywhere specific where it mentioned, uh, under, um, fluid management?

So management

and then they have big red sign,

So this one is right on the front page. Okay.

and what, in particular you're looking for at the moment. Um, so just an investigations I'm looking for, what's specified in the serum K plus levels being more than six, which is what I have on with that bullet here. And the recommended action. It says urgent 12 weeks. And is there anything that their management management flow chart?

Yes, it does. Management flow charts that you can click into.

Well, I don't know. Oh, see, original flowchart. That was a bit confusing. That's okay. Which bit were you clicking on? The title part there? The actual management blue header, since I assumed that was the link. Cause it was a different color. Okay. Um, and then it was when you scroll down, it says, see visual flow chart, which is yeah.

But it was, so that might be confusing. *Cause various, usually that's fine. If you want to try and select maybe as well. And these are actually buttons on there to select from the following, following that. Yeah.* But this one is this 6.4, keep ECG

all present.

So, yep. And then the recommendation comes up, please. Perfect. So what are your thoughts on how that works apart from the, the thing at the top and what changes do you think we could implement with regards to how that part is laid out? So that it's obvious to use those that we start, that there was buttons underneath there.

Right? So I feel, I think maybe that part should be maybe a little bit bigger or highlighted in a different way, just because from seeing the previous pages, from what I've used, everything says the, of a. Blue and white at the moment. Um, so maybe different colors to indicate that after that it was easy to use.

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	Yes	
Did they use the filter function in the guideline?	No	

Did they make any errors?	Yes	Did not access the correct section, not UI issue. Clicked on the header for the flowchart section to activate the flow chart
Other notes		

Session 1, 12th March 2020

So, just go down to cardiovascular and then click on unstable angina.

Um,

And then, so the immediate treatment, aspirin is 300 milligrams subsequent and 75. *Okay*. What are your *thoughts on how that's laid out and yeah,* I think that's okay. Um, I guess I just don't know what's coming next cause I haven't used it before, but if I used it more, I would say where to scroll to. Um, and then just going back, um, so then go to a acute heart failure and scroll down.

So what, what specifically are you looking for here? What are your sort of triggers for when you're searching through the text? Um, acute heart failure, but then we'll say fluid management. So maybe it will be under this section or in the food management.

Yeah, the fluid management section.

Alright. So what are your thoughts at the moment? I'm like at the fluid management but, there's nothing about ECGs. So unless I just can't read it.

Oh, there, echocardiogram. Yeah. *Yeah. So what was the reason that you maybe didn't read that?* I think if it was said ECG, I'd probably pick it out quick as an echocardiogram. Is it an acronym? something.

Which which part are you looking for at the moment, investigations, um, serum potassium greater than 6. Yep. *There should be a management, the flow chart you can access.* Oh here.

Okay. Say it says give calcium…. *Yep. Perfect. So what's your thoughts on how that's laid out again?* If I knew that was

I think it's just getting used to it, but it makes sense. Okay. And, um, with regards to, *in comparison to the original flow chart and both of those, what were displayed in the app? Is that something that would be useful?* I think so. Yeah, but interactive aspect makes easier. I think if you were in a rush and do you have *any thoughts on the design or layout?*

So anything that you would change? Anything you dislike? Anything? I think it's all right. Can you see a mental needs? Oh, not one specifically, but it will be something that will be available.

Yeah, I think it's like set out quite clearly.

Maybe like, like I said about like ECG and stuff, if it was like here, right? Yeah

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	No	
Did they use the filter function in the guideline?	No	
Did they make any errors?	No	
Other notes		

Session 2, 12th March 2020 - 20 seconds for interruption

So I'm just scrolling through the list and clicking on unstable angina. In the cardio section,

just scrolling through investigations.

So it's not the immediate management. Subsequent management is 75 milligrams. That's fine.. *what are your thoughts in how that's laid out?* It's very nice. I like how it sort of introduces the topic. And then sort of give to the Symptoms and signs and investigations. Okay. And how about the design in, in respect to how it's broken up for each section in terms of unstable angina, or just not necessarily the context itself, but how it's actually laid out?

Mmm, no, I think it's pretty good. I like how there's the headings are there. They're nice and clear. Um, And it just didn't seem like lots of words. It's just get straight. It's fine. The stuff in bold as well, which is quite important. Most of us, if you could move on to scenario two for me.

So let's come back to the homepage, right?

It's going through you get heart failure.

And then I guess someone else,

is it just here? It says requesting patients no touch in the, in the fluid management section

And why, why does he want to miss that? Which part of the, um, I don't know. Could you recall me reading the bits of it too obvious that it could have been there? Okay. Um, obviously is an emergency situation, which is why it's in red, but I didn't maybe necessarily associated as being, uh, I just couldn't see the word ECG.

I think that's what I've looking for. *That's fine. That's no problem. Um, what are your thoughts on how that's laid out and how that things are presented?* Um, I don't know, maybe something about echocardio echocardiogram could say ECG in a different color, like black or something. Maybe that be a bit bold.

I just feel like there's quite a lot of text for it to be like important information maybe.

So it's part of you're looking for at the moment. Um, so then for the plasma being between plasma potassium, between six and 604, Um, so it says if it's greater than 612 lead ECG. *Yep. So there should be a flow chart you can follow on there,*

So what are your thoughts on that? How that, um, I just like how it gives you the option, the three potential options that it could be, and then you can choose from that. And then it tells you that the information that as opposed to just having all of the information for it, that, yeah.

Cause it could just, you could misread it or something, but if you're selecting, what you know is infection are things.

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	No	
Did they use the filter function in the guideline?	No	
Did they make any errors?	Yes	Could not find ECG in warning and was prompted.
Other notes		

Session 3, 12th March 2020

Okay. It's looking in the cardiovascular section. Um, find that unstable angina section and some method of administering aspirin

Searching for the treatment immediate treatment section. So aspirin 300 milligrams, oral chew and swallow. Okay. *And is there anything in the subsequent management* and then use a literal Trinect spray? *Yes. In regards to aspirin.*

Um, Oh yeah. Aspirin 75 milligrams, oral daily. *So what are your thoughts on how that's laid out?* That's really simple. Just quick. It's all easy sections. You just scroll through. It was quite, nicely laid out. It's just really easy to find.

Okay. Just want to move back to main menu back to cardiovascular section. Looking for acute heart failure, going into the section and says, ECG looks if there's an investigation section and investigations C says ECG useful for red rhythm or genomic ischemic ophthalmology,

Is there anything with regards to that there? I haven't done the fluid management section.

Oh,

okay.

if you look in the red box at the bottom for me. Oh, okay. What are the reasons why you think you might have missed that? And because I was looking for ECG rather than echocardiograph. So would you normally search via acronyms? Yeah. Okay. So you would expect acronyms to be in there too.

Okay. That's fine. That's perfect. And that's good feedback. Um, right. Um, if you could move on to the lesson over there, this would be one for me. Okay.

Okay, so I'm going to quit back. So hyperkalemia I'm in the fluid and electrolytes section, top of the hyperkalemia. What does he recommend when plasma potassium is six to six weeks.

Okay. So I'm going to see if there's a management.

Six six 24. Okay. So imagine the section of Scott 66.4 section. Cool. so it says, here are key ECG changes, present to speak to you is broad QRS, pretty upset and plenteous. And then yes. Recommendation calcium clicking it's 10%. *And so what are your thoughts on how that's laid out and how that presents the information that you've got, especially the flow chart* sort of Oh yeah, it was quite logical. Yes., it took me through it really easily.

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	No	
Did they use the filter function in the guideline?	No	
Did they make any errors?	No	
Other notes		

Session 4, 12th March 2020

I mean, tons of management's looking for aspirin and it says…

Nice. That's really useful. Cause you got, you got a nice summary of what actually is. probably by signs a and symptoms that investigation that you performed to try and diagnose it, which is useful rather than going straight into management. Um, and he was busy differentials there, which is nice as well, in case you end up in the wrong space, sleep check on some actions.

Um, yes. Um, *if you could just move on to the subsequent management as well, just to make sure.* Thanks. Sure. So from my understanding, you initially started aspirin and then you were able to. Well, you can also give the, just refining the…. *Is there a subsequent management section?* Um,

Oh, there is actually just below. That's handy. So if the initial management doesn't work, so why is that handy? Um, well I guess if initial management, the initial successful or at least you have a fair idea of what the next step is. I saw it on the app as well, which makes it all easier and more efficient.

acute heart failure. And we're looking for when it ECG, so true. Okay.

Not here's the final section.

Alright, are we good

originally? *Yep. Perfect. Um, what your thoughts and how that's laid out?* Um, I mean, I guess because I'll leave them to sign in to take that. Initially. I was like, Oh, where is it? Where is it? But with time, I usually have a better understanding of how it actually works. You know, you just go a certain amount and those get to wherever it is.

I feel that will be something that would happen with this app. And how it's, I guess if people would be using on a daily basis, I assume say you get used to them now you have a fair idea of where different section will end up being. So it will make it a lot quicker, but I mean, it, wasn't too difficult to find that many it can be well.

Okay.

So what are your thoughts on how that's laid out? That's really good. Okay. Well, it's just very simple. We just, as a tick box and it eventually gives you the answer, so you and I can follow. *So why is it you prefer that over, say this kind of view* , um, I mean, with someone like this, you're having to zoom in a little bit to not read words in the first place. And it's just a little bit confusing as all over the place. Whereas something like where you tick a box of things, it's more just far more logical. I feel okay. I just ended up gaining to a right answer straight away, but than have to try to find it in a sectilon. That's just was jumbled up everywhere.

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	Yes	
Did they use the filter function in the guideline?	Yes	
Did they make any errors?	Yes	Initially searched for another guideline within a previous guidelines. User corrected without prompt.
Other notes		

Session 5, 12th March 2020

Yeah. So with unstable angina , uh, probably looking at maybe some things to do with, Oh, there's unstable angina like this it's cardiovascular. That's fine. So go on that. And then there's recognition assessment. I'm looking for the recommended dose of aspirin that has probably treatment. So that's all the way up the sign investigation, there was a lot of investigations, differential diagnoses, immediate treatment.

So it says here that okay. Was it recommended though? So it's aspirin 300 milligrams, *no. Subsequent management,* subsequent management is that that's probably often on underneath immediate treatment. So does referral. Oh, that's management. Awesome. Okay. And just to keep scrolling, um, yeah, it says aspirin 75 milligrams.

Okay. And what are your thoughts on how that's laid out? Um, this is laid out nicely. The only thing is there's quite a lot of. Investigation. So if it's possible to somehow make it. Maybe like subheadings on the **underneath, condense open** up cause that's cardiac biomarkers. And then the CCGs,

Yeah. So during fluent management and acute heart failure, when should an ECG be sought? Okay, so then I'll go back, press back. And then I'm looking for acute heart failure, which is again, right here. I just got that. And then, Oh, what that's nice.

Is that helping not diagnosing? Nice. Um, when should an easy, easy to be so, okay. So that's probably investigation. So I kept scrolling all the way bottom ECG, useful for rates. So that's saying that what's useful for. So that does save Oh, for the echo. Oh, it says it. Yeah. Um, request unless performed in last six months or no, new worsening symptoms and it's already thin in regards to fluid management probably we'll do at the bottom.

Okay. Yep. So there's a whole section on it. So it's to avoid in protocol fluid resuscitation, and then. He would manage cute heart. *So, so it's anything to do with an echocardiogram in fluid management*

mission, congestive symptoms.

No, I don't think so.

why is it you think you might miss that? I think it's because I think I just expected. Something like at the bottom, when they said how much fluid to use a then say, okay, get amended and then say, well, because I wouldn't put echo and fluid management in the same head. Okay. *So would you, would you expect this to be within the text as well then?*

Or like even, even infer, just be like, um, after fluid management, like next steps or something. That's what, maybe that's what I would do. Yeah, no, that's great.

In the management flow chart hyperkalemia.

Okay. So go back plus back and just go to hyperkalamia is first one and then recommended actions I'm looking for, um, investigation. It's not, yeah, it's it's serum.

Um, urgent as it says here, there's a potassium there's so there's above 6.0, and there's an acute ECG and there's abnormal ECG. Then you should have continuous three lead, cardiac monitoring, ideally in the high dependency setting. And then I'll go over with the flow chart. Oh, there you go. This flow chart, which is 6.0 to 6.4.

So it's right here. If I click into that. **Oh, that's quite nice**, acute. They're all. It keeps ECG. So pressing. Yes. *So what are your thoughts on that then?* Beautiful *Why is he like that?* Um, and that kind of set thing, **I'll probably be panicking. It will ask me the question and I'll be able to see it immediately, what I need to do.** So then it's not like me having to fumble about, I got the answer and I know what I need to do. Yeah. So I think that's quite clear, quite clear. Cut. So that's quite good.

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	No	
Did they use the filter function in the guideline?	No	
Did they make any errors?	No	
Other notes		

Session 6, 12th March 2020

Okay. So I'm going to search unstable, angina. Um, tell me what the recommended dose and method of ministration.

What is this differential treatment?

So it says immediate treatment, 300 milligrams of aspirin orally. Okay. And is there anything in subsequent management and say GTM to be symptoms? Um,.

Um,

I suppose, I don't know whether the doctors would obviously know this, but looking at this, I wouldn't know if you're supposed to do all four or which is indicated where, or for who, but I don't know whether that's on a different subheading and subsequent management. Aspirin 75 milligrams

Perfect. What are your thoughts on how it's laid out? Um, I think that it's useful to have it straight away. It's clear at the top aspirin 300 minute comes up straight away. Um, I didn't didn't realize that if you scroll down, you'd have the subsequent management that does make sense though.

Okay. Is there anything that you think would help in sort of helping to recognize that?

Maybe just put see below for further management, subsequent management a part thats on the screen that if those bit that refers you to below, um, because I would have seen referral to cardiology and think, Oh, okay. Maybe that's the end of the line, but then he said um, yeah.

Okay, Acute heart failure…

So scroll down, you

say it says request echo. Okay. And last second from the last six months. And now you worsening symptoms symptoms. Is that right? *Um, is there anything to do with fluid management specifically in that guideline?* Okay.

This is one of the issues as an echocardiogram and electrocardiogram, both technically referred to as ECG, but his echocardiogram in there. *Um, is there anything in there that, I mean, obviously, because. Is there anything that, in that sort of design that would, you would change maybe then if you've not noticed it straight away?*

Um, I would just thought I'm more familiar with echo just being ECHO in capitals. So if that was that I probably would have noticed it quicker. I think, I guess abbreviations. So that's perfect. That's really good feedback.

cheating by using so that this filter was on the top of that.

This is Nice. Um, uh, it just takes you through, it's very simple. Yes or no. Is this present, um, and then it gives you the recommendation, but also when you scroll down, it immediately jumps out at you, you know where you're going? Oh, see original flow chart. Oh, yeah, I like this. *Okay. What is it You like?* Uh, well you, so you've got the quick and simple approach here where you need, you know, something's wrong.

You need a recommendation on what to do. Uh, but then here you can see the overall management and say that potassium change, then you can go along and see the different treatments.

Further Analysis

Outcome	Answer	Further Information
Did they use the filter function on the menu?	No	
Did they use the filter function in the guideline?	No	
Did they make any errors?	No	
Other notes		

Session 7, 12th March 2020

Okay. And the subsequent management of unstable angina administers, aspirin, um, unstable angina. Okay. So I find it quite quickly in cardiovascular.

Some of it look for, um, Investigations, we're looking for sort of monitoring and comes to mind. I'll be looking for yeah. Management. Okay. So from the dose quite quickly, I think simplify the middle ground.. *So what your thoughts and how that's laid out?* Um, yeah, it's logical. So it started with differentials and symptoms.

Um, I tend to think of those being above investigation. So

like differentials before investigations and then the investigation, which you have your differentials in mind, what you would do. *Okay. And any feedback on the design and how that's laid out?* would be my only sort of thought with that is having the differentials above investigations. So as you read an investigations, you already know what really not helped.

Um, I think that might be the way it's laid out on NICE guidelines and things and other, other things I've used. Um, um, otherwise I think it's clear.

Okay. The fluid management of acute heart failure, once you ECG the sought. Okay. Acute heart failure again, probably quite quick symptoms and signs.

Oh, differentials is first on this one. So that's different. So that's, um, better, I think, but just also inconsistent. Um, then when should an ECG be sought? So investigations, ECG is included.

So I'm just scrolling down to see at what point in, I can see that most,

right?

It should be a specific fluid management section. Okay, so might go across

okay. In fluid management,

Arrange immediate. Oh my gosh. In the big red box. Why is it?. Yeah, because I was looking for ECG in capital letters as echocardiogram. *Okay. So using acronyms would be helpful?*

IThe question is leading me because it's called echocardiogram, ECG and brackets. So that's what I was looking for. Um, but I do tend to write ECG as well. I see the notes.

Yeah. What's what's the recommended function.

Okay. So hypo food. Okay. So it's in that section is

there's quite a big gap between management flow chart in the box to select from the following something.
Um, in my head they were just two separate things. Okay. Um, yes, perhaps just having and management flow chart is smaller than the font for select from the following. Yeah. So, which makes me think so that's the fallen was a new thing. Okay. Switching those font sizes.

