

Prifysgol Cymru
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A Medical Support System for the National Health Service's Minor Injury Unit

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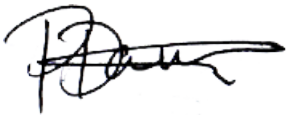
Project submitted as part of the requirements for the award of BSc(Hons) Web Development

May 2019

DECLARATION & FORM OF CONSENT

DECLARATION

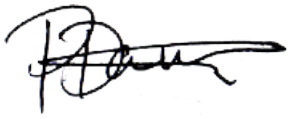
I, Peter Neil Davies declare that I am the sole author of this Project; that all references cited have been consulted; that I have conducted all work of which this is a record. This work has not previously been accepted as part of any other degree submission.

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Date: ***01/05/2019***

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ACKNOWLEDGEMENTS

This project would not have been undertaken without the love for UX instilled in me by the project supervisor Dr Nik Whitehead. Without the excellent IxD and UX modules none of this would have been possible. It is with great sadness I learnt neither module will be continuing after this year and I can only hope the university will reconsider their decision, as I consider UX as one of the most important scientific areas required by any developer.

Additionally, I would like to thank Dr Whitehead and Dr Kemi Ademoye who I am wholeheartedly indebted to, it has been a pleasure to work with two experts in their fields who have proactively sought to support me in the pursuit of my goals, not just for this project but throughout my entire academic life and professional career as a developer.

My gratitude also extends to Dr Ademoye, Mr Michael Dacey and Gaynor Thomas for passing on their excellent development knowledge, having no coding experience prior to starting university, my continued success speaks volumes about their standard of teaching and support. I also wish to show my appreciation to all UWTSD lecturers who I have had the pleasure of working with, you have helped me to succeed where I never believed I could.

I must also recognise my partner Amy, for your inspiration, love and support in helping me through the anxious moments of this project, and for your continued understanding of my late nights at the computer and the library!

Finally, I would like to thank the consultants, nurses and staff from NHS Wales. Without this wonderful institution, I would not be writing this report today. I hope this work can go some way in repaying the debt I will forever owe.

This dissertation is dedicated to my mother, Julia, who I inherit my drive to succeed from, your love, support and belief in me, whatever I did, will always be remembered, you were my ultimate role model, I know this moment would make you very proud.

ABSTRACT

Background

Paper-based clinical practice guidelines are useful memoir to aid clinicians and nurses in the MIU, however, these guidelines are cumbersome, expensive to produce, go out of date quickly, are easily misplaced, difficult to update and limit speed of access.

The proposed solution to this problem is computerisation of these guidelines to form a clinical decision support system, however, this study reveals that these systems are not adopted due to their users' poor experiences through usability. The aim is to research, develop and evaluate a CDSS for the MIU employing a user-centred approach to ensure clinicians' adherence to the pertinent guidelines.

Methods

Research was carried out into the history and current technologies of DSS and CDSS to determine the best suited system for the MIU. User experience and usability best practices were then researched and modified for use on a CDSS with the findings proposing a new framework for CDSS development.

Using these findings, a CDSS was developed using an SQL data service, a RESTful web API and HTML/CSS front-end which was exposed to rigorous user-testing and users perceived usability through system usability scales to discover whether a user-centred approach to development of CDSS could help adoption rates.

Results

The main problems discovered from research were that clinicians did not use CDSS implemented because of sub-standard usability and user experience. A graphical user interface was designed which followed known design patterns and current NHS digital guidelines. The evaluation showed that users of the system navigated and found guidelines easily and appreciated its familiar design. The system usability score value averaged 92.5 (between excellent & best imaginable).

Conclusion

A user-centred approach to CDSS design and implementation using the latest development technologies can improve the usability and user experience of such systems. To prove their adherence rates, testing is recommended under real-world conditions.