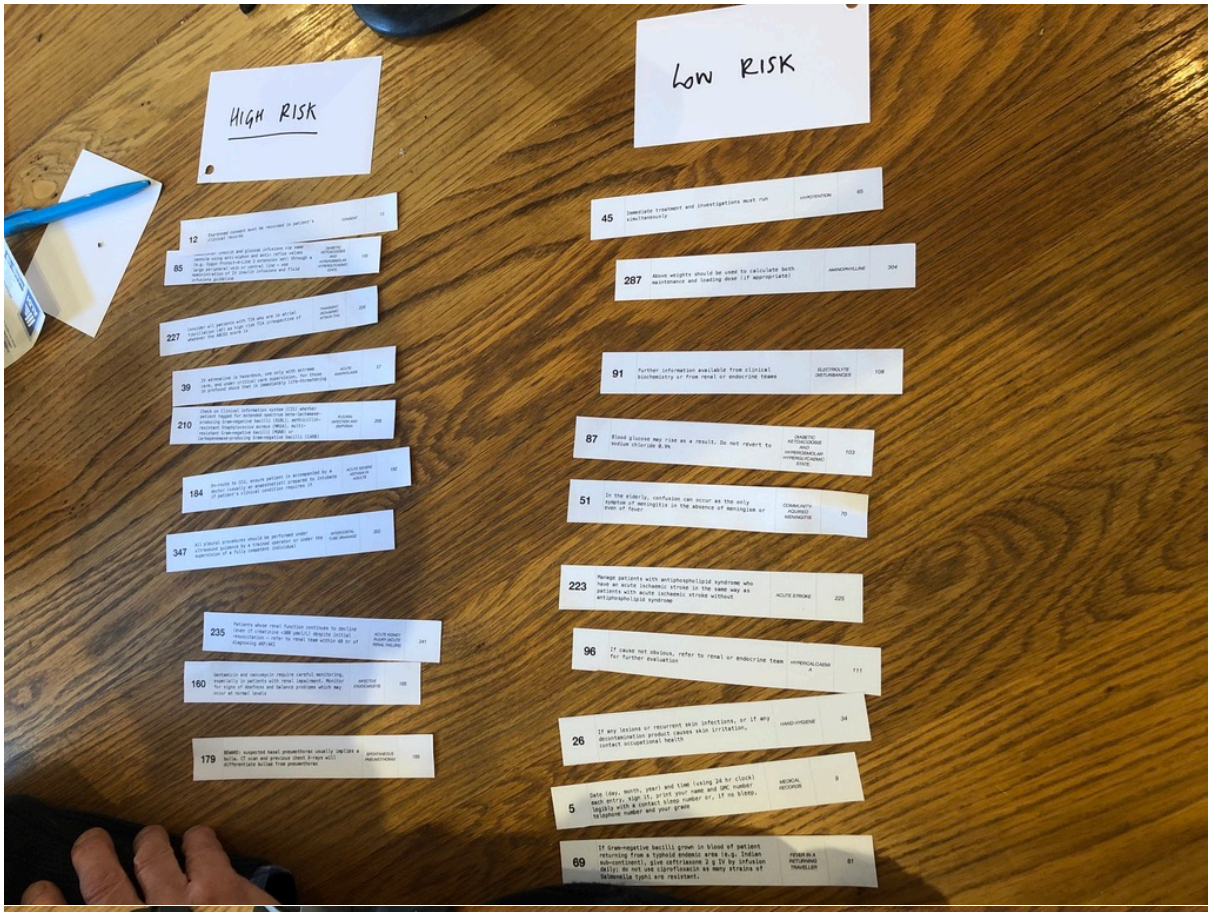
Between six, six point four.

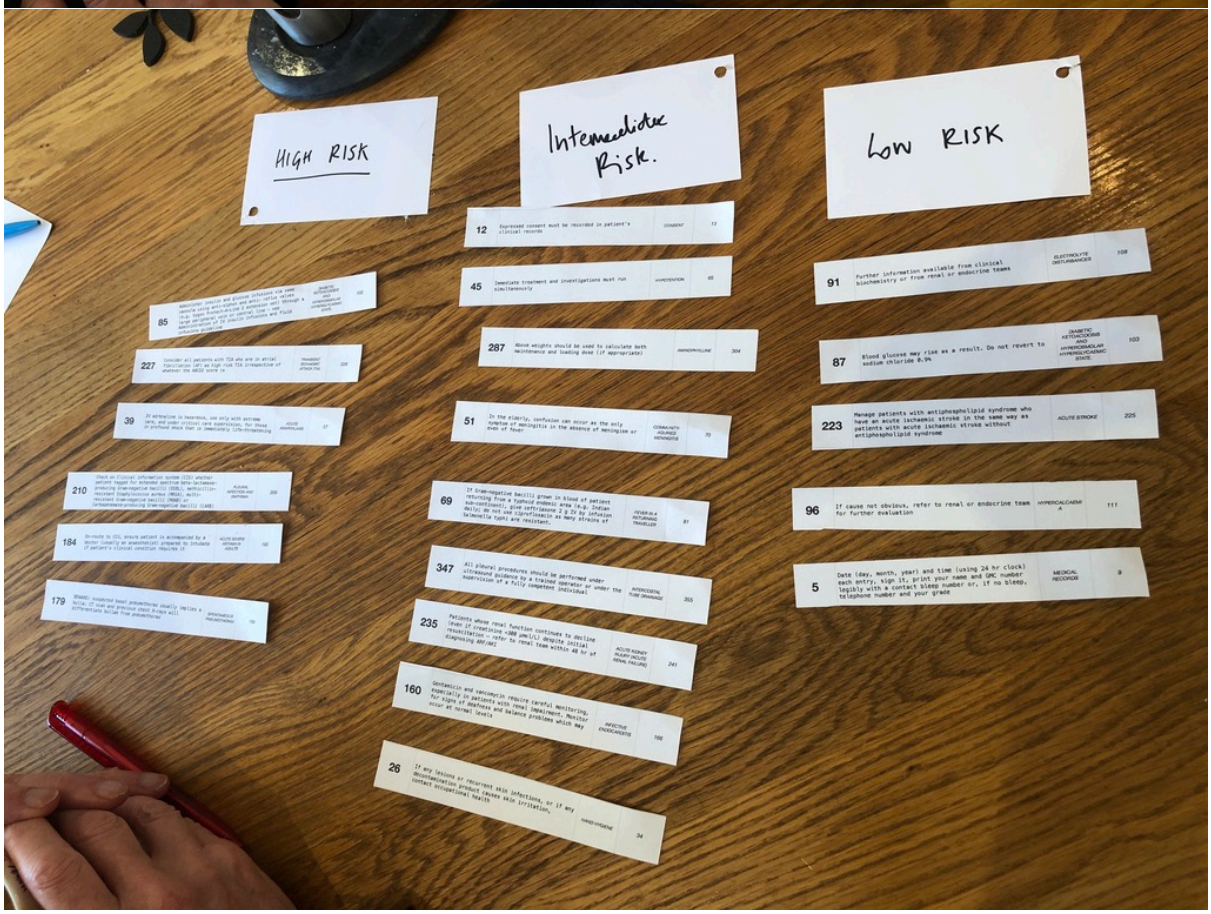
So the recommendation. Okay. *So what are your thoughts on how that's laid out?* Yeah, that's nice and easy to follow. Um, I prefer it being a flow chart like this, where, um, Oh, wow. Um, well you can just see the bit that's relevant. So like that picture underneath, there's a lot of sources online where they have all these complicated flow charts.**Um, and sometimes I think seeing all of the things. Can be a bit of a distraction. I mean, it's a bit difficult to try and zoom in on things.** Yeah. So by clicking, like yes or no, and then just popping up with bonuses, one recommendation for you is a lot simpler and easier to follow. It's good. Um, yeah. I th I think that my only criticism is finding it. Yeah. Well, once you understand how it works, I think it is really easy. It's a good tool.

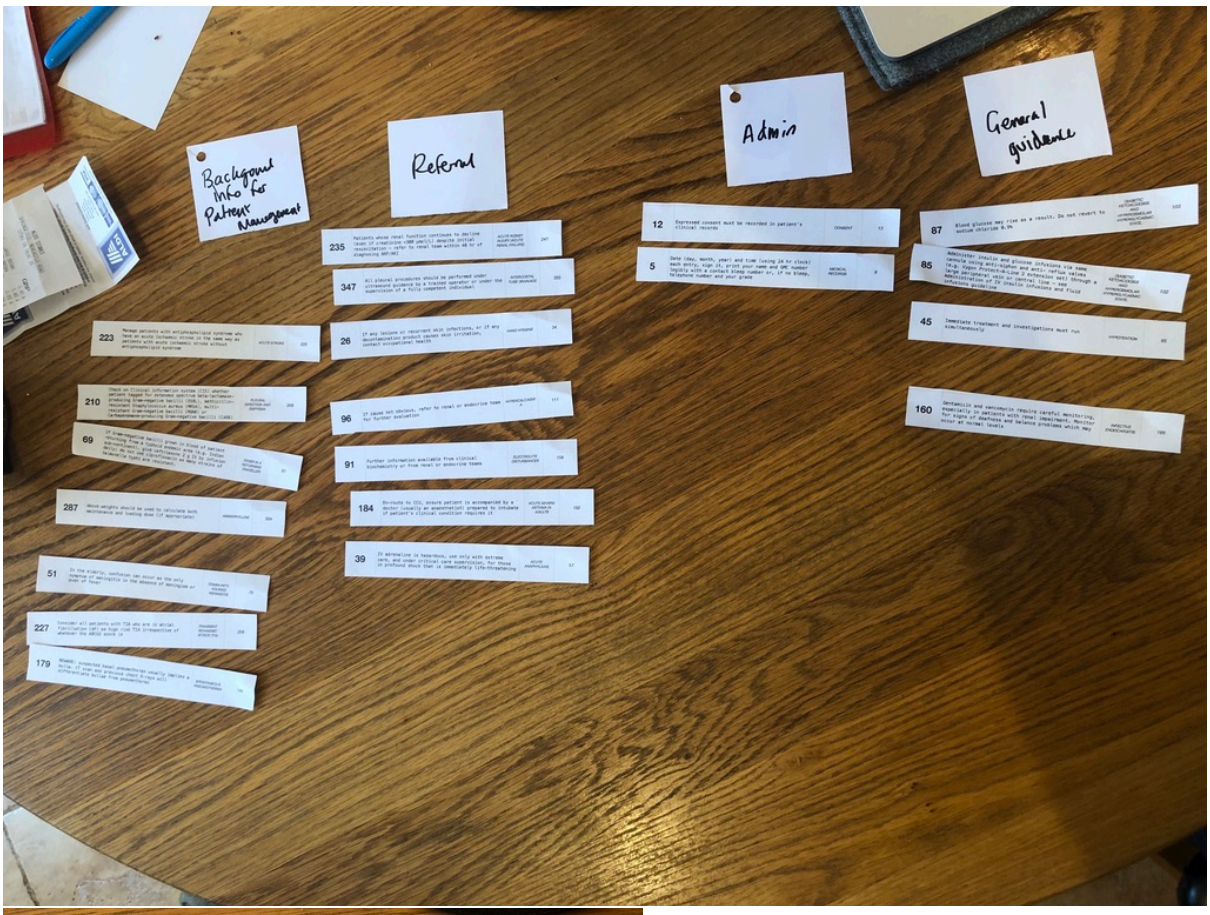
Further Analysis

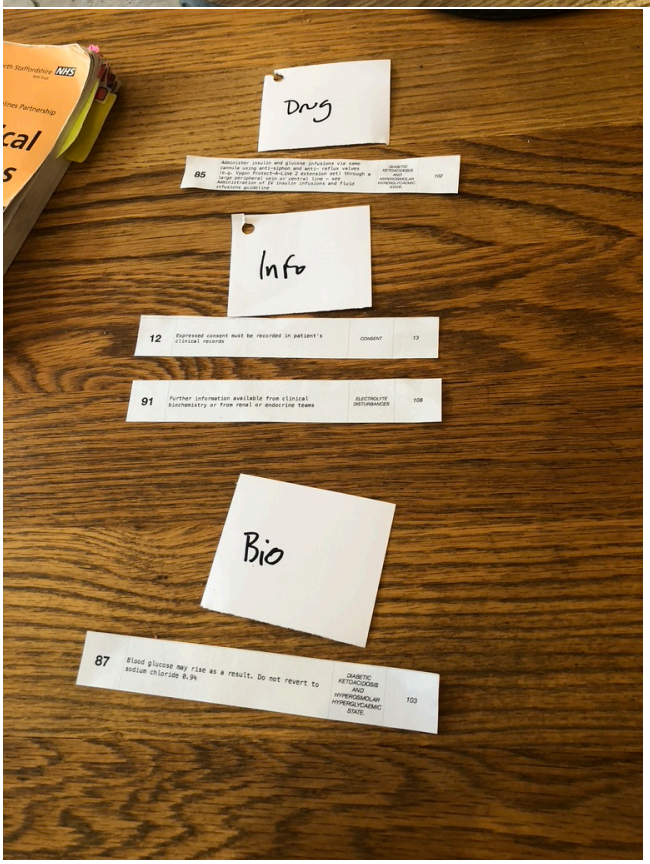
Outcome	Answer	Further Information
Did they use the filter function on the menu?	No	
Did they use the filter function in the guideline?	No	
Did they make any errors?	Yes	Locating echocardiogram in warning box Clicked header for flowchart
Other notes	No	

Appendix 6 - Card Sorting Results






Background info for Patient Management
Referral
Admin
General guidance
235
347
223
26
210
96
69
91
287
184
51
39
227
179
12
5
87
85
45
160


Drug
Info
Bio
85
12
91
87

Warning boxes
They must inform clinician of risk. Some with just background information have crept in. There are some that repeat similar message several times through one guideline-see Neutropenic Sepsis.

Classification
1=swift action
2=Stop hasty/over zealous action/drug interactions /point to which of two or more paths in guideline to take
3=Referral
4=When not to use this guideline/ Use appropriate guideline
5=Order of action/ use appropriate equipment/ correct doses calculations
6= Important statement applying whenever guideline is implemented

9=Inappropriate

Risk

Problem: If we classify risk, will people ignore lower level? A risk of 100 chance of occurring will still means 1 in 100 patients will be harmed.

A risk ranking of a warning box might be classified in two parts:
1. If clinician does not follow advice in the box, likelihood of event happening
2. Severity of event

These could be classified by analysis looking at the evidence. At the very least, speciality authors must classify risk for warning boxes-authoring tool

For each warning box, we need to record:
- Event trying to avoid
- Likelihood
- Severity

Examples:
Warning box (223): Sustained high BP alters cerebral autoregulation; sudden reduction of BP will reduce cerebral perfusion and can be dangerous. Aim to reduce BP by no more than 25% in first 24-48 hours
Event: Triggering Transient Ischaemic Attack or Stroke
Likelihood: I don't know
Severity: Is stroke more severe than death etc. We are in the field of utilities.

Warning box (218): Acute cord compression is an emergency and such should be referred IMMEDIATELY to a spinal specialist…..(note too long and should be in active tense: Refer IMMEDIATELY to a spinal specialist)
Event: Paraparesis
Likelihood: Very high
Severity: Very high

Classification of Risk-number scores
Event: write in
Likelihood: 1=high; 2=moderate; 3=low
Severity: 1=high; 2=moderate; 3=low

Notes: Classification of warning is relevant when taking action on that section(s) of guideline.
For first exercise, risk categories are mine or blank.

Highlighted Information in BCG Medical Guidelines (v. 2016-2017)

					Risk			
#	Information	*SECTION*	*Page*	***Classification***	***Event***	***Likliho od***	***Severi ty***	***COMMENT***
0	The guidelines are advisory, NOT mandatory Doses assume normal hepatic and renal function Refer to BNF for alternative doses	*Front page*		***6***				***Come up whenever use guidelines or as front ofApp***
1	Doses assume normal hepatic and renal function	*PREFACE*	*7*	6	*Give inappropriate drugs*			Not certain how many people read the premise. You could bring up whenever drug dose is stated
2	The guidelines are advisory, NOT mandatory	*PREFACE*	*7*	6	*Forget to be patient-centred and adapt guideline to each individual patient*			
3	DO NOT attempt to carry out any of these Practical procedures unless you have been trained to do so and have demonstrated your competence	*PREFACE*	*7*	6	*cause harm to patient when undertaking procedures*	*3*	*2*	This needs to come up whenever a practical procedure is accessed
4	Always use black ink. Never write offensive or inappropriate comments about patients, relatives, carers or staff in the notes – including acronyms/abbreviations. Avoid comments that can be interpreted as criticism	*MEDICAL RECORDS*	*9*	6	*Not documented,never occurred. No defence if patient disputes*			Come up whenever a guideline says document
5	Date (day, month, year) and time (using 24 hr clock) each entry, sign it, print your name and GMC number legibly with a contact bleep number or, if no bleep, telephone number and your grade	*MEDICAL RECORDS*	*9*	6	*Not documented,never occurred. No defence if patient disputes*			Come up whenever a guideline says document
6	Document events as soon as possible, and especially before going off duty. If there is a delay, record time of event and extent of delay. Good practice is to make an entry in records of acute patients at least daily. If a day is missed, document why in next entry	*MEDICAL RECORDS*	*10*	6	*Not documented,never occurred. No defence if patient disputes*			Come up whenever a guideline says document

7	Full Trust policy C43, 'Policy and Procedures for Obtaining Consent' is available on the intranet and must be adhered to at all times. Further information can also be obtained from 'Guidance to consent for examination or treatment' 2nd edition 2009 www.dh.gov.uk/consent	*CONSENT*	*12*	9				Hide Trust document behind
8	The greater the associated risks, the more stringent the consent process should be. This includes making comprehensive notes in the medical records	*CONSENT*	*12*	6				Come up whenever consent mentioned in guidelines or cross refer to Consent guideline
9	Where there is any doubt or disagreement about whether the patient has capacity, an application to the court MAY be necessary – you must seek advice, in office hours Monday–Friday, from Legal Services Department or, out-of-hours, from the medical director or executive director on-call, via hospital call centre (0)	*CONSENT*	*12*	3 and 6	*Become embroiled in dispute without legalcover*	*3*	*3*	
10	Consent must be given voluntarily and not under any form of duress or undue influence from healthcare professionals, family or friends	*CONSENT*	*13*	6	*Unfair consent leading to dispute*	*3*	*3*	
11	A signature on a consent form does not in itself prove that consent is valid – the law now requires explanation of all 'material risks'. A risk is material if 'that patient' would attach significance to it	*CONSENT*	*13*	2 and 6	*Failure to take time and explain fully while asking and listening to patients concerns*	*3*	*3*	

12	Expressed consent must be recorded in patient's clinical records	*CONSENT*	*13*	2 and 6	*Not documented,never occurred. No defence if patient disputes*	*3*	*3*	
13	If patient is not offered much information, in a form s/he can understand, as reasonably required to make a decision, consent will not be valid and may be challenged	*CONSENT*	*14*	2 and 6	*Failure to take time and explain fully while asking and listening to patients concerns*	*3*	*3*	We could layer this or do flowchart as not all needed for each patient and a logical flow
14	Give patient a copy of the consent form detailing nature, risks and benefits of procedure and patient leaflet where appropriate	*CONSENT*	*14*	2 and 6	*Not documented,never occurred. No defence if patient disputes*	*3*	*3*	
15	For all urgent microbiology specimens except blood cultures, bleep microbiology. On-call BMS may not be on site	*ON-CALL PATHOLOGY SERVICE*	*17*	3 and 6	*Delayed resultsso not acted on*	*3*	*3*	Should be microbiology be available if pressed whenever asked for? Connect to clock for out of hours
16	In patients at the extremes of age and body size with severe malnutrition, paraplegia, tetraplegia, known skeletal muscle disease or rapidly changing renal function, interpret eGFR with caution as it may underestimate the severity of renal impairment	*PREVENTION OF CONTRAST INDUCED ACUTE KIDNEY INJURY*	*24*	2	*Given contrast inappropriatel y and cause renal failure*			Whenever a guideline asks for a contrast medium , this needs to be available, especially the risk factors and how to prevent
17	Radiological investigations are not contraindicated during pregnancy where there is a significant clinical indication. Discuss with obstetric team	*PREGNANT WOMEN WITH A NON-OBSTETRIC PROBLEM (MANAGEMENT OF)*	*25*	3	*Unable to take action as not using appropriate ivestigation*			We need to discuss what to do if pregancy mentioned in text of another guideline