TABLE OF CONTENTS

1. Introduction 1

1.1 Aim & Objectives 2

1.1.1 Project Aim 2

1.1.2 Project Objectives 2

1.2 Report Structure 3

2. Research and Review of Literature 4

2.1 Literature Review Foreword 4

2.2 Decision Support Systems 4

2.3 Clinical Decision Support Systems 7

2.3.1 Main Groups of Clinical Decision Support Systems 9

2.3.1.1 Knowledge-Based Systems 9

2.3.1.2 Non-Knowledge-Based Systems 11

2.3.2 Application of Clinical Decision Support Systems 12

2.3.2.1 Alerts and Reminders 12

2.3.2.2 Diagnostic Assistance 12

2.3.2.3 Therapy Critique and Planning 12

2.3.2.4 Prescribing Decision Support Systems 13

2.3.2.5 Information Retrieval Systems (IRS) 13

2.3.2.6 Image Recognition and Interpretation 14

2.3.3 Usefulness of Clinical Decision Support Systems 15

2.3.4 Conclusion of Section 2.2 & 2.3 16

2.4. Guideline-Based CDSS Paradigms 18

2.4.1 Definition of Clinical Practice Guidelines 18

2.4.2 Flow-chart Paradigms and Clinical Algorithms 19

2.4.3 Creation of Clinical Algorithms and Computerising Clinical Practice Guidelines 22

2.4.4 Humans and Clinical Decision Support 24

2.4.5 Conclusion of Section 2.4 26

2.5 User Experience and Clinical Decision Support Systems 26

2.5.1 User Experience 27

2.5.2 User Experience Honeycomb and CDSS 29

2.5.3 Conclusion of Section 2.5 34

2.5.4 Discussion 35

3. Research Methodology 38

3.1 Introduction 38

3.2 Research Methodologies 38

3.2.1 Research Philosophy 39

3.2.2 Research Approach 39

3.2.3 Research Strategies 40

3.2.4 Literature Review 40
3.2.5 Case Study 40
3.2.6 Software Development 40
3.3 Conclusion 40
4. Development Methodology 42
4.1 Introduction 42
4.2 Interface Design Methodology 42
4.2.1 User Research & Personas 42
4.2.2 User Stories 43
4.2.3 Design Patterns 43
4.2.4 Paper Prototyping 44
4.2.4.1 Prototype Testing 45
4.3 Feature Driven Development 45
4.4 Software Testing 46
4.5 Usability & User Experience Testing Methodology 47
4.5.1 Usability Testing 47
4.5.2 System Usability Scales 48
4.5.3 Test Participants 49
4.2.4 Analysis of Results 51
4.5.5 Conclusion 52
4.6 Tool & Technologies 52
4.6.1 Software Used 52
4.6.2 Technologies Used 54
4.7 Conclusion 55
5. Design & Implementation 56
5.1 Introduction 56
5.2 Problem Formulation 56
5.2.1 System Requirements 56
5.2.2 MoSCow Requirements List 56
5.2.2.1 Functional Requirements 57
5.2.2.2 Non-Functional Requirements 59
5.2.3 Aim & Objectives Updated 61
5.2.3.1 Project Aim 61
5.2.3.2 Project Objectives 61
5.3 Design 61
5.3.1 Design Timebox One - Database Design 62
5.3.1.1 Formulation of Database Design One 62
i. Table & Column Descriptions 65
ii. Entity Relationship Diagram 66
iii. Testing of Database Version One 67

5.3.1.2 Formulation of Database Version Two 69
i. Table & Column Descriptions 74
ii. Entity Relationship Diagram 75
iii. Testing of Database Version Two 76
5.3.2 Audit Table, Metadata & Data Governance 76
5.3.2.1 Data Governance Policy 76
5.3.3 Design Timebox Two - Interface Design 77
5.3.3.1 User Personas for MIU 77
5.3.3.2 Initial Prototype UI Designs 83
i. Login Screen 84
ii. Home Page 87
iii. Guideline Page 90
5.3.3.3 Testing of initial Design 93
5.3.3.4 User Test Script Explained 93
5.3.3.5 Analysis of Results 93
i. Problem List 94
ii. Comments & Observations 94
iii. System Usability Scale Results 95
iv. Recommendations 95
5.3.3.6 Conclusion 96

5.4 Implementation 96

5.4.1 Develop Overall Model 96
5.4.2 Initial Feature List 99
5.4.3 Acceptance Test Design 100
5.4.4 Timebox Feature Plans 100
5.4.5 Timeboxes 100
4.4.5.1 Implementation - Timebox One 101
i. Timebox Feature Set 101
ii. Feature Design 101
iii. Feature Implementation 101
iv. Software Testing 105
v. Usability Testing 106
vi. Requirements Met 106
5.4.5.2 Implementation - Timebox Two 107
i. Timebox Feature Sets 107
ii. Feature Design 107
iii. Feature Implementation 107
iv. Software Testing 115
v. Usability Testing 116
vi. Requirements Met 119
5.4.5.3 Implementation - Timebox Three 120
i. Timebox Feature Sets 120
ii. Feature Design 120
iii. Feature Implementation 121
iv. Software Testing 129
v. Usability Testing 131

vi. Requirements Met 131
5.4.5.4 Implementation - Timebox Four 132
i. Timebox Feature Sets 132
ii. Feature Design 133
iii. Feature Implementation 133
iv. Software Testing 136
v. Usability Testing 137
vi. Requirements Met 139
5.4.5.5 Implementation - Timebox Five 139
vii. Feature Design 140
viii. Feature Implementation 140
ix. Software Testing 140
x. Usability Testing 140
xi. Requirements Met 140
5.5 Repositories 141
5.6 Conclusion 141
6. Evaluation 143
6.1 SQL Data Service 143
6.2 RESTful Web Service 144
6.3 Usable & Intuitive Interface 144
6.4 Conclusion 146
7. Conclusion & Recommendations 147
7.1 Conclusion 147
7.2 Recommendations 149
8. Reflection 150
8.1 Conclusion 152
9. References 154
10. Bibliography 179
11. Appendix 187
A. Abbreviations 187
B. Development Methodology 188
B1. User Persona Examples 188
B2. Design Patterns 190
B3. Feature Driven Development Processes 191
B3.1 FDD Stage One 191
i. Develop Overall Model 191
ii. Build Feature List 193

iii. Plan by Feature 195
B3.2 FDD Stage Two 196
iv. Design by Feature 196
v. Build by Feature 197
B4 Software Testing 200
B4.1 Introduction 200
B4.2 V-Model Software Testing 201
i. Requirements Analysis & Acceptance Tests 201
ii. Architectural Design & System Tests 202
iii. Subsystem Design & Integration Tests 202
iv. Detailed Design & Module Tests 202
v. Implementation & Unit Tests 202
B5. Usability Testing Methodology 203
B5.1 Test Task List 203
B5.2 Testing Script Description 204
B5.3 User Testing Script 204
B5.4 User Test Script Explained 214
B5.5 System Usability Scale Questionnaire 217
B5.6 Students Union Correspondence 218
B5.7 Usability Test Consent Form 219