	Tube feeding is a medical intervention and requires consent PEG feeding does not prevent aspiration pneumonia For an 'incompetent' adult – use a two-doctor consent form 4 signed by two senior doctors, one of whom must be a gastroenterologist, the other normally being the consultant or GP looking after patient Best practice suggests that any family or next-of-kin should countersign section D to confirm they have been involved/informed of decision – Section 4 of the Mental Capacity Act provides a list of those who 'must' be consulted in cases where best interest decisions are being made			9				These are bullet points bundled into warning box. Section requied on consent rather than warning box
18		*PRACTICE AND ETHICS OF NUTRITIONAL SUPPORT IN MEDICAL PATIENTS (ADULTS)*	*26*					
19	Make sure you document the decision-making process at the time it happens, in detail	*PRACTICE AND ETHICS OF NUTRITIONAL SUPPORT IN MEDICAL PATIENTS (ADULTS)*	*27*	6	*Not documented,never occurred. No defence if patient disputes*			
20	The Coroner must be contacted to discuss any case where there is doubt regarding any of the above circumstances	*VERIFICATION OF DEATH*	*30*	3	*Become embroiled in dispute without legalcover*			
21	A copy of 'Reportable deaths – a guide' can be obtained from the Coroner (01782 234777)	*VERIFICATION OF DEATH*	*30*	9				Place document in guideline lower level
22	Standard precautions are the essential infection prevention measures necessary to reduce the risk of transmission of infectious agents to patients, staff and visitors *Standard precautions are to*	*STANDARD INFECTION PREVENTION MEASURES*	*31*	9				This is the opening statement of these guidelines, no need to be in warning box

	be used by all staff, for all patients in all care settings at all times on the assumption that all contact with blood, body fluids, secretions and excretion (except sweat), non-intact skin and mucous membranes, along with contact with the healthcare environment may result in the transmission of infectious micro-organisms							
23	Hand hygiene is a term used to describe decontamination of hands by using soap and water, antiseptic wash or by using an alcohol hand rub solution Good hand hygiene is the most effective way to prevent spread of infection. Use this safe method of working at all times to protect staff, patients and others from infection. All practitioners are personally accountable for their hand hygiene practices Refer to the latest version of the Hand hygiene policy	*HAND HYGIENE*	*33*	9				This is the opening statement of these guidelines, no need to be in warning box
24	Hands must be decontaminated at critical points before, during and after patient care to prevent cross infection of micro-organisms. The World Health Organisation (WHO) "5 moments for hand hygiene" has been adopted as a standard model for hand hygiene compliance guidance and training at University Hospitals of North Midlands	*HAND HYGIENE*	*33*	9				rewrite as bullet pints
25	Alcohol hand rub alone must not be used after caring for patients (or their equipment/environment) who have suspected or known infectious diarrhoea such as Clostridium difficile or Norovirus, regardless of whether gloves are worn	*HAND HYGIENE*	*34*	4	*Carry bugs around*			

26	If any lesions or recurrent skin infections, or if any decontamination product causes skin irritation, contact occupational health	*HAND HYGIENE*	*34*	3	*Carry bugs around*			
27	As it is not always possible to identify individuals with an infection, adopt this safe method of working at all times to protect staff, patients and others from infection. PPE is equipment to help protect staff, patients and visitors from the risk of infection. It includes items such as gloves, aprons, gowns, masks, eye, facial protection, head cover and fluid repellent footwear e.g. Wellington boots. Refer to the latest personal protective equipment policy	*USE OF PERSONAL PROTECTIVE EQUIPMENT (PPE)*	*37*	9				This is the opening statement of these guidelines, no need to be in warning box
28	For details, see Trust policy IC22 – Procedure for screening for colonisation with relevant pathogens	*SCREENING FOR MRSA/SA AND MGNB*	*39*	9				Hide Trust document behind, specific for each trust
29	Do not use mupirocin for prolonged periods or repeatedly (for more than 2 courses of 5 days during an admission) as this can encourage resistance	*TOPICAL MRSA DECOLONISATION TREATMENT*	*43*	2	*Mupirocin resistance*	*3*	*3*	
30	Always discuss management of severe or life-threatening CDI with consultant microbiologist/consultant in infectious diseases. If a patient with mild or moderate CDI deteriorates, or if diarrhoea fails to respond to antimicrobial treatment of CDI for >5 days, seek advice from microbiologist or consultant in infectious	*CLOSTRIDIUM DIFFICILE INFECTION (CDI)*	*46*	3	*Non-maximal therapy*	*2*	*2*	one warning box is missijng in the guideline "If a patient with Clostridium difficile infection is identified on your ward, contact infection prevention team (IPT)" classification 3 3 3

	diseases. In general, avoid giving successive uninterrupted courses of different antimicrobials for any indication							
31	HIV testing remains voluntary and confidential	*HIV INFECTION TESTING*	*49*	2	*Break confidentiality*	*3*	*3*	
32	Non-genitourinary/ID specialist must discuss follow-up programme with infectious diseases/genitourinary specialist before informing patient of positive result	*HIV INFECTION TESTING*	*51*	3	*No plan of action when discuss postive HIV test with patient*	*3*	*3*	
33	Assessment must be by a fully registered doctor (FY2 or above). FY1 doctors are not qualified to assess mental capacity and must not attempt to do so. Inform senior member of medical team (SpR or consultant). If there are signs of impending violence, inform site manager who will identify any staff on duty who have been trained in restraint techniques	*AGGRESSIVE AND VIOLENT PATIENTS*	*52*	3	*Inappropriate personel undertake assessment*	*3*	*3*	Needs active
34	Where there is any doubt or disagreement whether patient has capacity, an application to the court will be necessary. You must seek advice, in office hours Monday–Friday, from medico-legal department or from medical director or executive director on-call via hospital call centre (0)	*AGGRESSIVE AND VIOLENT PATIENTS*	*53*	3	*Inappropriate personel undertake assessment*	*3*	*3*	Needs active. Apply to the court

35	Always ensure that any intervention used is the least harmful or restrictive of patient's basic rights and freedom, immediately necessary, reasonable, and in their best interest	*AGGRESSIVE AND VIOLENT PATIENTS*	*54*	2	*Over-aggressive restraint*	*3*	*3*	
36	The use of any physical holding is the last resort. Once staff attempt to restrain a patient, a threatening situation may turn violent. Medical and nursing staff should not attempt to physically restrain the individual, but should request assistance from any staff on duty trained in physical restraint techniques and who have completed the clinical holding course/update Under the Mental Capacity Act for a person lacking capacity, the person taking action must reasonably believe that restraint is necessary to prevent harm to the person who lacks capacity or staff and other patients	*AGGRESSIVE AND VIOLENT PATIENTS*	*54*	2	*Over-aggressive restraint*	*3*	*3*	Amalgamate and shorten 35 and 36
37	The police will always respond to a call for assistance, but are not allowed to assist in restraining patients for treatment	*AGGRESSIVE AND VIOLENT PATIENTS*	*54*	9	*Police restrain for treatment*	*3*	*3*	Should be text, not warning i.e.grey bullet- Police will not restrain for treatment
38	If new brain damage suspected, avoid medication until after CT scan. Check prescription chart for previously prescribed drugs. Reduce dosages of medication appropriately in the elderly or infirm If patient is elderly refer to Delirium (acute confusional state) in older people guideline instead, especially for doses of medication bearing in mind that olanzapine and risperidone can cause serious side effects including	*AGGRESSIVE AND VIOLENT PATIENTS*	*54*	2	*Medication given before CT scan*	*3*	*3*	Only warning is about avoiding medication until after CT scan. Rest should be in text.

	strokes in older patients. Unless dose for elderly is specified below, doses of medication should be halved for older people							
39	IV adrenaline is hazardous, use only with extreme care, and under critical care supervision, for those in profound shock that is immediately life-threatening	*ACUTE ANAPHYLAXIS*	*57*	3	*side-effects of IV adrenaline*	*3*	*2*	Needs rewriting to empasise, call Critical care staff. Note algorithm needs to say critical care, not just specialist
40	Establish cause of cardiac arrest and treat underlying diagnosis – if in doubt, seek advice from on-call medical SpR	*CARDIOPULMONARY RESUSCITATION - LIFE SUPPORT PROCEDURE*	*61*	9				Should be text
41	Discuss DNAR status with patient, if mentally competent, and/or family and carers and document in the medical record. If an emergency, document but discuss with them as soon as possible. Document clearly – see below for format	*CARDIOPULMONARY RESUSCITATION - LIFE SUPPORT PROCEDURE*	*62*	9				Should be text
42	Anticipate the likelihood of cardiopulmonary arrest and, if CPR may be inappropriate, discuss DNAR status with patient	*CARDIOPULMONARY RESUSCITATION - LIFE SUPPORT PROCEDURE*	*62*	2	*Stop inappropriate CPR*	*2*	*3*	
43	Consent process must be followed before DNAR order. Make sure you document the decision-making process at the time it happens, in detail. Read the Consent guideline carefully and follow the steps contained therein	*CARDIOPULMONARY RESUSCITATION - LIFE SUPPORT PROCEDURE*	*62*	9				should be text

44	Trust Red DNAR proforma is a flag to highlight that a DNAR decision has been made and is not part of the medical record. However, a copy should be kept in the patient's medical record. Complete the decision-making form and document the DNAR order in the nursing record	*CARDIOPULMONARY RESUSCITATION - LIFE SUPPORT PROCEDURE*	*62*	9				Bullet: complete Trust red DNAR proforma and place at front of medical record as a flag to highlight that a DNAR decision has been made
45	Immediate treatment and investigations must run simultaneously	*HYPOTENSION*	*65*	1	*Delay in treatment causing complications such as death from PE or shock in haemorrage*	*1*	*1*	Really depends on cause, gone for high risk causes
46	Be aware of MRSA and ESBL/MGNB/CARB tags1. If such a tag present, ensure appropriate account is taken in the choice of empiric antimicrobials (see Immediate treatment table below) For management of neutropenic haematology/oncology patients, see Neutropenic sepsis guideline	*SEPSIS, SEVERE SEPSIS AND SEPTIC SHOCK*	*67*	Second paragraph is 4	*Not ideal therapy given, although sepsis treatment will be given*	*3*	*2*	First paragraph is included in next warning box. Should be amalgamated
47	Check on iPortal whether patient has recently been found positive (tagged with alert) for Meticillin-resistant Staphylococcus aureus (MRSA), extended spectrum beta-lactamase-producing Gram-negative bacilli (ESBL), carbapenemase-producing Gram-negative bacilli (CARB), or other multi-resistant Gram-negative bacilli (MGNB)	*SEPSIS, SEVERE SEPSIS AND SEPTIC SHOCK*	*68*	5	*Not ideal therapy given, although sepsis treatment will be given*	*3*	*2*	
48	Early, aggressive and adequate fluid and oxygen therapy are essential. Administer antimicrobials within 1 hr of diagnosis	*SEPSIS, SEVERE SEPSIS AND SEPTIC SHOCK*	*68*	1	*Death or morbidy risk hightened*	*2*	*1*	

49	Penicillin allergy should only be accepted as genuine hypersensitivity if convincing history of either rash within 72 hr of dose or anaphylactic reaction. True penicillin allergy is rare and, in many infections, alternative antimicrobials are less effective with greater risks attached. If a patient reports penicillin allergy, it is imperative to establish, as far as possible, the nature of the reported allergy. In patients able to provide a history, the nature of the penicillin allergy must be recorded on admission. If any doubt about whether patient is truly allergic to penicillin, seek advice from a microbiologist or consultant in infectious diseases	*SEPSIS, SEVERE SEPSIS AND SEPTIC SHOCK*	*68*	2	*Less than ideal anti-microbial therapy*	*2*	*3*	
50	Interval between patient's arrival and commencement of lumbar puncture (if indicated) and antimicrobial treatment ('door-to-needle time') should not exceed 1 hr. The 'Gold standard' investigation is lumbar puncture and if there are no clinical contraindications it should not be delayed. If there are no clinical contraindications to LP, CT scan is not indicated (this is supported by recent BIA guidance). If bacterial meningitis strongly suspected, contact a consultant in infectious diseases via call centre	*COMMUNITY-AQUIRED MENINGITIS*	*70*	1	*Delay treatment causing death and morbidity*	*1*	*1*	
51	In the elderly, confusion can occur as the only symptom of meningitis in the absence of meningism or even of fever	*COMMUNITY-AQUIRED MENINGITIS*	*70*	9				text

52	Pyrexia may not be a feature of septic arthritis, especially in the elderly or immunocompromised, or in patients with diabetes, renal failure or rheumatoid arthritis	*ACUTE HOT JOINT, SEPTIC ARTHRITIS AND GOUT*	*73*	9				text
53	In patients with prosthetic joint and pyrexia of unknown origin (PUO) – consider prosthesis infection	*ACUTE HOT JOINT, SEPTIC ARTHRITIS AND GOUT*	*73*	9				text
54	If patient has acute arthritis affecting more than one joint, discuss case with on-call rheumatologist (page via call centre)	*ACUTE HOT JOINT, SEPTIC ARTHRITIS AND GOUT*	*73*	3	*Wrong diagnosis and treatment*	*2*	*2*	
55	Penicillin allergy should only be accepted as genuine hypersensitivity if convincing history of either rash within 72 hr of dose or anaphylactic reaction. True penicillin allergy is rare and, in many infections, alternative antimicrobials are less effective with greater risks attached. If a patient reports penicillin allergy, it is imperative to establish, as far as possible, the nature of the reported allergy. In patients able to provide a history, the nature of the penicillin allergy must be recorded on admission. If any doubt about whether patient is truly allergic to penicillin, seek advice from a microbiologist or consultant in infectious diseases	*ACUTE HOT JOINT, SEPTIC ARTHRITIS AND GOUT*	*74*	2	*Less than ideal anti-microbial therapy*	*2*	*3*	

56	If patient immunocompromised or has prosthesis, contact consultant in infectious diseases or consultant microbiologist for advice	*ACUTE HOT JOINT, SEPTIC ARTHRITIS AND GOUT*	*74*	3	*Less than ideal anti-microbial therapy*	*2*	*2*	
57	Do not start allopurinol in acute gout	*ACUTE HOT JOINT, SEPTIC ARTHRITIS AND GOUT*	*75*	2	*Increase uric acid in blood initially worsening gout attack*	*1*	*3*	
58	Neutropenic sepsis is potentially life-threatening and requires emergency treatment. In any patient with neutropenic fever, obtain appropriate blood culture(s) and administer appropriate antimicrobials as soon as possible and certainly WITHIN 1 HOUR of presentation. If patient 'tagged' on iPortal/ICM for an 'alert organism' (e.g MRSA, ESBL) ensure that this organism is covered in the initial empirical therapy (see Table below)	*NEUTROPENIC SEPSIS*	*76*	1	*Death or morbidy risk hightened*	*2*	*1*	There are 2 warnings in one box.First one classified
59	Risk of infection is proportional to duration of neutropenia (risk increases with prolonged neutropenia) and how far and how fast neutrophil count falls. Consider infection in any unwell neutropenic patient even if no fever	*NEUTROPENIC SEPSIS*	*76*	1	*Death or morbidy risk hightened*	*3*	*1*	Two warnings in one box . First one is information so only second one classified "Consider infection in…" 58 and 59 need rewriting
60	Even if other causes possible, always treat fever in neutropenic sepsis as if caused by infection. Treat with the utmost urgency any patient with features of severe sepsis	*NEUTROPENIC SEPSIS*	*76*	1	*Death or morbidy risk hightened*	*2*	*1*	Needs amalgamating with 58 as says the same

61	If any of this information not available, do not delay start of antimicrobial therapy. The safest option is to commence antimicrobial treatment and revise later, if necessary.	*NEUTROPENIC SEPSIS*	*76*	1	*Death or morbidy risk hightened*	*2*	*1*	
62	Discuss management of patients admitted with neutropenic fever with acute oncology specialist nurse (contact details on rota watch) Alternatively, haematology advice can be obtained on pager 15723 (0900–1700 Monday to Friday) and via call centre at other times Oncology advice is available from on-call oncologist, via call centre at all times	*NEUTROPENIC SEPSIS*	*77*	3	*Best treatment not given*	*2*	*2*	
63	Penicillin allergy should only be accepted as genuine hypersensitivity if convincing history of either rash within 72 hr of dose or anaphylactic reaction. True penicillin allergy is rare and, in many infections, alternative antimicrobials are less effective with greater risks attached. If a patient reports penicillin allergy, it is imperative to establish, as far as possible, the nature of the reported allergy. In patients able to provide a history, the nature of the penicillin allergy must be recorded on admission. If any doubt about whether patient is truly allergic to penicillin, seek advice from a microbiologist or consultant in infectious diseases	*NEUTROPENIC SEPSIS*	*77*	2	*Less than ideal anti-microbial therapy*	*2*	*3*	

64	If a patient who has had an allogeneic stem cell transplant is admitted febrile or unwell, admitting doctor must contact on-call haematology specialist trainee or consultant immediately after initial assessment.	*NEUTROPENIC SEPSIS*	*78*	3	*Best treatment not given*	*1*	*2*	
65	Be aware of MRSA and ESBL/MGNB/CARB tags1. If such a tag present, ensure appropriate account is taken in the choice of empiric antimicrobials (see Management below)	*FEVER IN A RETURNING TRAVELLER*	*79*	5	*Not ideal therapy given, although sepsis treatment will be given*	*3*	*2*	
66	Initial assessment is aimed primarily at early detection and treatment of falciparum malaria, which can be rapidly fatal. 10% of patients with falciparum malaria are afebrile at presentation	*FEVER IN A RETURNING TRAVELLER*	*79*	1	*Death or morbidy risk hightened*	*2*	*1*	Warning classified for first paragraph. 10% of patients with falciparum malaria are afebrile at presentation is a statement and should be a bullet in text
67	Some conditions e.g. Ebola and other viral haemorrhagic fevers or Middle East Respiratory Syndrome Coronavirus (MERS-CoV) may require immediate isolation if suspected	*FEVER IN A RETURNING TRAVELLER*	*79*	1	*Risk to others ofspread of disease*	*2*	*1*	
68	Thrombocytopenia present in >75% of patients with falciparum malaria, but also seen in dengue and other infections Neutrophilia suggests bacterial infection and eosinophilia may suggest parasitic infection	*FEVER IN A RETURNING TRAVELLER*	*81*	9				bullet point
69	If Gram-negative bacilli grown in blood of patient returning from a typhoid endemic area (e.g. Indian sub-continent), give ceftriaxone 2 g IV by infusion daily; do not use ciprofloxacin as many strains of Salmonella typhi are resistant.	*FEVER IN A RETURNING TRAVELLER*	*81*	9				bullet point

70	Penicillin allergy should only be accepted as genuine hypersensitivity if convincing history of either rash within 72 hr of dose or anaphylactic reaction. True penicillin allergy is rare and, in many infections, alternative antimicrobials are less effective with greater risks attached. If a patient reports penicillin allergy, it is imperative to establish, as far as possible, the nature of the reported allergy. In patients able to provide a history, the nature of the penicillin allergy must be recorded on admission. If any doubt about whether patient is truly allergic to penicillin, seek advice from a microbiologist or consultant in infectious diseases	*CELLULITIS*	*83*	2	*Less than ideal anti-microbial therapy*	*2*	*3*	
71	Pregnancy is an indication for very detailed assessment and close management of withdrawal because of risks to fetus. Refer to appropriate drug service (patients living in Stoke-on-Trent to Lifeline, patients living in the rest of Staffordshire to One Recovery) and contact on-call obstetric team – see Management of a pregnant woman with a non-obstetric problem guideline	*WITHDRAWAL OF DRUG(S) OF DEPENDENCE*	*85*	3	*Risk to Fetus*	*1*		
72	Discuss initiation of opiate substitution with drug agency (based on geography) that will continue input following discharge acute hospital. Do not give substitutes unless a screening test confirms presence of opiates. Drug of choice is methadone mixture (1 mg/1 mL) – do not use injectable or tablet forms of methadone. Do not give alternative forms of opiate unless discussed	*WITHDRAWAL OF DRUG(S) OF DEPENDENCE*	*86*	9				This is not a warning box, but several bullet points

	with relevant drug agency							
73	Maximum dose in 24 hr should not exceed 50 mg without specialist advice	*WITHDRAWAL OF DRUG(S) OF DEPENDENCE*	*86*	2	*Overdose*	*3*	*3*	
74	Do not write methadone prescription as a TTO	*WITHDRAWAL OF DRUG(S) OF DEPENDENCE*	*87*	2	*Overdose or sale of methadone to others*	*3*	*3*	
75	The aim is to prevent features of withdrawal without oversedation. Individual dose requirements vary considerably and can be decided only by assessing response regularly and omitting or adding doses as necessary. Lorazepam and diazepam normally given orally	*ALCOHOL WITHDRAWAL*	*90*	9 as information need re-writing as bullets				
76	Check that this is the correct guideline – see Triage of hyperglycaemia in the ill patient The guideline below must not be used in patients with metabolic acidosis and/or severe dehydration – see Diabetic ketoacidosis and hyperosmolar hyperglycaemic state guideline	*CONTROL OF HYPERGLYCAEMIA IN THE ILL PATIENT*	*95*	4	*Inappropriate and inadequate treament*	*3*	*2*	
77	Never give single doses of insulin (e.g. Actrapid) – they lead to large swings in glucose concentration	*CONTROL OF HYPERGLYCAEMIA IN THE ILL PATIENT*	*95*	2	*large swings in glucose ,could led to complications sich as hypoglycaemia*	*1*	*3*	

78	NB: If capillary blood ketones >3 mmol/L or urinary ketones >3, follow Diabetic ketoacidosis in the Diabetic ketoacidosis and hyperosmolar hyperglycaemic state guideline	*CONTROL OF HYPERGLYCAEMIA IN THE ILL PATIENT*	*96*	4	*Inappropriate and inadequate treament*	*3*	*2*	Combine with 76?
79	Insulin and sodium/glucose/potassium infusions must be administered via the same cannula using anti-siphon and anti-reflux valves (e.g. Vygon Protect-A-Line 2 extension set) to prevent inadvertent and dangerous administration of either insulin or sodium/glucose/potassium alone, and to prevent an overdose of insulin. This could occur as a result of a cannula restriction/occlusion, causing insulin to be pumped into the sodium/glucose/potassium giving set and then be administered as a bolus (if the restriction/occlusion resolves). See Figure 1 for appropriate set up of extension set	*CONTROL OF HYPERGLYCAEMIA IN THE ILL PATIENT*	*96*	2	*Dangerous administration of insulin*	*1*	*3*	Where is figure 1? This is lifted from Administration of fluid and insulin infusions guideline. This needs editing to refer to Administration of fluid and insulin infusions guideline page 345
80	Never give single doses of insulin (e.g. Actrapid) as this can lead to large swings in glucose concentration	*CONTROL OF HYPERGLYCAEMIA IN THE ILL PATIENT*	*96*	2	*large swings in glucose ,could led to complications sich as hypoglycaemia*	*1*	*3*	This is sameas 85 where it is correctly written
81	Always use commercially produced pre-mixed bags of infusion fluid and potassium chloride. NEVER add potassium chloride to infusion bags	*CONTROL OF HYPERGLYCAEMIA IN THE ILL PATIENT*	*97*	2	*death*	*2*	*1*	
82	Check you are using the correct guideline – see Triage of patients with hyperglycaemia guideline	*DIABETIC KETOACIDOSIS AND HYPEROSMOLAR HYPERGLYCAEMIC STATE.*	*99*	4	*Inappropriate and inadequate treament*	*3*	*2*	

83	The guideline below must be used in patients who have either metabolic acidosis or severe dehydration	*DIABETIC KETOACIDOSIS AND HYPEROSMOLAR HYPERGLYCAEMIC STATE.*	*99*					Actually re-iterating, check usng correct guideline. Amalgamate with 82
84	Search for precipitating causes of diabetic ketoacidosis (DKA) or hyperosmolar hyperglycaemic state, such as sepsis (signs of shock) or recent myocardial infarction	*DIABETIC KETOACIDOSIS AND HYPEROSMOLAR HYPERGLYCAEMIC STATE.*	*99*	9 as information need re-writing as bullets				Should be in text as bullet points
85	Administer insulin and glucose infusions via same cannula using anti-siphon and anti- reflux valves (e.g. Vygon Protect-A-Line 2 extension set) through a large peripheral vein or central line – see Administration of IV insulin infusions and fluid infusions guideline	*DIABETIC KETOACIDOSIS AND HYPEROSMOLAR HYPERGLYCAEMIC STATE.*	*102*	2	*Dangerous administration of insulin*	*1*	*3*	
86	While potassium is being infused, attach cardiac monitor to patient	*DIABETIC KETOACIDOSIS AND HYPEROSMOLAR HYPERGLYCAEMIC STATE.*	*102*	2	*Miss sign potassium is affecting cardiac functio*	*3*	*1*	
87	Blood glucose may rise as a result. Do not revert to sodium chloride 0.9%	*DIABETIC KETOACIDOSIS AND HYPEROSMOLAR HYPERGLYCAEMIC STATE.*	*103*	2	*Overtreatment with possibility of hypoglycaemi a*	*3*	*3*	
88	Consider hypoglycaemia in any patient with acute agitation, abnormal behaviour or impaired consciousness. These signs do not usually occur unless blood glucose falls below 2.5 mmol/L, but can occur at higher concentrations in patients with insulin- dependent diabetes whose day-to-day blood glucose is above normal	*ACUTE HYPOGLYCAEMIA*	*104*	9 as information need re-writing as bullets				

89	Do not use glucagon, especially in sulphonylurea-induced hypoglycaemia as any response will be short-lived and followed by further hypoglycaemia	*ACUTE HYPOGLYCAEMIA*	*104*	this contradicts text of bullet point above . Needs editing. Is there a missing IV				
90	Obtain blood sample for serum cortisol (gold top) and plasma ACTH (purple top bottle on ice) before hydrocortisone is given but treatment must not await result. If urgent cortisol required, inform biochemistry laboratory (bleep 143)	*ACUTE ADRENAL INSUFFICIENCY*	*107*	5	*Loss of confirmation of diagnosis*	*1*	*3*	
91	Further information available from clinical biochemistry or from renal or endocrine teams	*ELECTROLYTE DISTURBANCES*	*108*	9 as information				
92	Hypertonic saline is almost never justified, carries a significant risk, should be given only with consultant approval and requires monitoring in a high dependency area	*ELECTROLYTE DISTURBANCES*	*108*	2	*What risk?*	*?*	*?*	
93	It is important to note that if a patient has a high urine output and/or very low Na <115 mmol/L, 4-hrly monitoring of electrolytes is initially required to avoid sudden rises in serum Na	*ELECTROLYTE DISTURBANCES*	*108*	2	*What risk?*	*?*	*?*	
94	Failure to correct, or recurrence of hyponatraemia merits referral to the team appropriate to the underlying cause (e.g. renal, endocrine, psychiatric). Review drug treatment before discharge	*ELECTROLYTE DISTURBANCES*	*108*	9 as information				

95	Insulin/glucose or intravenous calcium do not cause excretion of excess total body K+. Use only as temporary measures until underlying cause can be treated	*ELECTROLYTE DISTURBANCES*	*110*	2	*Fail to treat correctly*	*3*	*3*	
96	If cause not obvious, refer to renal or endocrine team for further evaluation	*HYPERCALCAEMIA*	*111*	3	*Fail to treat correctly*	*3*	*3*	
97	In presence of life-threatening features, a bolus of 2–4 g over 20 min is appropriate but requires high dependency facilities/critical care staff	*HYPOMAGNESAEMIA*	*115*	3	*death*	*?*	*1*	In presence of life-threatening features, transfer to high dependency facilities/critical care staff to give a bolus of 2–4 g over 20 min
98	In all patients at risk of hypovolaemia, make a clinical assessment of degree and type of fluid deficit. See Fluid resuscitation guideline	*MAINTENANCE FLUID THERAPY*	*119*	4	*Inappropriate and inadequate treament*	*2*	*2*	
99	If possible, use enteral replacement. Re-evaluate need for parenteral fluids at least twice daily	*MAINTENANCE FLUID THERAPY*	*119*	2	*increased risk of over or under therapy*	*3*	*3*	
100	If patient requires additional resuscitation fluid after commencing maintenance regimen, follow guidance in Fluid resuscitation guideline	*MAINTENANCE FLUID THERAPY*	*120*	4	*Inappropriate and inadequate treament*	*2*	*2*	
101	Content of maintenance fluid (especially hypotonic or high potassium-content) is inappropriate/dangerous when given in large volumes required for resuscitation. Do not increase rate of maintenance	*MAINTENANCE FLUID THERAPY*	*120*	2	*increased risk of over therapy*			

	fluids to resuscitate. Prescribe and administer resuscitation fluid separately							
102	As soon as possible, re-establish oral fluids and remove indwelling intravenous lines	*MAINTENANCE FLUID THERAPY*	*122*	2	*increased risk of over therapy*			
103	See Specific conditions and Clinical application of guidance sections at beginning of this guideline for exclusions to the use of this table Always use commercially produced pre-mixed bags of any fluid with potassium chloride. NEVER add potassium chloride to infusion bags. Rapid infusion of bags containing potassium 40 mmol/L causes dangerous arrhythmias. Suggestion – place a handwritten label on any bag containing potassium, warning staff NOT TO INCREASE INFUSION RATE	*MAINTENANCE FLUID THERAPY*	*122*	2	*death*	*2*	*1*	First paragraph is a bullet point. Second paragraph is a warning and classified
104	Oliguria in an otherwise well patient during early post-operative period in the absence of other signs of volume depletion does not indicate need for IV fluid therapy. It is a normal physiological response to surgery	*FLUID RESUSCITATION*	*123*	2	*overtreatment*	*3*	*3*	
105	All treatment is given as boluses of fluid in addition to, or before starting, maintenance therapy	*FLUID RESUSCITATION*	*124*	2	*overtreatment*	*3*	*3*	

106	Regular reassessment is required to assess magnitude and duration of response to initial treatment, and to avoid iatrogenic fluid overload Note: Spinal cord injured patients may be hypotensive despite adequate filling	*FLUID RESUSCITATION*	*124*	9 as information				This two different items in one warnig box. Both should be bullets in text
107	Resuscitate using initial fluid therapy recommended in Table 3, use blood products if indicated by major haemorrhage/coagulopathy. Continue prescribed maintenance fluid therapy concurrently with resuscitation therapy but disregard maintenance volume administered in assessment of required resuscitation volume. Hypotonic or potassium-rich maintenance fluid is inappropriate/dangerous when given in large volumes required for resuscitation	*FLUID RESUSCITATION*	*124*	9 as information				Should be bullets
108	Never infuse fluids containing >5 mmol/L potassium rapidly (compound sodium lactate contains 5 mmol/L and can, therefore, be infused rapidly), consideration should be given to using isotonic sodium bicarbonate in hyperkalaemia to encourage intracellular shift of potassium). If a patient requiring rapid fluid boluses for resuscitation is also hypokalaemic, prescribe potassium separately in their maintenance fluid regimen or, if hypokalaemia severe (serum potassium <3 mmol/L), follow Hypokalaemia guideline	*FLUID RESUSCITATION*	*125*	2	*death*	*2*	*1*	First line is warning:Never infuse fluids containing >5 mmol/L potassium rapidly. Others should be bullet points

109	Bright red rectal bleeding in the absence of hypotension is likely to arise from lower gastrointestinal tract	*UPPER GASTROINTESTINAL HAEMORRHAGE*	*126*	5	*Inappropriate treatment*	*3*	*3*	
110	It is essential to categorise patients according to their risk of death/rebleeding – use Glasgow Blatchford score (GBS) (see Figure 1): ≥1 high-risk; 0 low-risk	*UPPER GASTROINTESTINAL HAEMORRHAGE*	*126*	2	*Don't miss high risk*	*2*	*2*	
111	The first priority is to replace fluid loss and restore BP	*UPPER GASTROINTESTINAL HAEMORRHAGE*	*128*	5	*Fail to fluid load correctly which may lead to hypotension, shock and death*	*3*	*1*	
112	Haemorrhage from oesophageal varices is always life-threatening	*UPPER GASTROINTESTINAL HAEMORRHAGE*	*129*	1	*Act fast to avoid death*	*1*	*1*	
113	Do not refer to surgical team	*UPPER GASTROINTESTINAL HAEMORRHAGE*	*129*	2	*Surgery will kill patient*	*3*	*1*	
114	Preferred eradication regimen for Helicobacter pylori is: omeprazole 20 mg oral 12-hrly amoxicillin 1 g oral 12-hrly metronidazole 400 mg oral 12-hrly for 7 days* In patients allergic to penicillin: omeprazole 20 mg oral 12-hrly clarithromycin 250 mg oral 12-hrly metronidazole 400 mg oral 12-hrly for 7 days* Absolute compliance with regimen essential in order to	*UPPER GASTROINTESTINAL HAEMORRHAGE*	*129*	9=information				Should be bullets

	achieve an eradication rate of 90% *If ulcer large, or complicated by haemorrhage or perforation, then omeprazole treatment continued for a further 21 days							
115	Simvastatin contraindicated in combination with clarithromycin see current BNF for other interactions)	*UPPER GASTROINTESTINAL HAEMORRHAGE*	*130*	2				Reads better as: Check drug interactions, e.g. Clarithromycin is contraindicated if patient on simvastatin
116	Consider liver failure in all patients with abnormal liver function tests or coagulopathy whose conscious level deteriorates	*ACUTE LIVER FAILURE WITH ENCEPHALOPATHY*	*131*	9 as information				It is better asbullet point. It is fact whole section. If you view guideline, you will already have considered patient has liver failure.
117	Treat all infections as serious as these patients exhibit few clinical signs of infection	*ACUTE LIVER FAILURE WITH ENCEPHALOPATHY*	*132*	1	*Infection takes a grip and kills*	*1*	*1*	
118	Do not treat urgently unless it is causing symptoms. If encephalopathic, avoid or stop diuretics even if symptomatic	*ACUTE LIVER FAILURE WITH ENCEPHALOPATHY*	*133*	2	*Overtreatment will cause deterioration*	*1*	*2*	
119	DO NOT GIVE anti-diarrhoeal drugs in acute phase – they increase the risk of toxic dilatation DO NOT PERFORM barium enema or colonoscopy in acute phase – there is a high risk of perforation of the colon	*ACUTE ULCERATIVE COLITIS AND CROHN'S DISEASE*	*135*	2	*Overtreatment will cause deterioration*	*1*	*2*	Two warnings in one box. Both have same risk and classification

120	Use this guideline after an initial clinical assessment fails to identify a more likely explanation for chest pain other than angina or acute myocardial infarction. Do not use indiscriminately in all patients presenting with chest pain	*ASSESSMENT OF CHEST PAIN SUSPECTED TO BE CARDIAC IN ORIGIN*	*137*	4	*inappropriate investigation. Waste of resources*	*3*	*3*	
121	An attack of angina that lasts >20 min or keeps recurring despite repeated use of glyceryl trinitrate (GTN) is an indication for immediate admission to hospital	*UNSTABLE ANGINA*	*139*	1	*discharge patient with high probability of MI*	*3*	*1*	
122	Risk of bleeding is increased in patients with low body weight (<50 kg), physiological frailty, severe liver or renal failure (eGFR <20 mL/min), thrombocytopenia or defective platelet function and following surgery, trauma or haemorrhagic stroke. Seek advice from appropriate team e.g. cardiology, renal, liver or haematology	*UNSTABLE ANGINA*	*140*	3	*Bleeding*			
123	Patients with ST segment depression on ECG – consider for urgent coronary angiography with a view to revascularisation. Contact on-call cardiology SpR/SHO	*UNSTABLE ANGINA*	*140*	3 and 1	*increased long term damage to heart*	*1*	*2*	
124	Patients who fail to settle or whose GTN infusion cannot be withdrawn – consider for urgent coronary angiography with a view to revascularisation. Contact on-call cardiology SpR/SHO	*UNSTABLE ANGINA*	*140*	3 and 1	*increased long term damage to heart*	*1*	*2*	
125	Cardiogenic shock and ventricular arrhythmias are not contraindications to thrombolysis. There is no upper age limit for this treatment	*ACUTE MYOCARDIAL INFARCTION*	*143*	9				Write as bullet point: Not a contra-indication