C. Design 220
C1. Excel Testing of Database Design One 220
C2. Excel Testing of Database Design Two 229
C3 Data Governance Policy 238
C4. Remaining Paper Prototype Designs 240
C5. Prototype Testing Usability Test Script & Results 249
C5.1 Test Participant One Script 249
C5.2 Test Participant One Results 256
C5.3 Test Participant Two Script 258
C5.4 Test Participant Two Results 265
C5.5 Test Participant Three Script 267
C5.6 Test Participant Three Results 274

D. Implementation 276
D1. Timebox One Questions & Answers 276
D1.2 Questions 276
D1.2 Answers 277
D2. Acceptance Test Design 278
D3. Timebox Two Acceptance Test Results 279
D4. Timebox Two Usability Test Script 281
D5. Timebox Two Usability Test Script & Results 286
D5.1 Test Participant One Script 286
D5.2 Test Participant One Results 291
D5.3 Test Participant Two Script 294
D5.4 Test Participant Two Results 300
D5.5 Test Participant Three Script 302
D5.6 Test Participant Three Results 308

D6. Timebox Three Acceptance Tests 310
D7. Timebox Four Acceptance Tests 311
D8. Cognitive Walkthrough Results 313
D8.1 Task One 313
D8.2 Task Two 316

TABLE OF FIGURES

Figure 1 - Types of Decision Support System 5
Figure 2 - General Model of Knowledge Based Clinical Support System 10
Figure 3 - Backward Chaining Rule-based System 11
Figure 4 - Ontology Based Information Retrieval 14
Figure 5 - Example of Warner's Clinical Flow Chart 20
Figure 6 - Interactive Dialogue Guided by Clinical Algorithm (Flow-Chart) 21
Figure 7 - Example of XML Mark-up for GEM CIG 23
Figure 8 – Shiffman's Asthma Guideline Interface 25
Figure 9 - Saffer's Disciplines of User Experience. 28
Figure 10 - Morville's User Experience Honeycomb 29
Figure 11 - Formula of Usefulness for Medical Information 30
Figure 12 - Information Ecology Venn 33
Figure 13 - CDS Five Rights and Morville's UX Honeycomb 37
Figure 14 - Research Wall 39
Figure 15 - Feature Driven Development Product Lifecycle 45
Figure 16 - Proposed Development & Software Testing Model 47
Figure 17 - Sample System Usability Scale 49
Figure 18 - System Usability Scale Grading 49
Figure 19 - Nielsen & Landauer's Usability Testing Curve 50
Figure 20 - Triangulation of Usability Test Results 51
Figure 21 - Document Sections in Section Table 62
Figure 22 - Section and Sub-Section 63
Figure 23 - Sub-Section & Sub-Section Headings 64
Figure 24 - Sub-Section Table V1 67
Figure 25 - Sub-Section Headings Table V1 68
Figure 26 - Page Table 69
Figure 27 - Headings Repository Table 69
Figure 28 - Guideline Heading Table 70
Figure 29- Hand Injuries Section Version Two 71
Figure 30 - Level 3 & 4 Headings 72
Figure 31 - Overall Model Example using Colour UML 192
Figure 32 - Develop Overall Model Process Flowchart 193
Figure 33 - Snippet of Business Area from Overall Model 194
Figure 34 - Build Feature List Process Flowchart 195
Figure 35 - Plan by Feature Process Flowchart 196
Figure 36 - Design by Development Process Flowchart 197
Figure 37 - Build by Feature Process Flow Chart 199
Figure 38 - Software Development Life Cycle V-Model 201

TABLE OF TABLES

Table 1 - Computerising CPG Problems 22
Table 2 - Nielsen's Five Quality Usability Components 31
Table 3 - Objectivist and Subjectivist Philosophies 38
Table 4- Database Model Tables Version Two 65
Table 5 - Database Model Tables Version Two 74
Table 6 - User Persona One 78
Table 7 – User Persona Two 80
Table 8 - User Persona Three 82
Table 9 - Login Screen Behavioural Patterns 84
Table 10 - Home Page Behavioural Patterns 87
Table 11 - Guideline Page Behavioural Patterns 90
Table 12 - Initial Feature List 99
Table 13 - Azure SQL Connection Credentials 102
Table 14 - Basic Example User Persona 188
Table 15 - Basic Needs for Example Persona 188
Table 16 - Related Interface Behavioural Patterns 190
Table 17 - Example Task & Scenario 203

1. INTRODUCTION

Accident and Emergency departments are the busiest in any hospital [1] with the range of ailments encountered extensive. Emergency health staff are amid the most information-intensive of health professionals as their departments treat patients whenever *they* choose or their condition decrees: 24 hours a day, seven days a week [2]. Newport's Royal Gwent Hospital, of the Aneurin Bevan Health Board [3] is no different, with the A&E department seeing over 82,000 patients a year, averaging nearly 7000 a month [4].