126	Treatment of choice for most patients for NSTEMI is inpatient cardiac catheterisation with early revascularisation, either by percutaneous intervention (PCI) or CABG. For patients unlikely to be suitable for an early invasive strategy because of frailty or multiple co-morbidities should have that decision made early and by an experienced clinician Refer to on-call cardiology SpR (07936 182946)	*ACUTE MYOCARDIAL INFARCTION*	*144*	1 and 9				Management of STEMI is of similar urgency written as bullet points. I suggest NSTEMI should be written the same
127	Risk of bleeding is increased in patients with low body weight (<50 kg), physiological frailty, severe liver or renal failure (eGFR <20 mL/min), thrombocytopenia or defective platelet function and following surgery, trauma or haemorrhagic stroke. Seek advice from appropriate team e.g. cardiology, renal, liver or haematology	*ACUTE MYOCARDIAL INFARCTION*	*144*	3	*Bleeding*			
128	Dopamine must only be used in critical care and in the coronary care unit and administered preferably via a central line	*ACUTE MYOCARDIAL INFARCTION*	*145*	3	*side-effects canbe severe*			Better written as a If considering using dopamine, refer to critical care or coronary care unit
129	If aortic dissection suspected, refer for urgent investigation. Do not delay; mortality is 1% per hour and can be reduced by prompt treatment. "Type A" Thoracic dissection is managed by cardiothoracic surgery. Uncomplicated "Type B" dissection is managed conservatively by cardiology. (Abdominal aortic dissection is managed by vascular surgeons)	*THORACIC AORTIC DISSECTION*	*147*	3 and 1	*death*	*1*	*1*	

130	If patients are haemodynamically unstable with likely aortic dissection – discuss urgently with cardiothoracic surgeon and cardiologist. Meanwhile arrange CT with appropriate monitoring	*THORACIC AORTIC DISSECTION*	*147*	3 and 1	*death*	*1*	*1*	same as 130. Do we need both
131	Nil-by-mouth. Do not give anti-platelet or anticoagulation medications	*THORACIC AORTIC DISSECTION*	*148*	2	*delayed surgery canlead to death*	*2*	*1*	
132	Obtain objective evidence (echocardiogram) as soon as possible. Heart failure is not a diagnosis in itself, and always has an underlying cause	*ACUTE HEART FAILURE*	*153*	2	*Stop inappropriate diagnosis and live long treatment*	*1*	*3*	Acute cardiac failure is a full NICE guideline, even has indications for hospitalisation. Tit needs to be clarified in its purpose, who it is for
133	Remember BNP is elevated in primary and secondary causes of heart failure (Table 3). Its utility is mainly as a rule-out test but a BNP <100 ng/L does not mean that the patient does not have heart failure it just means it is less likely	*ACUTE HEART FAILURE*	*153*	9				This information is already in table 1
134	Give single IV doses of furosemide >80 mg by IV infusion no faster than 4 mg/min	*ACUTE HEART FAILURE*	*154*	2	*?*			
135	Avoid empirical fluid resuscitation in patients with pulmonary oedema, hypotension and normal JVP, even after right ventricular infarction Arrange immediate echocardiogram or seek advice from cardiology team (15107)	*ACUTE HEART FAILURE*	*155*	2 and 3	*Worsen failure*	*1*	*3*	

136	Always identify cause(s)/trigger factor for current decompensation and if a primary cardiac cause is suspected, refer to cardiology team as inpatient. Optimise treatment of non-cardiac conditions responsible for, or contributing to, heart failure (see Table 3)	*ACUTE HEART FAILURE*	*155*	9 as information need re-writing as bullets				
137	Metolazone can induce massive diuresis. Monitor patients carefully to prevent hypovolaemia or electrolyte disturbance	*ACUTE HEART FAILURE*	*156*	2 and 9				This applies only to one bullet point write as attached grey bullet point
138	Consider decreasing dosage of furosemide after successful treatment of cause/trigger factor or introduction of ACEI	*ACUTE HEART FAILURE*	*156*	9				This is inapproprite place as it is subsequent management
139	Optimise time spent in hospital after an acute admission – in addition to sustaining a diuresis, take opportunity to introduce and adjust dosage of medicines that will improve symptoms, prolong life and reduce re-admission. And optimise co-morbidity management	*ACUTE HEART FAILURE*	*157*	9				This is too like an exhortation-do good
140	Remember that patients in the palliative phase of their illness may still be candidates for palliative interventions such as revascularisation, aggressive arrhythmia management or IV inotropes – discuss with palliative care team	*ACUTE HEART FAILURE*	*157*					should this not say refer to palliative care team
141	Before discharge, give patient traffic light warning system for action should symptoms worsen	*ACUTE HEART FAILURE*	*158*	9				We need more information on referral t o specilalistteam. It is so ifand but, thsat guideline does not guide the reader

142	Mode of presentation dictates urgency of assessment and treatment. Treat patient first and arrhythmia second. Accurate diagnosis is not possible without a 12-lead ECG	*CARDIAC ARRHYTHMIAS*	*159*					This is three aphorisms; first two vague; what prsentations need urgency? Last should say Obtaina 12 lead ECG.
143	Successful management of cardiac arrhythmias often requires specialist experience	*CARDIAC ARRHYTHMIAS*	*159*	9				Yes, but need to know when as in text. Not needed
144	Monitor the effects of all the following treatments by continuous ECG recording	*CARDIAC ARRHYTHMIAS*	*159*	5	*Miss change inrythm*	*3*	*3*	
145	If tachycardia associated with hypotension, shock, or cardiac failure, before giving any anti-arrhythmic drug IV, seek urgent advice from cardiology team to discuss DC cardioversion (or overdrive pacing for selected tachycardias)	*CARDIAC ARRHYTHMIAS*	*160*	9				Should be amalgamated with first bullet point in guideline
146	Do not give verapamil if patient already taking a beta-blocker	*CARDIAC ARRHYTHMIAS*	*160*	2	*hypotension and aystole (no heart beat)*	*3*	*2*	
147	If specialist intervention required for patients with serious or recurrent arrhythmias, seek advice of cardiology team	*CARDIAC ARRHYTHMIAS*	*161*	9				Does not say anything apart from the specialist needed is a cardiologist.

148	Do not use amiodarone as a first-line agent for long-term treatment because of the risk of serious adverse effects. Reserve for life-threatening arrhythmias not responding to other agents	*CARDIAC ARRHYTHMIAS*	*161*	2	*Stop side-effects*	*3*	*3*	Surely by now this would a cardiologist anyway
149	If intracardiac electrophysiological studies or ablation therapy contemplated, send formal referral to cardiac electrophysiology department	*CARDIAC ARRHYTHMIAS*	*161*	9				Should be bullet, not a risk statement
150	Low priority as rate control affords the same clinical benefit as rhythm control. Be certain that AF started <24 hr previously	*ATRIAL FIBRILLATION*	*162*	2	*Rythym treatment fails if given after 24hrs of start of AF*	*3*	*3*	
151	If unfractionated heparin commenced – see Heparin-induced thrombocytopenia guideline	*ATRIAL FIBRILLATION*	*162*	9				Amalgamate with bullet point above,which shouldrefer to both guidelines
152	Do not give beta blockers and calcium antagonists: including patients already on either drug orally	*ATRIAL FIBRILLATION*	*162*	2	*hypotension and aystole (no heart beat)*	*3*	*2*	Needs clarifying
153	The decision whether to anticoagulate is patient-specific, guided by weighing the risk of thromboembolic stroke against the adverse risk of bleeding	*ATRIAL FIBRILLATION*	*163*	9				Basically says take care: how to take care is in next set of bullet points and table
154	If a decision is made not to anticoagulate the patient document the reason in the notes	*ATRIAL FIBRILLATION*	*163*	9				Basically, need a heading/bullet point reminding doctor to document, but should be routine for all actions; if not recorded it never happened

155	Do NOT discharge patient from hospital taking rhythm-controlling agents (unless advised to by a cardiologist) as these are unlikely to restore sinus rhythm and expose patient unnecessarily to risk of drug-induced arrhythmia	*ATRIAL FIBRILLATION*	*164*	2	*Drug induced arrthymias*	*3*	*3*	
156	Aseptic technique vital. Follow Collection of blood culture specimens guideline. Take each sample via an entirely separate venepuncture and not from an indwelling catheter	*INFECTIVE ENDOCARDITIS*	*165*	5	*Contaminated samples*	*2*	*2*	
157	Aseptic technique vital. Follow Collection of blood culture specimens guideline. Take each sample via an entirely separate venepuncture and not from an indwelling catheter	*INFECTIVE ENDOCARDITIS*	*165*	repeated 156				
158	Do not prescribe antimicrobials until at least three separate sets of blood cultures have been taken UNLESS patient has severe sepsis or septic shock in which case: take 2 separate sets of blood cultures and administer empirical antimicrobials within 1 hr of diagnosis	*INFECTIVE ENDOCARDITIS*	*166*	2	*Reduced likelihood of finding bacteria in sample*	*3*	*3*	
159	Penicillin allergy should only be accepted as genuine hypersensitivity if convincing history of either rash within 72 hr of dose or anaphylactic reaction. True penicillin allergy is rare and, in many infections, alternative antimicrobials are less effective with greater risks attached. If a patient reports penicillin allergy, it is imperative to establish, as far as possible, the nature of the reported allergy. In patients able to provide a history, the nature of the penicillin allergy must be recorded	*INFECTIVE ENDOCARDITIS*	*166*	2	*Less than ideal anti-microbial therapy*	*2*	*3*	

	on admission. If any doubt about whether patient is truly allergic to penicillin, seek advice from a microbiologist or consultant in infectious diseases							
160	Gentamicin and vancomycin require careful monitoring, especially in patients with renal impairment. Monitor for signs of deafness and balance problems which may occur at normal levels	*INFECTIVE ENDOCARDITIS*	*166*	9				Repeat of bullet point above. Need bullet points in box to go in text. Already refer to Vancomycin and Gentamicin guidelines
161	Serum concentrations of vancomycin and gentamicin must be monitored to avoid toxicity. Monitor for signs of deafness and balance problems which may occur at normal levels	*INFECTIVE ENDOCARDITIS*	*167*	9				Should be bullet point in monitoring treatment section
162	Remember to read contraindications and precautions on the risk assessment proforma	*PROPHYLAXIS AGAINST VENOUS THROMBOEMBOLISM*	*169*	2	*Fail to stop to think about each patient when doing routine task*	*3*	*3*	
163	If patient pregnant, contact obstetric team. See Management of a pregnant woman with a non-obstetric problem guideline and VTE – Deep venous thrombosis guideline in Obstetric guidelines	*DEEP VENOUS THROMBOSIS (DVT)*	*172*	3 and 4	*Harm to fetus*	*2*		
164	If outpatient, ensure form authorising daily injections of dalteparin and provision of Class 3 compression hose is completed once diagnosis confirmed	*DEEP VENOUS THROMBOSIS (DVT)*	*174*	9				This is home treatment guideline. Surely should be in dischargeand not bulleted
165	If anticoagulation contraindicated, consultant physician, staff physician must decide which carries most risk – complications of therapy, or the DVT and consider a vena caval filter	*DEEP VENOUS THROMBOSIS (DVT)*	*174*	3	*Junior doctor decides very finely baanced decision*	*3*	*3*	

166	PREGNANCY If a pregnant woman has collapse or shock associated with a massive pulmonary embolism, consider thrombolytic therapy – associated with 1–6% maternal bleeding complication rate, 1.7% fetal mortality, but no maternal mortality – discuss with on-call obstetric consultant Nurse women in the second and third trimester on a left lateral tilt (never supine) or with manual displacement of the uterus to prevent aortocaval compression – see VTE – Pulmonary embolism guideline in Obstetric guidelines	*MASSIVE PULMONARY EMBOLISM*	*177*	3				
167	D-dimer is not relevant in probable massive PE	*MASSIVE PULMONARY EMBOLISM*	*177*	1	*Delay in acting in an emergency situation*	*3*	*1*	
168	If there are contraindications to giving alteplase or anticoagulation, a consultant physician, or SpR must make a decision as to which carries most risk – possible complications of therapy, or embolism	*MASSIVE PULMONARY EMBOLISM*	*177*	3	*Junior doctor decides very finely baanced decision*	*3*	*1*	
169	ECG and chest X-ray are often normal and should not be used to confirm/refute the diagnosis, but are useful for identifying other diseases and explaining symptoms. ECG may show sinus tachycardia, an S1 Q3 T3 pattern, right bundle branch block, P pulmonale or right axis deviation. Chest X-ray may show non-specific shadows or a raised hemidiaphragm, pulmonary oligaemia, linear atelectasis or small pleural effusion	*SMALL-TO-MODERATE PULMONARY EMBOLISM*	*179*	9				BEST WRITTEN AS BULET POINTS FOR NON-DIAGNOSTIC tests

170	Whereas a normal D-dimer concentration virtually rules out thrombosis, a raised D-dimer concentration cannot be used confidently to confirm that thrombosis has occurred	*SMALL-TO-MODERATE PULMONARY EMBOLISM*	*180*	2	*What weight to put on d-dimer result*	*3*	*3*	
171	If anticoagulation contraindicated, a consultant physician, staff physician or SpR must decide which carries most risk – possible complications of therapy, or embolism and consider a vena caval filter	*SMALL-TO-MODERATE PULMONARY EMBOLISM*	*181*	3	*Junior doctor decides very finely baanced decision*	*3*	*1*	
172	INR may be elevated by heparin if APTT ratio exceeds 2.5 in a patient being given unfractionated heparin, and must not be used as a guide to adjustment of warfarin dosage	*SMALL-TO-MODERATE PULMONARY EMBOLISM*	*181*	2	*Low dose of heparin given*	*3*	*3*	
173	Document in medical record that patient has been given written and verbal information about warfarin and has been referred to anticoagulation clinic	*SMALL-TO-MODERATE PULMONARY EMBOLISM*	*182*	9				Bullet point
174	Nurse patients in the second and third trimester on a left lateral tilt (never supine) or with manual displacement of the uterus to prevent aortocaval compression – see VTE – Pulmonary embolism guideline in Obstetric guidelines	*SMALL-TO-MODERATE PULMONARY EMBOLISM*	*183*					Shouldwenot say just go anduse the guideline in obstetrics
175	If contraindications to anticoagulation, a consultant physician and obstetrician, staff physician or SpR must make a decision as to which carries most risk – possible complications of therapy, or embolism	*SMALL-TO-MODERATE PULMONARY EMBOLISM*	*183*	3	*Junior doctor decides very finely baanced decision*	*3*	*1*	

176	Thrombocytopenia is rarely severe in HIT Despite low platelet count, bleeding is uncommon	*HEPARIN-INDUCED THROMBOCYTOPENIA*	*185*	9 as information				Put in bullet
177	Contraindicated in patients with severe hepatic impairment	*HEPARIN-INDUCED THROMBOCYTOPENIA*	*187*	2				Would this section be better if it was a referral?
178	If patient in extremis, very dyspnoeic with circulatory compromise, and trachea or mediastinum (apex beat) displaced, consider TENSION PNEUMOTHORAX (very rare). Give oxygen (10 L/min) through a high concentration (60–100%) mask. Insert a large bore cannula of at least 4.5 cm in length into second anterior intercostal space, midclavicular line, then insert intercostal tube – see Intercostal tube drainage guideline. Remove emergency cannula when bubbling in underwater seal system confirms intercostal tube system functioning	*SPONTANEOUS PNEUMOTHORAX*	*189*	1	*death*	*1*	*1*	
179	BEWARE: suspected basal pneumothorax usually implies a bulla. CT scan and previous chest X-rays will differentiate bullae from pneumothorax	*SPONTANEOUS PNEUMOTHORAX*	*189*	2	*Place drain in inapproprite place.It can lead to infection and lung damage*	*2*	*3*	
180	Do not clamp chest tube unless advised by pleural team or thoracic surgeon	*SPONTANEOUS PNEUMOTHORAX*	*190*	2	*Failure of drainage of air.If broncho-pleural fistula, it may lead to tension pneumothorax*	*3*	*3*	

181	Patients with severe or life-threatening attacks may not be distressed and may not have all these abnormalities. The presence of any one of these should alert the clinical team	*ACUTE SEVERE ASTHMA IN ADULTS*	*191*	1	*Failure to appreciate severity of asthma attack*	*2*	*2*	
182	If SpO2 <92% or patient has any life-threatening features or not responding to treatment, measure arterial blood gases (ABG)	*ACUTE SEVERE ASTHMA IN ADULTS*	*191*	1	*Failure to appreciate severity of asthma attack*	*2*	*2*	
183	DO NOT LEAVE THE PATIENT Ask medical SpR, staff physician or consultant physician, ideally respiratory, to review urgently	*ACUTE SEVERE ASTHMA IN ADULTS*	*192*	1 and 3	*Failure to appreciate severity of asthma attack*	*1*	*1*	
184	En-route to CCU, ensure patient is accompanied by a doctor (usually an anaesthetist) prepared to intubate if patient's clinical condition requires it	*ACUTE SEVERE ASTHMA IN ADULTS*	*192*	3	*Unable to take emergency action fast*	*1*	*1*	
185	If patient requires IV fluid with potassium, always use commercially produced pre-mixed bags of sodium chloride 0.9% and potassium chloride. NEVER add potassium chloride to infusion bags	*ACUTE SEVERE ASTHMA IN ADULTS*	*192*	2	*death*	*2*	*1*	
186	Fax referral to clinical nurse specialist in asthma on 74072 or call 74068 to review patient	*ACUTE SEVERE ASTHMA IN ADULTS*	*192*	9				A contact deytail
187	Ask medical SpR, staff physician or consultant physician, ideally respiratory, to review urgently	*ACUTE SEVERE ASTHMA IN ADULTS*	*192*	1 and 3	*Failure to appreciate severity of asthma attack*	*1*	*1*	

188	En-route to CCU, ensure patient is accompanied by a doctor (usually an anaesthetist) prepared to intubate if patient's clinical condition requires it	*ACUTE SEVERE ASTHMA IN ADULTS*	*192*	3	*Unable to take emergency action fast*	*1*	*1*	
189	Document in medical record patient's functional status before the exacerbation. A consultant, staff physician or SpR must document patient's ventilation and resuscitation status	*EXACERBATION OF CHRONIC OBSTRUCTIVE PULMONARY DISEASE (COPD)*	*194*	2	*Do not have the information to make decision on treatment if patient later deteriorates*	*3*	*3*	
190	Document in medical record patient's functional status before the exacerbation. A consultant, staff physician or SpR must document patient's ventilation and resuscitation status	*EXACERBATION OF CHRONIC OBSTRUCTIVE PULMONARY DISEASE (COPD)*	*194*	2	*Do not have the information to make decision on treatment if patient later deteriorates*	*3*	*3*	copy of 189
191	High percentage (>24%) oxygen must NOT be given unless ABG confirm absence of CO2 retention	*EXACERBATION OF CHRONIC OBSTRUCTIVE PULMONARY DISEASE (COPD)*	*194*	2	*Patient falls asleep andgently drifts to death*	*2*	*1*	
192	Simvastatin contraindicated in combination with clarithromycin (see current BNF for other interactions)	*EXACERBATION OF CHRONIC OBSTRUCTIVE PULMONARY DISEASE (COPD)*	*195*	2	*Inadequate level of clarithrmycin antibiotic*	*3*	*3*	
193	Penicillin allergy should only be accepted as genuine hypersensitivity if convincing history of either rash within 72 hr of dose or anaphylactic reaction. True penicillin allergy is rare and, in many infections, alternative antimicrobials are less effective with greater risks attached. If a patient reports penicillin allergy, it is imperative to establish, as far as possible, the nature of the	*EXACERBATION OF CHRONIC OBSTRUCTIVE PULMONARY DISEASE (COPD)*	*195*	2	*Less than ideal anti-microbial therapy*	*2*	*3*	

	reported allergy. In patients able to provide a history, the nature of the penicillin allergy must be recorded on admission. If any doubt about whether patient is truly allergic to penicillin, seek advice from a microbiologist or a consultant in infectious diseases							
194	If patient conscious and not confused, and has no unstable concurrent clinical conditions, ring supported early discharge team for assessment of home care	*EXACERBATION OF CHRONIC OBSTRUCTIVE PULMONARY DISEASE (COPD)*	*195*	9				Important information, but not a risk. Will enable patient to go home early
195	Treat as pneumonia if patient has symptoms and signs below plus new unexplained chest X-ray shadowing, and the illness is the primary clinical problem	*COMMUNITY-ACQUIRED PNEUMONIA*	*197*	1	*Failure to treat correctly speedily*	*3*	*2*	
196	Enquire about pet birds (psittacosis, chlamydial infection) and recent hotel residence away from home (legionellosis)	*COMMUNITY-ACQUIRED PNEUMONIA*	*197*	9				Should be sepaaate section entitled v
197	If SpO2 <94% or features of severe pneumonia (see severity assessment below), measure arterial blood gases	*COMMUNITY-ACQUIRED PNEUMONIA*	*197*	1	*Underestimate severity of pneumonia*	*3*	*3*	
198	Check on iPortal whether patient is positive for extended-spectrum beta-lactamase-producing Gram-negative bacilli (ESBL), meticillin-resistant Staphylococcus aureus (MRSA) or multi-resistant Gram-negative bacilli (MGNB). If unavailable, then check the previous 12 months of microbiology reports: if MRSA present then treat as tagged for	*COMMUNITY-ACQUIRED PNEUMONIA*	*197*	5	*Not ideal therapy given, although sepsis treatment will be given*	*3*	*2*	

	MRSA; if ESBL present then treat as tagged for ESBL							
199	If a previously healthy young adult presents with acute necrotising pneumonia with rapid lung cavitation, suspect Panton-Valentine leukocidin (PVL) toxin-producing Staphylococcus aureus. Isolate in single room and contact microbiologist, infectious disease, or respiratory consultant for advice (antimicrobials in Table)	*COMMUNITY-ACQUIRED PNEUMONIA*	*198*	1 and 3	*Danger of transmission and incorrect treatment*	*2*	*2*	
200	Penicillin allergy should only be accepted as genuine hypersensitivity if convincing history of either rash within 72 hr of dose or anaphylactic reaction. True penicillin allergy is rare and, in many infections, alternative antimicrobials are less effective with greater risks attached. If a patient reports penicillin allergy, it is imperative to establish, as far as possible, the nature of the reported allergy. In patients able to provide a history, the nature of the penicillin allergy must be recorded on admission. If any doubt about whether patient is truly allergic to penicillin, seek advice from a microbiologist or consultant in infectious diseases	*COMMUNITY-ACQUIRED PNEUMONIA*	*199*	2	*Less than ideal anti-microbial therapy*	*2*	*3*	

201	DO NOT use this guideline for immunosuppressed patients Check on iPortal whether patient is positive for extended-spectrum beta-lactamase-producing Gram-negative bacilli (ESBL), meticillin-resistant Staphylococcus aureus (MRSA), multi-resistant Gram-negative bacilli (MGNB) or Carbapenemase-producing Gram-negative bacilli (CARB). If unavailable, then check the previous 12 months of microbiology reports: if MRSA present then treat as tagged for MRSA; if ESBL present then treat as tagged for ESBL	*HOSPITAL-ACQUIRED PNEUMONIA*	*202*	First paragraph is 4	*Not ideal therapy given, although sepsis treatment will be given*	*3*	*2*	Second section is in 202.Delete from this warning
202	Check on iPortal whether patient is positive for extended-spectrum beta-lactamase-producing Gram-negative bacilli (ESBL), meticillin-resistant Staphylococcus aureus (MRSA), multi-resistant Gram-negative bacilli (MGNB) or Carbapenemase-producing Gram-negative bacilli (CARB). If unavailable, then check the previous 12 months of microbiology reports: if MRSA present then treat as tagged for MRSA; if ESBL present then treat as tagged for ESBL	*HOSPITAL-ACQUIRED PNEUMONIA*	*202*	5	*Not ideal therapy given, although sepsis treatment will be given*	*3*	*2*	
203	If deteriorating, contact critical care early	*HOSPITAL-ACQUIRED PNEUMONIA*	*203*	1 and 3	*Failure to give critical care support early*	*3*	*3*	
204	For further advice on antimicrobial therapy, contact microbiologist	*HOSPITAL-ACQUIRED PNEUMONIA*	*203*	9				This would be better strenghtened to say I what circumstances to contact. At present, best as bullet point

205	Many patients with severe hospital-acquired pneumonia will have some renal impairment; seek advice when selecting antimicrobial dosage. Contact pharmacy medicines information	*HOSPITAL-ACQUIRED PNEUMONIA*	*203*	2	*Incorrect doses of medicines*	*3*	*2*	
206	Penicillin allergy should only be accepted as genuine hypersensitivity if convincing history of either rash within 72 hr of dose or anaphylactic reaction. True penicillin allergy is rare and, in many infections, alternative antimicrobials are less effective with greater risks attached. If a patient reports penicillin allergy, it is imperative to establish, as far as possible, the nature of the reported allergy. In patients able to provide a history, the nature of the penicillin allergy must be recorded on admission. If any doubt about whether patient is truly allergic to penicillin, seek advice from a microbiologist or consultant in infectious diseases	*HOSPITAL-ACQUIRED PNEUMONIA*	*204*	2	*Less than ideal anti-microbial therapy*	*2*	*3*	
207	>4 days after admission including patients admitted from nursing home/care home/ residential home or community hospitals with pneumonia treat according to Community acquired pneumonia guideline Patients re-admitted with pneumonia after >4 days of discharge from acute hospitals should be treated according to the community acquired pneumonia guidelines	*HOSPITAL-ACQUIRED PNEUMONIA*	*204*	4	*Less than ideal anti-microbial therapy*	*2*	*3*	

208	It may be necessary to accept only a modest increase in PaO2; most patients will survive if PaO2 >6.7 kPa	*RESPIRATORY FAILURE*	*207*	2	*in type 2 respiratory failure, If force Pao2> 8kPa, SpO2 may rise > 92% so raising risk of hypercapnia*	*2*	*2*	I would add in box as first sentence " Keep SpO2 between 88-92%
209	Antimicrobials alone are not enough to treat an empyema. It is important to drain the infected pleural fluid. Unless absolutely impossible, send sample of fluid for culture before starting antimicrobial therapy. Start empirical therapy while awaiting results of culture	*PLEURAL INFECTION AND EMPYEMA*	*209*	9				This is mass of bullet points put in a warning box. The first sentence should come as bullet point just below heading IMMEDIATE TREATMENT Treatment is antimicrobials and drainage of the infected pleiural fluid
210	Check on Clinical information system (CIS) whether patient tagged for extended spectrum beta-lactamase-producing Gram-negative bacilli (ESBL), methicillin-resistant Staphylococcus aureus (MRSA), multi-resistant Gram-negative bacilli (MGNB) or Carbapenemase-producing Gram-negative bacilli (CARB)	*PLEURAL INFECTION AND EMPYEMA*	*209*	5	*Not ideal therapy given, although sepsis treatment will be given*	*3*	*2*	
211	Penicillin allergy should only be accepted as genuine hypersensitivity if convincing history of either rash within 72 hr of dose or anaphylactic reaction. True penicillin allergy is rare and, in many infections, alternative antimicrobials are less effective with greater risks attached. If a patient reports penicillin allergy, it is imperative to establish, as far as possible, the nature of the reported allergy. In patients able to provide a history, the nature of the penicillin allergy must be recorded on admission. If any doubt about whether patient truly allergic to penicillin, seek advice from a microbiologist or	*PLEURAL INFECTION AND EMPYEMA*	*209*	2	*Less than ideal anti-microbial therapy*	*2*	*3*	

	consultant in infectious diseases							
212	Refer urgently to on-call neurology SpR any patient with a seizure lasting >10 min	*STATUS EPILEPTICUS*	*213*	3 and 1	*Less than ideal therapy*	*2*	*2*	
213	Generalised tonic-clonic status is potentially life-threatening – treat without delay	*STATUS EPILEPTICUS*	*213*	1	*Death is possible*			
214	Do not attempt to put anything into patient's mouth during a seizure, even if tongue injured. Intubation, if necessary, requires special care	*STATUS EPILEPTICUS*	*213*	2	*Injury to patient*	*3*	*3*	
215	Avoid rolling patient during a seizure unless absolutely necessary as this can cause injury to shoulder/hip joints	*STATUS EPILEPTICUS*	*213*	2	*injury*	*3*	*3*	
216	All patients should now be under the care of the neurology team	*STATUS EPILEPTICUS*	*215*	3	*Less than ideal therapy*	*2*	*3*	
217	EEG can be arranged: Monday-Friday 0830-1700 hr via EEG department, out-of-hours contact on-call technician via call centre. Out-of-hours EEGs may not be reported until next working day,	*STATUS EPILEPTICUS*	*215*	9 as information				How to contact EEG, best as bullet

	discuss with technician							
218	If focal neurological abnormalities found or CT scan abnormal, contact on-call neurology SpR while patient in A&E for advice about further action to be taken	*FIRST SEIZURE*	*218*	1 and 3	*Less than ideal therapy*	*2*	*3*	
219	Many of these features are similar to those of drug toxicity or behavioural problems	*CLUSTER SEIZURES AND COMPLEX PARTIAL AND NON-CONVULSIVE STATUS*	*219*	4	*Incorrect diagnosis*	*3*	*3*	
220	Many of these features are similar to those of drug toxicity or behavioural problems	*CLUSTER SEIZURES AND COMPLEX PARTIAL AND NON-CONVULSIVE STATUS*	*219*	4	*Incorrect diagnosis*	*3*	*3*	copy of 219
221	Treat all patients with symptoms at time of assessment as a stroke, even if minor or improving. Diagnose TIA only if symptoms have completely resolved	*ACUTE STROKE*	*220*	1	*failure to treat stroke early leading to more disability and even death in long term*	*1*	*1*	
222	Ensure stroke team aware of all patients with stroke not admitted to stroke unit. Members of stroke team will assess patient and arrange transfer to stroke unit, if other concurrent conditions allow	*ACUTE STROKE*	*224*	3	*Less than ideal therapy*	*2*	*3*	
223	Manage patients with antiphospholipid syndrome who have an acute ischaemic stroke in the same way as patients with acute ischaemic stroke without antiphospholipid syndrome	*ACUTE STROKE*	*225*	2	*Over zealous treatment*	*3*	*3*	

224	Acute stroke unit provides information packs for patients and carers, and will assist in discharge planning and arrangements for continued outpatient rehabilitation. They will also contact stroke family support worker where needed	*ACUTE STROKE*	*227*	3	*Less than ideal therapy*	*1*	*3*	Should this warning be more definite. Contact Acute stroke unit for…
225	Treat patient who still has symptoms at time of assessment as stroke and consider for thrombolysis (see Acute stroke guideline) if within <4 hr of symptom onset. TIA can only be diagnosed once all symptoms have resolved	*TRANSIENT ISCHAEMIC ATTACK (TIA)*	*228*	1	*failure to treat stroke early leading to more disability and even death in long term*	*1*	*1*	
226	Treat patient who still has symptoms at time of assessment as stroke and consider for thrombolysis (see Acute stroke guideline) if within <4 hr of symptom onset. TIA can only be diagnosed once all symptoms have resolved	*TRANSIENT ISCHAEMIC ATTACK (TIA)*	*228*	1	*failure to treat stroke early leading to more disability and even death in long term*	*1*	*1*	Copy of 225
227	Consider all patients with TIA who are in atrial fibrillation (AF) as high risk TIA irrespective of whatever the ABCD2 score is	*TRANSIENT ISCHAEMIC ATTACK (TIA)*	*228*	1	*delay in treatment could lead to stroke*	*2*	*1*	
228	Where patients have repeated attacks of transient neurological symptoms despite best medical treatment, and an embolic source has been excluded, consider an alternative neurological diagnosis	*TRANSIENT ISCHAEMIC ATTACK (TIA)*	*230*	3	*Incorrect diagnosis*	*2*	*2*	Should this not read refer to neurologist for condsideration of a an alternative diagnosis../
229	Symptoms can sometimes resolve within a few hours but should still be investigated with CT scan of head. Thirty percent of patients with SAH may have 'minor' leaks hours or days before the major haemorrhage, which are often misdiagnosed as simple headaches or migraine	*SUBARACHNOID HAEMORRHAGE*	*232*	1	*Late diagnosis with more disability and even death*	*2*	*1*	

230	When lumbar puncture performed, send sample to clinical biochemistry immediately for centrifugation to allow CSF spectrophotometry for xanthochromia. This is especially important if tap was traumatic. You must protect sample from light and warn clinical biochemistry before you send sample. Do not use air tube to transport sample	*SUBARACHNOID HAEMORRHAGE*	*232*	5	*Failure to maxmise information from lumbar punture procedure*	*1*	*2*	
231	Early diagnosis is imperative, high index of suspicion necessary in patients with mild weakness and urinary hesitancy especially if history of cancer	*ACUTE SPINAL CORD COMPRESSION*	*234*	1	*Delay in acting in an emergency situation leading to severe disabillity and even death*	*1*	*1*	
232	Acute spinal cord compression is an emergency – refer such patients IMMEDIATELY to a spinal specialist. Do not delay referral; it is better that the spinal specialist organises emergency MRI scan than referral be delayed until a scan has been done	*ACUTE SPINAL CORD COMPRESSION*	*234*	1 and 3	*Delay in acting in an emergency situation leading to severe disabillity and even death*	*1*	*1*	
233	Hospital-acquired renal failure is often multifactorial, with contributions from hypotension, sepsis and drugs. Risk of ARF resulting from obstruction or renovascular disease is greater if patient has single kidney	*ACUTE KIDNEY INJURY (ACUTE RENAL FAILURE)*	*239*	9				This should be first bullet points below heading causes
234	Identify patients with developing or established multiple organ failure early and refer to critical care for further investigation and management	*ACUTE KIDNEY INJURY (ACUTE RENAL FAILURE)*	*240*	3	*Less than ideal therapy*	*1*	*1*	
235	Patients whose renal function continues to decline (even if creatinine <300 µmol/L) despite initial resuscitation – refer to renal team within 48 hr of diagnosing ARF/AKI	*ACUTE KIDNEY INJURY (ACUTE RENAL FAILURE)*	*241*	3	*Less than ideal therapy*	*1*	*1*	

236	Recognition of a hypertensive emergency is essential for effective triage and treatment If accelerated hypertension suspected examine fundi thoroughly	*ACCELERATED (MALIGNANT) HYPERTENSION*	*242*	1	*Delay in acting in an emergency situation leading to severe disabillity and even death*	*1*	*1*	
237	If there is any doubt about the need for treatment, seek advice from an SpR or consultant in renal medicine	*ACCELERATED (MALIGNANT) HYPERTENSION*	*242*	3	*Less than ideal therapy*	*2*	*1*	
238	Sustained high BP alters cerebral autoregulation; sudden reduction of BP will reduce cerebral perfusion and can be dangerous. Aim to reduce blood pressure by no more than 25% in first 24–48 hr	*ACCELERATED (MALIGNANT) HYPERTENSION*	*242*	2	*Over zealous treatment could lead to stroke or MI*	*2*	*2*	
239	If parenteral therapy indicated, contact on-call renal SpR and request transfer to care of renal team	*ACCELERATED (MALIGNANT) HYPERTENSION*	*243*	3	*Less than ideal therapy*			Should the actions be taken with advice of renal team
240	Sublingual nifedipine and captopril can substantially lower BP within 10–30 min. A more rapid response is seen when liquid nifedipine is swallowed. Ischemic symptoms (e.g, angina pectoris, myocardial infarction, or stroke) are a major risk due to an excessive and uncontrolled hypotensive response. Avoid their use in the treatment of hypertensive crises	*ACCELERATED (MALIGNANT) HYPERTENSION*	*243*	2	*Over zealous treatment could lead to stroke*	*2*	*1*	
241	If this condition is suspected, refer to the renal team urgently	*ACCELERATED (MALIGNANT) HYPERTENSION*	*243*	1	*Less than ideal therapy*	*1*	*2*	

242	If patient severely disturbed and a danger to self or others – see recommendations for assessment and non-medical management in Aggressive and violent patients guideline	*DELIRIUM (ACUTE CONFUSIONAL STATE) IN OLDER PEOPLE*	*247*	4	*Less than ideal management of aggression*	*2*	*3*	
243	Do not use anti-psychotic medication (e.g. haloperidol, risperidone, olanzepine) or sedatives for insomnia, restlessness, wandering or disruptive behaviour	*DELIRIUM (ACUTE CONFUSIONAL STATE) IN OLDER PEOPLE*	*247*	2	*worsen condition with drug sideeffects*	*1*	*3*	
244	As risperidone is only indicated for persistent aggression, it must only be prescribed by a consultant geriatrician or psycho-geriatrician. It should never be prescribed by junior staff to treat acute episodes out-of-hours	*DELIRIUM (ACUTE CONFUSIONAL STATE) IN OLDER PEOPLE*	*248*	2 and 3	*Difficult decision taken by junior doctor. Treatment with dangerous sideeffects may be given*	*2*	*2*	
245	In mild cases, patient may complain of being cold but this is not reliable	*HYPOTHERMIA IN OLDER PEOPLE*	*250*	9 as information				Bullet point
246	Prognosis poor if patient fails to warm. High risk of death if temperature <30°C	*HYPOTHERMIA IN OLDER PEOPLE*	*251*	9 as informatiom				Bullet point
247	Hypothermia protects against cerebral hypoxia so continue cardiac arrest procedures for longer than usual, if necessary until core temperature reaches 37°C	*HYPOTHERMIA IN OLDER PEOPLE*	*251*	1	*Stop cardiac arrest procedure too early*	*2*	*1*	