The pressurised environment which staff work in requires quick and easy access to pertinent and precise clinical guidelines. However, access to such information has historically been limited to large cumbersome, paper-based documentation, limiting speed of access. Additionally, paper-based guidelines are expensive, reach obsolescence quickly and are easily misplaced [5][6] with acceptance and adherence low [7], [8]. Computerised Clinical Practice Guidelines as a form of Clinical Decision Support System can provide a powerful solution to these problems.

Sister Claire McCarthy [9], has recognised the problems with her MIU paper-based guidelines, and, realising the potential of CCPG, has approached Dr Nicola Whitehead [10] of the University of Wales Trinity Saint David's School of Applied Computing [11] to propose development of their existing guidelines into an electronic form. However, despite evidence showing that CCPG have the potential to solve the problems encountered with paper-based CPG and improve patient care, safety and outcomes [12]–[14], use of CCPG is still trivial [15],[16].

This project aims to deliver a functional, usable and extendable CCPG system which can improve patient outcomes by reducing memory and time-related stress on MIU staff which, in turn, can help reduce costs and increase efficiency of the A&E department by reducing the percentage (44.2%) of patients who waited over four hours for treatment [17].

The objective of the report is to deliver the aim, firstly, by means of a literature review looking at by looking into the history of CDSS, the technologies and theories surrounding them and the evidence which suggests that usability has a main part to play in low clinician adoption. User experience theories are then explored with findings carried forward to discover the most pertinent methodologies to ensure a user centred approach. These methodologies are exercised in the development and testing stages with constant involvement from the user. Finally, the system is evaluated to discover if a user centred approach can deliver a CDSS which is useful, usable and provides a good user experience using semantic database design and the latest web technologies.

1.1 Aim & Objectives

The aim and objectives outlined below are taken directly from the project proposal submitted in May 2018 [18].

1.1.1 Project Aim

Design and develop a web application using an MVC framework with RESTful web service approach which will computerise current paper documentation of minor injury guidelines for Newport's MIU in a clear, concise format considering the latest studies in user interaction and experience for web front end design. If possible, the system will incorporate *'physical web'* technology utilising BLE *(Bluetooth Low Energy)* beacons around the unit.

1.1.2 Project Objectives

1. Compare current MVC frameworks which support RESTful web services and conclude a suitable choice to implement the web application.
2. Analyse and evaluate current medical information and diagnostic systems and current interaction design, user experience and presentation of data for medical purposes.
3. Write a system requirements specification for the proposed web application including a MoSCow analysis of the specified requirements.
4. To design, develop and construct the web application using the chosen MVC framework.
5. To scrutinise and evaluate the completed system in the form of user feedback and reflect on findings to recommend future improvements.

1.2 Report Structure

This project has been broken up into four parts: research, methodologies, development and evaluation. Firstly, a review of literature investigates the history, current technologies and reasons for poor adoption of CDSS, offering solutions to the problem. Explanations of the methodologies used to solve the problem are then offered followed by documentation of how the problem was solved. An evaluation rounds off the project, discovering if the project aim has been met.

i. ***Chapter One*** – illustrates the overview of the report, acknowledgements, abstract, introduction, aim and objectives and the report's structure.
ii. ***Chapter Two*** – offers the research and review of current literature surround DSS and CDSS and UX.
iii. ***Chapters Three & Four*** – explanations of the research and development methodologies used to solve the problem presented.
iv. ***Chapter Five*** – details how the problem has been solved, documenting interesting features of the solution.
v. ***Chapter Six –*** evaluation of the project's results in relation to the research carried out.
vi. ***Chapter Seven*** – conclusion of the project overall and recommendations for future work.
vii. ***Chapter Eight*** – personal reflection of what has been learnt and what could have been improved.
viii. ***Chapter Nine*** – reference list of current works cited in the report.
ix. ***Chapter Ten*** – bibliography listing works which have been read but not cited in the report.
x. ***Chapter Eleven*** – appendix of the report containing abbreviations, detailed methodology research and test results.

2. RESEARCH AND REVIEW OF LITERATURE

2.1 Literature Review Foreword

The review of literature investigates decision support systems and their implementation into clinical settings, through their history, the technologies used and their current application, to firstly, identify CDSS, then gain understanding of their mechanics and usefulness. In-depth examination of computerised clinical practice guidelines ensues, looking at the challenges faced, and their interaction with humans in a clinical setting to gain an understanding of why adoption and usage is still not common. Findings from the research leading to an updated set of aims and objectives is found from section six.

2.2 Decision Support Systems

Humans throughout history have faced the cognitive problem-solving process of decision-making, where the stakes of decisions faced rise throughout life. Business, engineering and clinical organisations risk even higher stakes, as their decisions affect the lives of others.

Support of the decision-making process has been a scientific research area throughout history, calling on the scientific disciplines of psychology, economics, operations, management and since the 1950's, computing [19], [20]. With increased computing power, humans have strived to design, develop and implement systems to aid their cognitive decision-making abilities, and thus, decision support systems were born.