248	Before prescribing laxatives, carry out digital rectal examination in all patients and document findings. Take care when using laxatives of any kind in patients with suspected intestinal obstruction (ask for senior advice in these patients) If haemorrhoids or anal fissure, avoid rectal preparations. In patients with inflammatory bowel disease, colitis or Crohn's disease, avoid macrogols	*MANAGEMENT OF CONSTIPATION IN HOSPITALISED ELDERLY PATIENTS*	*252*	9				Many bullet points
249	For patients with severe opioid-induced constipation, consider methylnaltrexone SC as it may be more effective than repeating macrogols; can only be prescribed on advice from the palliative care team	*MANAGEMENT OF CONSTIPATION IN HOSPITALISED ELDERLY PATIENTS*	*254*	9				bullet points
250	Brief non-specific symptoms/signs (e.g. nausea, and diaphoresis) and brief myoclonic jerking are common in syncope Syncope may present as true seizure, owing to cerebral hypoperfusion	*TRANSIENT LOSS OF CONSCIOUSNESS (BLACKOUT/SYNCOPE)*	*258*	9				Should be bullet poit under definition heading
251	Pain relief should be by the mouth (oral), by the clock (regular) and by the ladder	*PAIN CONTROL IN PALLIATIVE CARE*	*261*	2	*Less than ideal therapy*	*3*	*2*	
252	If considering alternative opioid preparations, seek advice from hospital palliative care team via call centre 7 days a week 0900–1700 or from Douglas Macmillan Hospice out-of- hours (01782 344300)	*PAIN CONTROL IN PALLIATIVE CARE*	*263*	3	*Less than ideal therapy*	*3*	*3*	

253	Opioids via continuous subcutaneous infusion will not provide better analgesia than oral route unless there is a problem with absorption or administration	*PAIN CONTROL IN PALLIATIVE CARE*	*263*	2	*Over zealous treatment*	*3*	*3*	
254	Always add up total of the regular and breakthrough dose of morphine over a 24 hr period – see Example 2	*CONTINUOUS SUBCUTANEOUS INFUSIONS (CSCI) IN PALLIATIVE CARE*	*264*	5	*Less than ideal therapy*	*1*	*3*	
255	Do not use this guideline in patients presenting with acute bleeding	*CHRONIC ANAEMIA*	*270*	4	*Miss major emergency-acute bleeding*	*1*	*1*	
256	Patients with severe anaemia may have no symptoms because of their compensatory mechanisms. They may just appear pale	*CHRONIC ANAEMIA*	*270*	9				bullet point
257	Patients admitted with chronic anaemia have often had blood tests requested via their GP. Check with laboratory as diagnosis may have been made already	*CHRONIC ANAEMIA*	*270*	9				FIRST BULLET POINT UNDER investigationshe ading
258	BEWARE a second acute cause of anaemia on a background of chronic anaemia can cause rapid fall in Hb in someone with little reserve and can confuse the clinical picture	*CHRONIC ANAEMIA*	*271*	4	*Miss major emergency-acute bleeding*	*1*	*1*	
259	Urgent transfusion is not required unless there is active bleeding EXCESSIVE OR RAPID TRANSFUSION CAN BE HARMFUL	*CHRONIC ANAEMIA*	*271*	2				Could be amalgamated with 258:. Whole immediate treatment could be rewritten, When confirmed no evidence of of GI bleeding… no immediate treatment required

260	Ensure haematinic assays have been taken and received by the laboratory before commencing therapy	*CHRONIC ANAEMIA*	*271*	5	*Inabilty to diagnose cause of anaemia after treatment starts*	*3*	*3*	
261	If macrocytic anaemia, discuss with consultant in charge before any transfusion	*CHRONIC ANAEMIA*	*272*	9				This should be bullet point under If symptomatic, comsider blood tranfusion-see Flow chart in SUBSEQUENT TREATMENT
262	Presence of sickle cells in blood film does not correlate with clinical events	*MANAGEMENT OF SICKLE CELL DISEASE*	*274*	9				Should this not be bullet point Blood film. With sub bulllet point: Presence of sickle cells in blood film does not correlate with clinical events
263	Do not use pethidine for treating pain in an acute painful sickle cell episode	*MANAGEMENT OF SICKLE CELL DISEASE*	*275*	2	*Pethidine causes epileptic seizure*			
264	Always use commercially produced pre-mixed bags of infusion fluid and potassium chloride. NEVER add potassium chloride to infusion bags	*MANAGEMENT OF SICKLE CELL DISEASE*	*276*	2	*death*	*2*	*1*	
265	Avoid using veins in ankles/feet for venous access; cannulation carries high risk of leg ulceration. Avoid central lines as they carry high complication rate	*MANAGEMENT OF SICKLE CELL DISEASE*	*276*	2	*hign risk of leg ulcers*			
266	Discuss patients with suspected acute chest syndrome urgently with consultant haematologist	*MANAGEMENT OF SICKLE CELL DISEASE*	*277*	3 and 1	*Emergency not correctly treatedby non-specialist*			All sickle cell crisis have to referred to haematologist see first paragraph,so this is reinforcement

267	Do not initiate exchange transfusion before discussing with on-call consultant haematologist	*MANAGEMENT OF SICKLE CELL DISEASE*	*279*	3 and !	*Emergency not correctly treatedby non-specialist*			All sickle cell crisis have to referred to haematologist see first paragraph,so this is reinforcement
268	All patients known to have an inherited bleeding disorder possess a medical card identifying their condition and severity. Contact haematology medical staff for advice immediately regarding management even if no treatment deemed necessary. Unless major trauma or head injury, advise patient to attend emergency admissions bay on ward 201. To confirm nature of inherited bleeding disorder diagnosis, severity and treatment, contact main blood bank where information file is stored	*BLEEDING DISORDERS IN ADULTS*	*280*	3	*Emergency not correctly treatedby non-specialist*			This is another guideline where treatment should be guided by the specialist. This box should be in top level withdefinition and presentationt in top level with rest. Second level is reached through referral statement saying to be instituted on advice of specialist
269	Desmopressin is available in 15 microgram/mL vials for SC administration or 4 microgram/mL vials for IV. Care must be taken to ensure correct vial used at administration	*BLEEDING DISORDERS IN ADULTS*	*281*	2	*incorrect dose*			
270	Desmopressin has no role in treating Haemophilia B	*BLEEDING DISORDERS IN ADULTS*	*281*	2	*wrong treatment*			
271	Always wear gloves	*BLEEDING DISORDERS IN ADULTS*	*282*	2	*Infection in infusions*			

272	For further information refer to Trust Policy C03. For advice contact numbers are listed below	*HOW TO ADMINISTER BLOOD AND BLOOD COMPONENTS TO ADULTS*	*288*	9 as informatiom				
273	Jehovah's witnesses: Transfusion without consent is a gross physical violation. Discuss consequences of not transfusing. Record discussion in medical notes signed by patient and doctor. For further advice, contact Jehovah's witness liaison officer (313014) or patient visitation co-ordinator on (620903) 'No blood' logo wristbands are available from specimen reception or blood bank	*HOW TO ADMINISTER BLOOD AND BLOOD COMPONENTS TO ADULTS*	*288*	2				Should this not bein opening paragraph or assessment as first subsection
274	Take blood from only one patient at a time. Do not pre-label sample tubes	*HOW TO ADMINISTER BLOOD AND BLOOD COMPONENTS TO ADULTS*	*289*	5	*muddle of tubes leading to mis transfusion*			
275	When labelling sample tubes, REFER ONLY to patient's ID wristband DO NOT USE patient's medical record or any other reference source for this information	*HOW TO ADMINISTER BLOOD AND BLOOD COMPONENTS TO ADULTS*	*289*	5	*muddle of tubes leading to mis transfusion*			
276	When identifying unconscious patients, be especially careful to use both notes and wristband	*HOW TO ADMINISTER BLOOD AND BLOOD COMPONENTS TO ADULTS*	*289*	5	*muddle of tubes leading to mis transfusion*			
277	Never store blood/blood products in a non-designated refrigerator	*HOW TO ADMINISTER BLOOD AND BLOOD COMPONENTS TO ADULTS*	*290*	5	*Loss of transfusin and at inappropriate temeratures*			

278	If no name is available, use patient's temporary number and gender as a unique identifier. Remember that consecutive patients admitted through A&E or SAU may have temporary numbers that differ by only one digit	*HOW TO ADMINISTER BLOOD AND BLOOD COMPONENTS TO ADULTS*	*290*	5	*muddle of tubes leading to mis transfusion*			
279	Transfuse units as soon as possible Transfusion of red cells must start within 30 min of removal from refrigerator and be completed within a maximum of 4 hr from leaving controlled storage	*HOW TO ADMINISTER BLOOD AND BLOOD COMPONENTS TO ADULTS*	*290*	1	*Less effective transfusion*			
280	Administer all blood components using a blood component administration set that incorporates a 170–200 micron filter	*HOW TO ADMINISTER BLOOD AND BLOOD COMPONENTS TO ADULTS*	*291*	5	*More likelihood of reaction*			
281	Patient exhibiting possible features of an acute transfusion reaction, which may include: Fever, chills, rigors, tachycardia, hyper- or hypotension, collapse, flushing, urticaria, pain (bone, muscle, chest, abdominal), respiratory distress, nausea, general malaise	*ADVERSE REACTIONS TO BLOOD AND BLOOD PRODUCTS*	*292*	9				bullets
282	Discuss need for cryoprecipitate with haematologist before ordering	*CRYOPRECIPITATE*	*296*	3	*Less than ideal therapy*			this guidel;ine is specilalist specific. Suggest lower tier of guideline for this specialist advice
283	Discuss need for FFP with haematologist before ordering	*FRESH FROZEN PLASMA (FFP)*	*297*	3	*Less than ideal therapy*			this guidel;ine is specilalist specific. Suggest lower tier of guideline for this specialist advice

284	Solvent Detergent FFP (SDFFP) or Methylene Blue Treated FFP (MBFFP) should be given to those born after 1st January 1996 (use within 4–8 hr – see Storage of blood/blood components guideline)	*FRESH FROZEN PLASMA (FFP)*	*297*	5	*inppropriate for age group*			this guidel;ine is specilalist specific. Suggest lower tier of guideline for this specialist advice
285	Administer all blood components using a blood component administration set that incorporates a 170–200 micron filter	*STORAGE OF BLOOD AND BLOOD COMPONENTS*	*301*	5	*More likelihood of reaction*			
286	Blood components and dosages are for guidance and are taken from the Handbook of Transfusion Medicine [Norfolk (5th ed) 2014] unless otherwise stated	*STORAGE OF BLOOD AND BLOOD COMPONENTS*	*301*	?				Odd guideline is it in orrect guidelines
287	Above weights should be used to calculate both maintenance and loading dose (if appropriate)	*AMINOPHYLLINE*	*304*	5	*Too high a dose in obese patient or too little in emaciated*	*2*	*3*	
288	Give loading dose only if patient has NOT received any theophylline or aminophylline within last 24 hr	*AMINOPHYLLINE*	*304*	2	*too high dose given*	*2*	*3*	
289	There are several medications that may increase or decrease theophylline concentration. Always check current BNF Appendix 1 for full list of interactions	*AMINOPHYLLINE*	*305*	2	*too much or too little aminophylline goven*	*2*	*3*	
290	This guideline is only for use in patients with venous thromboembolism Guidance on use in other clinical problems is contained in appropriate guidelines e.g. unstable angina	*DALTEPARIN FOR VTE*	*306*	4	*inappropriate doses given*			

291	ALWAYS weigh patient – do NOT guess the body weight or rely on patient's own estimate	*DALTEPARIN FOR VTE*	*306*	5	*inappropriate doses given*			
292	Risk of bleeding is increased in patients with severe liver or renal failure (eGFR <20), thrombocytopenia or defective platelet function, and following surgery, trauma or haemorrhagic stroke. Adjust dalteparin dose accordingly with advice from appropriate team e.g. renal (see Table 4), liver or haematology	*DALTEPARIN FOR VTE*	*306*	3	*inappropriate doses given. Risk of bleeding*			
293	Administer dobutamine through a central line, if available. Dobutamine should only be given peripherally on the advice of a consultant; use a large vein high up in a limb, preferably the arm, in order to reduce risk of tissue necrosis and administer the 2 mg/mL solution only	*DOBUTAMINE HYDROCHLORIDE*	*310*	5	*Tissue necrosis*			
294	Seek advice from cardiology team before commencing dobutamine	*DOBUTAMINE HYDROCHLORIDE*	*310*	3	*Less than ideal therapy*			this guidel;ine is specilalist specific. Suggest lower tier of guideline
295	Dopamine must only be used in critical care and in the coronary care unit and administered preferably via a central line Dopamine should only be given peripherally on the advice of a consultant; use a large vein high up in a limb, preferably the arm, in order to reduce risk of tissue necrosis and administer the 2 mg/mL solution only	*DOPAMINE HYDROCHLORIDE*	*312*	3 for first para	*Less than ideal therapy*			Second para is 5 as 293

296	Dopamine given at rates >5 microgram/kg/min causes vasoconstriction, which can reduce renal perfusion and worsen heart failure	*DOPAMINE HYDROCHLORIDE*	*312*	2	*Side-effects*			
297	The 2 mg/mL solution is preferable where dopamine is being infused via a peripheral vein. Reserve 4 mg/mL solution for infusion via a central line	*DOPAMINE HYDROCHLORIDE*	*312*	5	*Tissue necrosis*			
298	Withdraw dopamine gradually, monitoring for hypotension	*DOPAMINE HYDROCHLORIDE*	*313*	2	*Hypotension*			Could be section Withdrawal
299	Do not prescribe gentamicin treatment for >3 days unless advised in a guideline or by consultant in infectious diseases or consultant microbiologist. In all patients being treated with gentamicin, measure serum creatinine daily and serum gentamicin where recommended. As gentamicin has a narrow therapeutic index, accurate dosing is essential to prevent toxicity Note – deafness and balance problems may occur at therapeutic levels. If they occur, stop gentamicin	*GENTAMICIN*	*314*	Too many points				Write as introductory paragraph
300	DO NOT use this protocol for patients in the following categories: · Ascites · Pregnant women · Endocarditis · Cystic fibrosis (CF) · Major burns · Creatinine clearance (CrCl) <20 mL/min In these situations, unless a specific protocol exists, use gentamicin nomogram for	*GENTAMICIN*	*314*	4	*Less than ideal therapy*			

	multiple daily dose regimens (see Multiple daily dosing) to select an initial dosage and regimen, then adjust on the basis of serum gentamicin concentration (see Monitoring multiple daily dose regimens)							
301	If patient emaciated and unfit to be weighed do not use IBW. Estimate weight (this estimate will be lower than ideal body weight in emaciated patients)	*GENTAMICIN*	*314*	5	*underestimate dose*			
302	After measuring gentamicin concentration, do not give more than one dose to any patient without knowing the assay result	*GENTAMICIN*	*316*	2	*overdose with sideeffects or underdose with reduced anti-microbial action*			
303	Do not send pre-dose (to measure trough concentration) or 1 hr post-dose (to measure peak concentration) sample unless treatment is following multiple daily dose regimen	*GENTAMICIN*	*316*	4	*inappropriate doses given*			
304	This nomogram is NOT to be used for children or patients with cystic fibrosis (CF)	*GENTAMICIN*	*317*	4	*inappropriate doses given*			
305	Use this guideline for drug dose calculations. Do not use as a dietary advice guideline	*IDEAL BODY WEIGHT*	*320*	4	*not to give diet*	*3*	*3*	
306	Before prescribing, check indication for use of IV unfractionated heparin in relevant guideline. Is this correct regime? E.g. use for post thromboembolism but not following post MI	*IV UNFRACTIONATED HEPARIN*	*321*	4 for first para. 3 for second				Two warnings in one box

	thrombolysis In the event of overdose or incorrect administration, contact on-call haematology consultant, who will advise whether patient requires urgent reversal of anticoagulant effect							
307	If starting a pregnant woman on IV unfractionated heparin, discuss with consultant haematologist to arrange anti-Xa monitoring	*IV UNFRACTIONATED HEPARIN*	*321*	3				
308	Use the separate pre-printed supplementary prescription chart (NSH8051) to prescribe IV infusion of unfractionated heparin. Ensure that use of the supplementary chart is documented on the front of the main adult inpatient prescription chart, drug infusion section 'Heparin infusion'	*IV UNFRACTIONATED HEPARIN*	*321*	9				How do we findsuch a chart?
309	Do you need loading dose? Check indication for use of IV unfractionated heparin in relevant guideline	*IV UNFRACTIONATED HEPARIN*	*321*	4	*Give too much heparin with risk of bleed*	*3*	*3*	
310	IV unfractionated heparin is supplied in various concentrations. Check concentration carefully to avoid risk of overdose and death due to over anticoagulation. IV heparin therapy without strict monitoring as stated below carries high risk of bleeding. Warn all staff members involved when patient on IV heparin infusion	*IV UNFRACTIONATED HEPARIN*	*321*	2	*Give too much heparin with risk of bleed*	*2*	*2*	

311	Patients with COPD and other risk factors for hypercapnia who develop critical illness should have the same initial target oxygen saturation as other critically ill patients pending blood gas results, after which these patients may need controlled oxygen therapy or supported ventilation if there is severe hypoxia and/or hypercapnia. See Flowchart	*OXYGEN THERAPY IN ACUTELY HYPOXAEMIC PATIENTS*	*324*	1	*Inadequate oxygenation for circumstances*	*3*	*3*	
312	Do not restrict oxygen therapy below minimum target saturations of 88% in patients retaining C02 Patients with obstruction or pseudo-obstruction of bowel and reduced conscious level may not be suitable for non-invasive positive pressure ventilation (NIPPV)	*OXYGEN THERAPY IN ACUTELY HYPOXAEMIC PATIENTS*	*325*	9				two warnings second in wrong place in guideline or even in wrong guideline: the ..NIPPV statement First statement is in guideline flowchart not needed here
313	Critically ill patients and those in peri-arrest situation – give maximal oxygen therapy via reservoir mask or bag-valve-mask whilst awaiting arrival of medical help. Patients with COPD and other risk factors for hypercapnia who develop critical illness should have the same initial target saturations as other critically ill patients pending the results of blood gas measurements, after which these patients may need controlled oxygen therapy or supported ventilation if there is severe hypoxaemia and/or hypercapnia with respiratory acidosis	*OXYGEN THERAPY IN ACUTELY HYPOXAEMIC PATIENTS*	*327*	9				Do we need whole flowchart on page 4.It muddles clear message of rest of guideline , evenif I put it in initially
314	Use the following nomogram only if serum phenytoin is reported in units of mg/L	*PHENYTOIN – ADJUSTMENT OF ORAL DOSAGE*	*328*	2	*Wrong dose of phenytoin*			

315	If phenytoin is given too rapidly, hypotension, cardiac arrhythmias, impaired cardiac conduction, CNS depression or respiratory arrest can occur. Monitor all patients with continuous ECG and BP throughout the infusion	*INTRAVENOUS PHENYTOIN(LOADING DOSAGE IN STATUS EPILEPTICUS)*	*329*	2	*Give it too fast with consequences*			this warning box needs to come below table 1Should it mention follow rates given in text
316	This is a slow bolus for immediate treatment – see Acute severe asthma in adults guideline – Patients with life-threatening features. Do not use injection in absence of life-threatening features	*SALBUTAMOL IV*	*331*	9	*side-effects when not bolus not needed*			Is this needed as warning box. It is indication. Best to put in INDICATIONS Bronchospasm If life threatening features, use bolus If not lifetreatening features, use IV infusion
317	Use this regimen for patients with non-life-threatening features. Note that the concentration is different from the IV bolus injection guidance above	*SALBUTAMOL IV*	*331*	9				Is this needed as warning box. It is indication. Best to put in INDICATIONS Bronchospasm If life threatening features, use bolus If not lifetreatening features, use IV infusion
318	Sodium nitroprusside is a very potent agent and should only be used on the advice of a renal SpR or consultant and only on wards (e.g. Critical Care Unit) where continuous monitoring of BP (preferably via arterial line) is possible	*SODIUM NITROPRUSSIDE*	*332*	3	*Used on general wards without monitoring*	*3*	*3*	
319	Note that half-lives of anticonvulsants can vary in patients taking >1 anticonvulsant	*THERAPEUTIC DRUG MONITORING*	*335*	9				Better as bullet point
320	Unless these data are recorded, correct interpretation of assay result may not be possible	*THERAPEUTIC DRUG MONITORING*	*335*	2	*Unable to interpret result*	*2*	*3*	

321	For further advice on therapeutic drug monitoring, or assistance when selecting a dose adjustment, contact your ward's clinical pharmacist or medicines information. Ensure you have details of the dose regimen, sample time and assay result to hand, together with patient's clinical details and other drug treatment. For advice on optimal use of antimicrobial agents, contact a microbiologist	*THERAPEUTIC DRUG MONITORING*	*335*	9 as informatiom				
322	Do not use this guideline if CrCl <10 mL/min or patient on haemodialysis/peritoneal dialysis – seek advice from renal SpR or consultant	*VANCOMYCIN*	*337*	2 and 3	*Danger of side-effect*	*2*	*2*	
323	Give first maintenance dose 12, 24 or 48 hr after start of loading dose according to dose interval in Table 2	*VANCOMYCIN*	*337*	9				Part of how to do it
324	Target trough concentration: 10–15 mg/L In some serious infections the target trough concentration may be up to 20 mg/L but this is on advice only from microbiology or infectious diseases consultant	*VANCOMYCIN*	*338*	9				Very important part of how to do it. Needs to stand out but not as warning box. Will this all be overtaken by drug calculators?
325	For further advice, contact ward pharmacist, antimicrobial pharmacist (via call centre or bleep), or Medicines information. Out-of-hours contact on-call pharmacist or microbiologist via call centre	*VANCOMYCIN*	*338*	9 as informatiom				
326	Decision to anticoagulate orally, including duration and intensity of treatment, must be made by senior clinician responsible for patient. Refer inpatients to anticoagulation management service	*WARFARIN INITIATION*	*339*	9 -Intoductory paragraph				

	(AMS), following the referral process below. If patient not referred to AMS, follow this guideline							
327	Have you checked if patient is sensitive to warfarin? See BEFORE STARTING TREATMENT above. If patient has increased sensitivity to warfarin, use half the doses recommended below	*WARFARIN INITIATION*	*339*	2	*Overdose of warfarin leading to bleeding*	*3*	*3*	
328	Have you checked if patient is sensitive to warfarin? See BEFORE STARTING TREATMENT above. If patient has increased sensitivity to warfarin specifically use the OATES regimen	*WARFARIN INITIATION*	*341*	2	*Overdose of warfarin leading to bleeding*	*3*	*3*	
329	In patients with prosthetic heart valves, reversal of anticoagulation can increase risk of valve thrombosis. Discuss management with cardiothoracic unit and haematologist before considering full reversal	*OVERANTICOAGULATION WITH WARFARIN*	*343*	2 and 3	*Clot off prosthetic heart valve*	*2*	*2*	Change wording to active: Check if patient has prosthetic heart valve……
330	You must be supervised by a doctor experienced in this procedure until you are familiar with it, and competent to perform it independently	*ARTERIAL PUNCTURE*	*346*	6	*cause harm to patient when undertaking procedures*	*3*	*2*	This needs to come up whenever a practical procedure is accessed
331	Always aspirate before injection of local anaesthetic to prevent injection of lidocaine into the artery	*ARTERIAL PUNCTURE*	*345*	2	*Lidocaine into vein causing???*			

332	If shooting pain felt, nerve may have been entered. Remove needle and redirect	*ARTERIAL PUNCTURE*	*345*	9				This statement and 2 bullet points below it, should be in separate section **potential difficulties** need a better title
333	This guideline applies only to drug infusions where inadvertent administration of the drug infusion or the fluid infusion at an unintended rate would not be clinically unsafe. If that would be dangerous (e.g. insulin) use the Administration of IV insulin infusions and fluid infusions guideline instead	*CO-ADMINISTRATION OF DRUG INFUSIONS AND INTRAVENOUS FLUIDS VIA SINGLE CANNULA*	*348*	4	*Over and underdosing*			I find this a difficult guideline to follow as so many ifs and buts. For example, "Ideally, run IV fluids via a volumetric pump. Occasionally, if pump unavailable, it is safe to use a gravity set with anti-reflux valve" Define occasionally
334	Maintenance/keep-vein-open fluid delivered by volumetric pump (B Braun). Connect the administration set to a two-way needle-free extension set	*CO-ADMINISTRATION OF DRUG INFUSIONS AND INTRAVENOUS FLUIDS VIA SINGLE CANNULA*	*348*	9				I find this a difficult guideline to follow as so many ifs and buts. Why is this statement more important than bullet points above.
335	Do not use a gravity set for administration of IV fluids where administration rate is critical (e.g. glucose administered alongside insulin) use a volumetric pump as in Figure 1, see separate insulin guideline	*CO-ADMINISTRATION OF DRUG INFUSIONS AND INTRAVENOUS FLUIDS VIA SINGLE CANNULA*	*349*					This s again a difficult statement to follow
336	Blood culture specimens are essential in managing patients with serious infection. Collect blood culture specimens before starting antimicrobial drugs. Procedure to be carried out only by trained and assessed healthcare professionals	*COLLECTION OF BLOOD CULTURE SPECIMENS*	*350*	9 - Introductory paragraph				Third sentence is same as 346, coming up whenever a practical procedure is done.
337	If available, use vacuum-assisted blood collection system as it reduces risk of needle- stick injury	*COLLECTION OF BLOOD CULTURE SPECIMENS*	*350*	9				A bulletp oint

338	Contamination with skin organisms is a significant problem when drawing blood for blood cultures. The following procedure will minimise the chance of skin contamination entering bottles with the blood	*COLLECTION OF BLOOD CULTURE SPECIMENS*	*351*	9 -Intoductory paragraph				Bullet point" Use fllowing procedure to minimise chance of skin contamintion" Should bein introductory paragraph
339	Use cannula (e.g. arterial line, central line) samples for blood culture ONLY when no other option or for evaluation of line sepsis	*COLLECTION OF BLOOD CULTURE SPECIMENS*	*351*	2	*More likely contamination*			
340	Do not palpate the vein again after skin cleansing	*COLLECTION OF BLOOD CULTURE SPECIMENS*	*351*	2	*More likely contamination*			I know the temptation
341	It is essential to fill blood culture bottles first before collecting blood samples for any other tests (e.g. FBC). This reduces risk of contamination from non-sterile containers	*COLLECTION OF BLOOD CULTURE SPECIMENS*	*352*	2	*More likely contamination*			
342	Do not stick any labels over remaining bar codes on blood culture bottles	*COLLECTION OF BLOOD CULTURE SPECIMENS*	*352*	2	*Mis identification of patient*			
343	Ensure aseptic technique used – follow Trust standard operating procedures for infection control	*FLUSHING INTRAVENOUS LINES*	*353*	9 -Intoductory paragraph				
344	Ensure correct procedure for flushing used – follow Royal Marsden Manual of Clinical Nursing Procedures – Vascular access devices: insertion and management or local Trust policy and procedures	*FLUSHING INTRAVENOUS LINES*	*353*	Too many points in one risk warning box				If it says follow Royal Marsden, why is there a guideline? Is this a nursing guideline?

345	Heparin is a potentially dangerous drug. Higher strengths given inadvertently can lead to full anticoagulation. Ensure that correct strength of heparin is prescribed and administered. Do not use heparin in any strength as a flush without a valid prescription. Do not use if any history of adverse reaction, e.g. heparin induced thrombocytopenia (HIT)	*FLUSHING INTRAVENOUS LINES*	*353*	9				These are a list of worries Any drug must be prescribed. This might be a section called Preparation before giving a list of Flushing solutions
346	Volume of heparin flushing solution used must be 0.5 mL greater than the volume of the catheter and any other equipment attached to it (e.g. one-way tap, short extension). Draw up 0.5 mL more heparin solution than is required. This ensures flushing completed on the downstroke of syringe plunger. If plunger allowed to reach the end the of the barrel it can 'bounce back' and draw blood into catheter tip	*FLUSHING INTRAVENOUS LINES*	*353*	9				Section how to draw up
347	All pleural procedures should be performed under ultrasound guidance by a trained operator or under the supervision of a fully competent individual	*INTERCOSTAL TUBE DRAINAGE*	*355*	6	*cause harm to patient when undertaking procedures*	*3*	*2*	This needs to come up whenever a practical procedure is accessed
348	Penicillin allergy should only be accepted as genuine hypersensitivity if convincing history of either rash within 72 hr of dose or anaphylactic reaction. True penicillin allergy is rare and, in many infections, alternative antimicrobials are less effective with greater risks attached. If a patient reports penicillin allergy, it is imperative to establish, as far as possible, the nature of the reported allergy. In patients able to provide a history, the	*INTERCOSTAL TUBE DRAINAGE*	*355*	2	*Less than ideal anti-microbial therapy*	*2*	*3*	

	nature of the penicillin allergy must be recorded on admission. If any doubt about whether patient truly allergic to penicillin, seek advice from a microbiologist or consultant in infectious diseases							
349	Knowledge of knee anatomy is essential	*KNEE ASPIRATION*	*357*	9				This should be replaced by the trained operator warning
350	DO NOT ATTEMPT INSERTION UNLESS YOU ARE FULLY TRAINED Use whichever line you have been trained to use	*LONG LINE INSERTION*	*359*	6	*cause harm to patient when undertaking procedures*	*3*	*2*	This needs to come up whenever a practical procedure is accessed
351	Use an aseptic technique when accessing the system or for dressing changes	*LONG LINE INSERTION*	*361*	6				This is a important statement applying to any guideline
352	If taking CSF samples for both diagnostic microbiology and suspected SAH, take samples for microbiology first	*LUMBAR PUNCTURE*	*364*	2	*More likely to miss bugs in sample drawn second*			
353	When taking samples of CSF for suspected SAH, also obtain a blood sample 5–7 mL in serum separator tube (gold top) for determination of total protein and bilirubin concentrations – send to clinical biochemistry	*LUMBAR PUNCTURE*	*364*	9				"For diagnosis of SAH, take CSF and blood samples" as top bullet in section. Add what you sample as blood below

354	If no intercostal tube in situ, insert one. Use small (12–14 FG) tube – see Intercostal tube drainage guideline	*MEDICAL PLEURODESIS*	*365*	9 -Intoductory paragraph				
355	Presence of continuing air leak is not a contraindication to pleurodesis provided lung has expanded	*MEDICAL PLEURODESIS*	*365*	5	*Stop useful procedure being carried out*	*3*	*3*	
356	Pyrexia up to 38°C can occur for 48 hr, and does not necessarily imply infection	*MEDICAL PLEURODESIS*	*366*	9				This is difficult as do not wish unnecessary antimicrobial treatment. Suggest bullet "If pyrexia up to 38oC in first 48 hors, look for othersigns of ifvtion, but it may be due to pleurodesis
357	Also refer to Trust intranet>Clinicians>Medical and nursing>Nursing essentials>Nasogastric tubes	*NASOGASTRIC TUBE (NGT) INSERTION*	*367*	9				Supporting Informatin
358	Never reintroduce a guide wire back into a nasogastric tube once it has been removed	*NASOGASTRIC TUBE (NGT) INSERTION*	*368*	2	*Crack the nasogastric tube?*			
359	If patient has recently undergone facial, airway or upper gastrointestinal surgery, do not remove NGT but discuss with operating surgeon	*NASOGASTRIC TUBE (NGT) INSERTION*	*368*	3	*Junior doctor takes inappropriate decision*			

360	Central venous cannulation can cause serious morbidity and must only be performed by those who have appropriate training and experience in the technique or who are appropriately supervised. Failure to use full sterile technique can lead to life-threatening infection. When inserting CVC into internal jugular vein in an elective situation, use 2-dimensional (2D) imaging ultrasound guidance. Consider dynamic (realtime) 2D ultrasound for subclavian vein CVC insertion as it has been shown to result in fewer complications and a higher success rate than landmark techniques. 2D imaging ultrasound should be available in areas where central line cannulation is carried out on a regular basis. Equipment and assistance to place line under 2D imaging ultrasound guidance is present in theatres and Critical Care for those trained in its use	*PERCUTANEOUS CENTRAL VENOUS CANNULATION*	*369*	6 and 9				This is a important statement applying to any guideline about trained operator. But rest needs untangling andplacing as introductory paragraph or sectionentitled where
361	Perform procedure using full sterile technique, considering the environment in which line is placed, placement in critical care or theatres may facilitate sterile technique	*PERCUTANEOUS CENTRAL VENOUS CANNULATION*	*369*	9				To go in 360
362	If patient has chlorhexidine allergy, do not use chlorhexidine impregnated cannula	*PERCUTANEOUS CENTRAL VENOUS CANNULATION*	*369*	9				should read Ask patient chlorhexidine allergy , best put in section on cosent when talking to patient. Move consent to above equipment. Replace present consent with confirm consent

363	Whichever vein used, avoid air embolism by maintaining venous pressure above atmospheric by correct position or tourniquet on limb	*PERCUTANEOUS CENTRAL VENOUS CANNULATION*	*371*	2	*Stop air entering circulation with potential of causing*			
364	Catheter passage through cephalic vein may be impeded by fascia deep to axillary vein	*PERCUTANEOUS CENTRAL VENOUS CANNULATION*	*371*	9				This is bullet point in new section of Potential Problems under Ante-cubital fossa
365	In 50% of patients, catheter cannot be threaded into an intrathoracic vein. If so, try finger pressure above clavicle, depressing shoulder, or flushing catheter. Use of Seldinger or a spiral J-shaped wire may help. DO NOT use excessive force	*PERCUTANEOUS CENTRAL VENOUS CANNULATION*	*371*	9				This is bullet point in new section of Potential Problems under External Jugular vein
366	All practitioners involved in placement of CVCs into internal jugular vein must be trained in using 2-D imaging ultrasound	*PERCUTANEOUS CENTRAL VENOUS CANNULATION*	*371*	6	*cause harm to patient when undertaking procedures*	*3*	*2*	This is same as must be trained practitioner needs to come up whenever a practical procedure is accessed
367	Operators of limited experience can try cannulation with small (21 G) needle to locate vein first and then use small needle as guide. If artery is punctured, compress firmly for ≥ 5 min	*PERCUTANEOUS CENTRAL VENOUS CANNULATION*	*371*	9				grey bullet point under Insert canula
368	Strict asepsis at all times to avoid infection	*PERCUTANEOUS CENTRAL VENOUS CANNULATION*	*372*	6				This is a important statement applying to any guideline

369	All pleural procedures should be performed under ultrasound guidance by a trained operator or under the supervision of a fully competent individual	*PLEURAL ASPIRATION OF FLUID*	*374*	6	*cause harm to patient when undertaking procedures*	*3*	*2*	This is same as must be trained practitioner needs to come up whenever a practical procedure is accessed
370	Avoid site where pyoderma or Herpes zoster present	*PLEURAL ASPIRATION OF FLUID*	*374*	2	*spread infection*	*3*	*3*	
371	Avoid inferior border of upper rib	*PLEURAL ASPIRATION OF FLUID*	*374*	2	*Damage to intercostal nerve*	*3*	*3*	
372	Do not aspirate more than 1 L of fluid at one time to avoid re-expansion pulmonary oedema	*PLEURAL ASPIRATION OF FLUID*	*375*	2	*Sob patient*	*3*	*3*	
373	Insertion of a Sengstaken-Blakemore (S-B) tube can cause serious morbidity Not to be performed by inexperienced operators	*SENGSTAKEN-BLAKEMORE TUBE INSERTION*	*376*	6	*cause harm to patient when undertaking procedures*	*3*	*2*	This is same as must be trained practitioner needs to come up whenever a practical procedure is accessed
374	Caution: If malignant ascites suspected, discuss with relevant on-call specialist to determine risk of potential local seeding	*TAPPING ASCITES AND PARACENTESIS*	*379*	3	*spread cancer*			
375	If patient has previously undergone a radical prostatectomy, he must be catheterised by a urologist as urethral damage can easily occur	*URETHRAL CATHETERISATION*	*381*	3	*junior causing worses ymptomsto patient*	*3*	*3*	

376	Use catheter appropriate to task for which it is required. NB: Female catheters exist that are shorter than standard catheters. They must not be used in men as balloon will damage urethra	*URETHRAL CATHETERISATION*	*381*	9				Delete as only saying use bullet points below
377	Patients who have had chronic retention of urine sometimes have obstructive renal failure. Catheterisation can be followed by a spectacular post-obstructive diuresis with profound metabolic consequences. Be prepared to start an IV infusion in these patients, who may not be able to drink enough to replace their fluid losses. They are best managed by urology team as inpatients	*URETHRAL CATHETERISATION*	*383*	9				Subsection on Potential problems
378	Remove catheter as soon as possible to minimise risk of infection, especially with extended spectrum beta-lactamase producing Gram-negative bacilli (ESBL)	*URETHRAL CATHETERISATION*	*383*	9				Need to divide aftercare into those with short-term and those woth long-term catheters
379	Bacteriuria associated with an indwelling catheter without clinical evidence of infection does not require antimicrobial treatment	*URETHRAL CATHETERISATION*	*383*	9				Grey bullet with boldig of not
380	Effective bladder washout for blood clots is a specialised technique. Refer to urology team	*URETHRAL CATHETERISATION*	*383*	9				Bullet: If blood clots causing blocage, refer to urology team for specialised washout