Ambiguity surrounds definition for this type of system, definitions often as ambiguous as the questions the systems are tasked. An official definition in the Oxford dictionary states a DSS is:

> *"a set of related computer programs and the data required to assist with analysis and decision-making within an organisation"* [21]

However, Keen [22] argues it is impossible to precisely define all aspects of DSS, only that of decision support [23]. Fick and Sprague [24] also highlight the complexity of defining DSS stating that attempting a definition of DSS is '*frustrating'*, adding that attempts are '*doomed to failure'* due to the complexity of the subject. Despite this evidence, many scholars attempt to define what DSS are. Each concluding that, although designed in very different ways and used in different industries, DSS are computer

programs/systems designed to support humans with complex decision making and problems solving [23], [25]–[28]. DSS aid a range of problems: from simple queries to complex systems modelling of the human's decision-making process. This broad scope of DSS sees the varying systems classified into five major categories [19]:

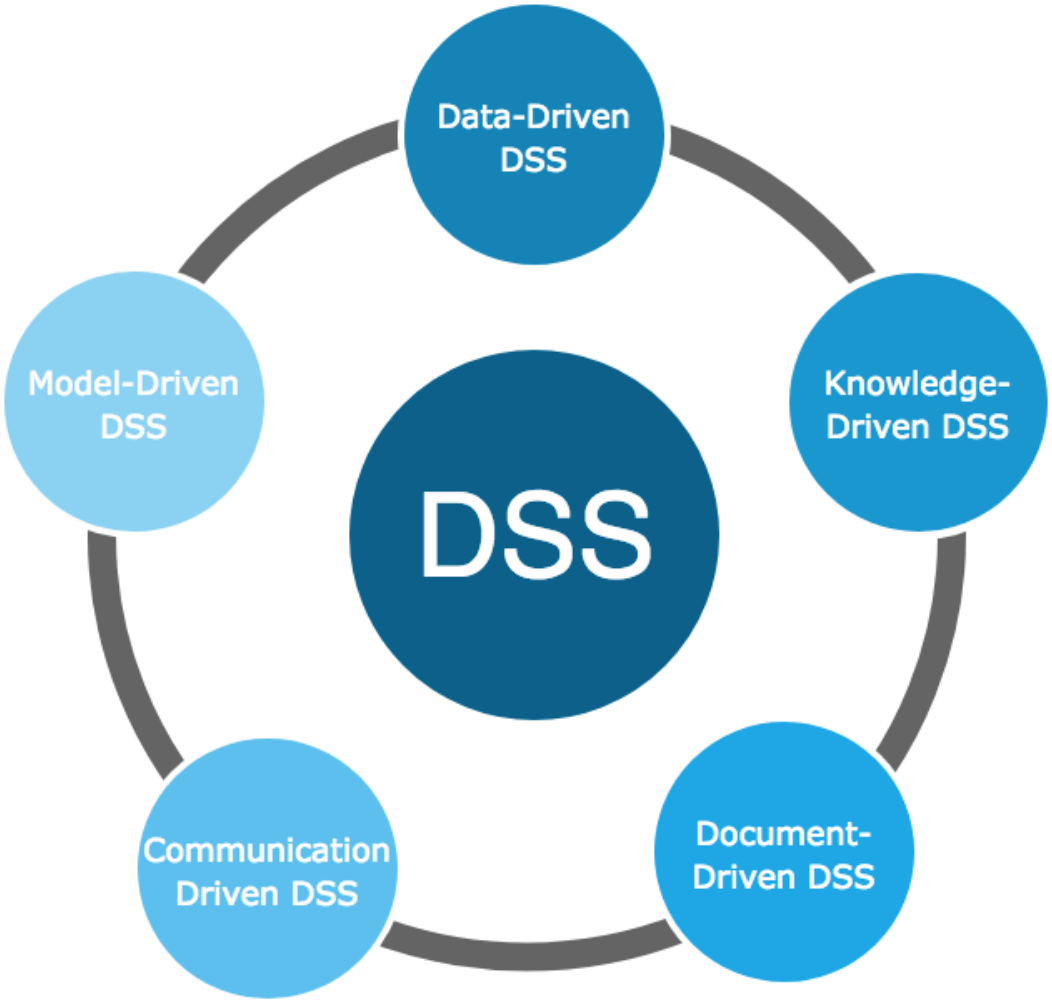


Figure 1 - Types of Decision Support System [29]

i. ***Data-Driven***

The most common type of DSS, which utilises access to and handling of internal and external company data in databases or data warehouses. Often targeted at managers, staff and service providers to aid specific questions with specific answers [30]–[32].

ii. ***Communication-Driven***

AKA 'Group Decision Support Systems'. A hybrid type of DSS allowing users to collaborate by working in groups. Targeting an organisation's team to aid decision-making collectively using network and communication technologies. E.g. instant messaging software, bulletin boards, email, or video conferencing software [32]–[34].

iii. ***Document-Driven***

Focusing on retrieval and management of unstructured company and non-company documents of many forms; hypertext, images, sounds and video. Integrated with different storage and processing technologies and often driven by a task-specific search engine [32], [33], [35], [36].

iv. ***Knowledge-Driven***

Known as a *'knowledge-based'*, *'expert systems'*, or *'intelligent support systems'* these systems recommend or suggest actions to managers based on analysed data from a specific knowledge base, such as a database. This DSS is sometimes used with data-mining, where large data is analysed for patterns [32], [33], [37].

v. ***Model-Driven***

The most complex DSS which analyses decisions or chooses different possibilities. Utilising complex models from different areas like accounting, financial or medical. Using data from decision makers to help analyse situations, these systems are not data intensive and do not require large databases or data warehouses [32], [33], [38].

The history and origins of DSS prove just as ambiguous as the definition, neither neat nor linear [36], nonetheless, Power [39] reports that DSS were first studied in the 1960's, where pioneers Keen and Stabell studied theories of organisational decision-making. However, possibly the first DSS is accredited to business theorist, Morton [40]. Known then as a 'management decision system', Morton, in 1969, experimented with marketing and production managers using a model based DSS to coordinate planning for laundry equipment [36], [41], [42].

Ferguson and Jones [36], [42] continued experimentation with DSS. In 1969, they investigated and tested a production scheduling application. Their findings concluding that even with no computer experience,

their subjects abilities to make decisions was enhanced in most instances [43]. Providing early evidence that computerised DSS can aid humans with decision-making.

Development of DSS continued throughout the 70's and 80's, however, the early 90's saw the next major shift in DSS: technology transferred from mainframe-based systems to internet-based client/server systems, combining with advanced DBMS technology. With the addition of on-line analytical processing (OLAP) tools, data-mining and data-warehousing tools, DSS were becoming increasingly powerful. Circa 1993, developers introduced an object orientated approach when developing DSS, allowing for greater reusability across different platforms and industries, add the fast expansion of the internet, and the scope of DSS was ever increasing [25], [32], [39].

2.3 Clinical Decision Support Systems

Clinical decisions carry an arguably higher risk than decisions in any other industry. Decisions gambling on the life of another are decisions where any possibility to increase the odds of exactitude are welcomed.

Evidence of physicians seeking good council is traceable back 2500 years to Hippocrates:

> *"Life is short, the art long; opportunity fleeting; experience treacherous, judgement difficult"* [44].

In the modern day, the search for expert experience and judgement translates into a long infatuation with clinical decision support systems (CDSS) [45].

Defining CDSS is both simple and complex. Systems range from alerts linked to EHR or healthcare literature databases, to complex Bayesian logic-based systems and even AI with machine learning capabilities. Subsequent definitions are broad:

i. Greenes [46] – *"the use of information and communication technologies to bring relevant knowledge to bear on the health care and wellbeing of a patient".*

ii. Berner and Lande [47] – *"CDSS are computer systems designed to impact clinician decision making about individual patients at the point in time that these decisions are made".*

Greenes [46] adds that most, if not all CDSS share a number of characteristics. His first characteristic adding weight to the argument that CDSS satisfy an enormous diversity of applications, stating that the general aim of CDS can be either one or both of:

a. *To make data about a patient easier to asses by, or more apparent to, a human.*

Referring to systems which collect or present patient health records or, a guideline/literature database which is displayed meaningfully and relevantly at the point of care. Berner and Lande [47] agree literature databases are a form of CDS, however, they add that retrospective analyses of clinical data and EHR are generally not considered CDSS, but with increased interest, these systems are being incorporated.

b. *To foster optimal problem solving, decision making, and action by the human.*

Referring to systems which provide their own support, solutions and decisions to supplement a physician's actions based on clinical data [48]. Again, Berner and Lander [47] agreeing that these are different systems: ones which are KB or non-KB which utilise statistical pattern recognition or machine learning.

Surprisingly, the more complex knowledge-based (KB) CDSS came first with research beginning approximately the same time as DSS for business and management use. In 1959, Ledley and Lusted [49] researched how physicians form medical diagnoses. Their findings revealed that computers could use mathematical disciplines of symbolic logic, probability and value theory to aid diagnosis based on applying Bayesian statistics to the diagnostic data collected [46], [50] .

Bayes' theorem works by producing a posterior probability for each disease being considered. The order they are ranked corresponds to the relative magnitude of the posterior probability. With all possibilities being considered, the posterior disease probability equals 1.0 [46].

Using conditional probability, Bayes' theorem allows predictions to be made by using previous knowledge to inform decisions, where results will usually differ if the previous knowledge wasn't used, then the degree of the change in result could be equal to its usefulness. The theorem proving useful in a medical setting for calculating the probability of diseases given positive or negative results [51], [52].

Ledley and Lusted's work led to the first CDSS being built and tested by H. Warner *et al.* [53] in 1961 for diagnosing congenital heart disease, followed by a system for bone tumour diagnosis by Lodwick [50] in 1965, both using Bayesian methodology. In 1969, Homer *et al.* [54] proved Bayesian systems drastically improved diagnosis, their program diagnosing patients for polycythaemia rubra vera correctly in 95% of

cases when compared to 76% and 65% for haematologists and GP's, respectively. Evidently, systems of this nature could prove significant.

The significance of Bayesian systems is still recognised today: West Midlands and Northern Ireland's NHS trust's using Odyssey [55] CDSS software for their NHS 111 service, which is based on the Bayesian formula and probability scores [56].

2.3.1 Main Groups of Clinical Decision Support Systems

CDSS can firstly, be categorised by their functionality. *'Passive'* systems require users to initiate requests for information, for example, systems which access online research databases. *'Active'* systems make decisions or provide guidance automatically without input from the user, in the form of reminders or alerts for drug interactions [57], [58]. Secondly, there are two main types of system, knowledge-based and non-knowledge based.

2.3.1.1 Knowledge-Based Systems

KBS, the most prolific type of CDSS in use [59][60], often referred to as *'expert systems'* [60], [61], comprise of three parts. A KB, mainly, but not always, containing compiled medical information in the form of if-then rules. A reasoning/inference engine containing formulas and/or algorithms and logic to combine inputted and KB data, e.g. a Bayesian formula. A communication or input/output mechanism, e.g. a GUI, to allow users to input data and read resulting data [47], [48], [59]. DXplain [62] and Isabelle [63] are some of the well-known systems currently in use [46].

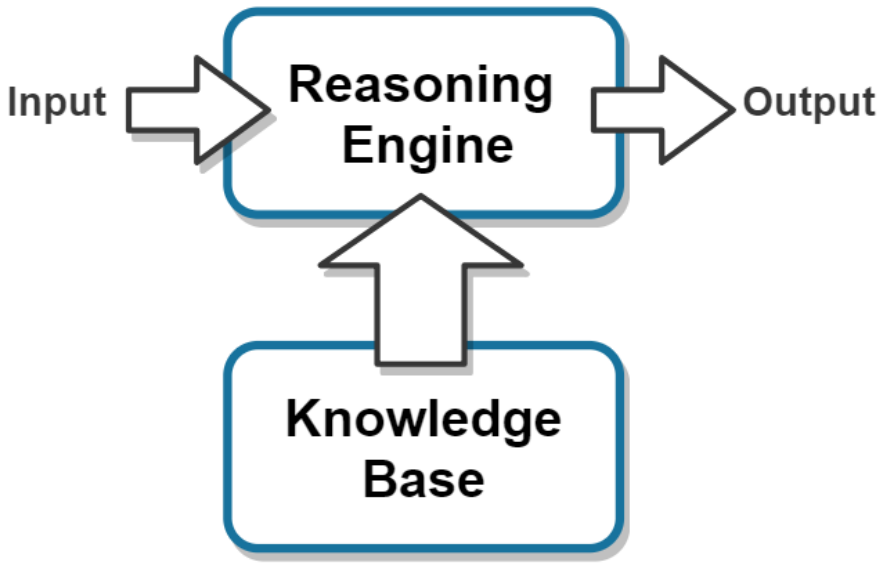


Figure 2 - General Model of Knowledge Based Clinical Support System [48]**.**

KBS come in three forms; Fuzzy logic Rule-Based, Rule-Based and Evidence-Based systems [59]. Rule-based systems are a heuristic approach to CDSS, where logical conditions, formed as production rules are gathered from observing and/or interviewing physicians endeavouring to imitate their reasoning and decision processes [46].

These observations then translate into rules like *'locality'*, which is especially useful with rule-based systems. For example; ***if x diagnose y*** was a rule and ***x*** is known to be true then ***y*** is also true, relating to *modus ponens*, meaning 'mood that affirms' [64], [65]. However, locality is only useful where conditions are either true or false, a simplistic condition which in medicine is rarely met [66]. If a more complex rule is examined; ***if patient 1 has condition x and y then diagnose disease a,*** condition ***x*** could also be present in disease ***b,*** therefore condition ***x*** does not always indicate disease ***a*** [66].

Shortliffe's [67] MYCIN, developed in 1975, addressed this issue by acknowledging inconsistencies in the knowledge base and inheriting properties of logic systems [66]. As ***x*** and ***y*** are Boolean combinations, when trying to diagnose disease ***a***, the systems inference engine must check all of the data and rules to satisfy terms of conditions ***x*** and ***y*** (see Fig. 4. the arc representing Boolean combinations). This process continues evaluating antecedent conditions until both ***x*** and ***y*** conditions are satisfied. The system can then give a diagnosis. MYCIN also addressed uncertainty issues by using '*uncertainty factors'*, which were numerical estimates of the probability of a correct diagnosis [46], [66], [68].

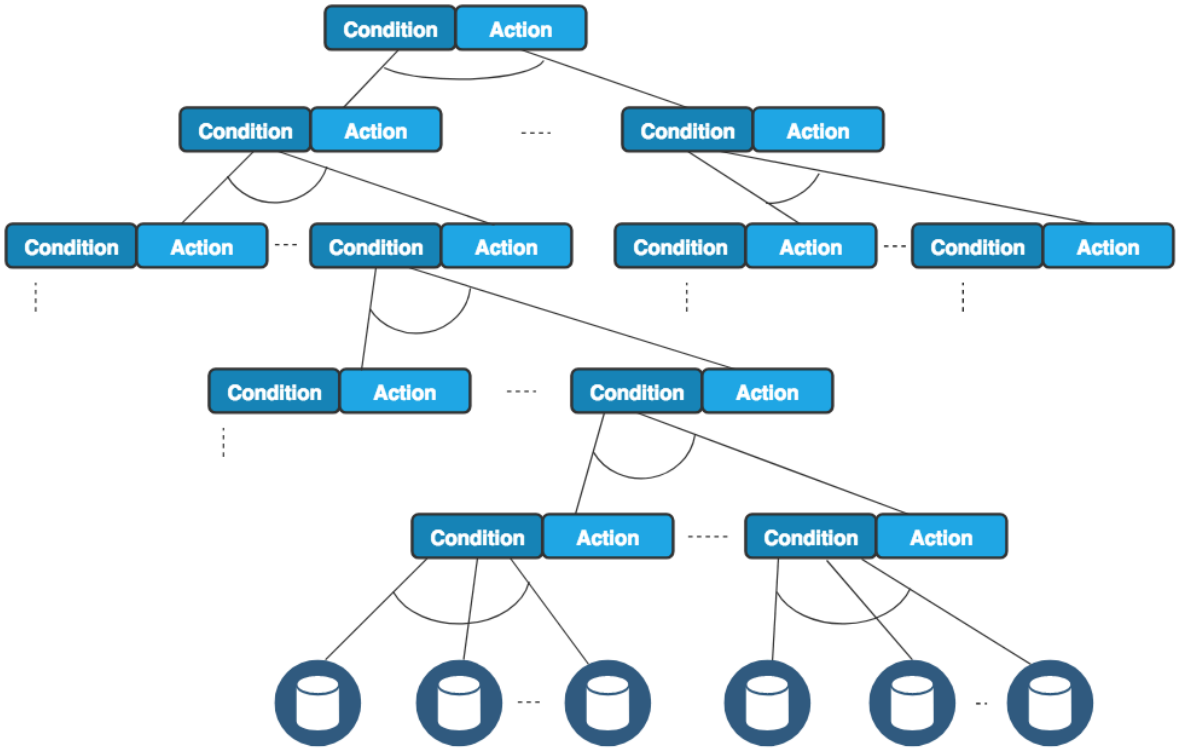


Figure 3 - Backward Chaining Rule-based System [46]***.***

2.3.1.2 Non-Knowledge-Based Systems

NKBS use a form of AI, known as machine learning, which recognise patterns in clinical data, and even learn from past experiences. These systems have three main categories: neural networks, genetic algorithms and support vector machines [47], [59], [69].

Recent headline grabbing Babylon Health developed a NKBS AI CDSS: an automated triage system, integrated into their GP at Hand [70] app. Their 2016 evaluation reported diagnosis accuracy of 88.2% compared to 77.5% from doctors and 73.5% from nurses [71], however, this evaluation was criticised as the paper was not peer-reviewed. A second, non-peer-reviewed, study in 2018 saw Babylon Health report their triage system's precision and recall was 'comparable to, and sometimes exceeded human performance' [72]. Babylon also boast that their AI achieved a score of 81% in the MRCGP [73], [74].

Evidence of this magnitude is an exciting prospect for AI and machine learning in CDSS, however, it is possible to argue that AI is inscrutable as it cannot be known how the AI arrived at a diagnosis and until these AI systems are peer-reviewed their safety will be questioned.

2.3.2 Application of Clinical Decision Support Systems

KBS are applied to many clinical tasks, such as, alerts and reminders, diagnostic assistance, therapy critique & planning, prescribing systems, information retrieval and image recognition and interpretation [60].

2.3.2.1 Alerts and Reminders

A useful application for CDS. By monitoring and evaluating inputs and outputs, systems produce alerts/reminders based on conditions, with warnings being triggered by an event which has been prior identified for potential cause for concern. For example, checking values entered into a laboratory system are within a range, or ordering of medication ensuring dosage is within specified limits [46].

In real-time situations, monitoring devices, such as ECG machines can notify clinicians of any changes in patient condition. Reminders can be simple systems which inform clinicians of tasks which need to be done [60]. In pressurised workplaces like hospitals or clinical practices, these simple systems relieve stress, potentially saving lives.

2.3.2.2 Diagnostic Assistance

These systems are specifically relevant when a patient's case is complicated, rare or the clinician is inexperienced or educated in a different specialism like nursing, or paramedicine. These ES (expert systems) can aid clinicians with likely diagnoses when presented with patient data which is then compared to its KB of understood illnesses. The ES may be of Bayesian type, where complex data, e.g. an ECG, is evaluated by the system and presents the clinician with alternative diagnoses, possibly eliminating misdiagnoses of serious conditions like myocardial infarction [60]. ES can also be CPG [75] where nurses, or inexperienced physicians may refer to for guidance when patients present particular symptoms, reducing chances of misdiagnoses. Ceccarelli *et al.* [76] add that guideline-based DSS are especially useful where complex or unusual cases are present and may require the use of different health professionals, as CPG aim to both share and standardise clinical knowledge.

2.3.2.3 Therapy Critique and Planning

These systems function with CPOE and aim to reduce inconsistencies, omissions and errors in a patient's existing or future treatment by evaluating data entered and highlighting disparities against a KB. If problems are found, alternative therapeutic approaches are proposed. A system developed for the LDS Hospital, based on the HELP [77] KBS, manages orders for blood transfusions. Orders entered are

compared to the KB and the patient's EHR, if discrepancies exist, clinicians must justify the order before completion [60], [78].

2.3.2.4 Prescribing Decision Support Systems

Prescription systems support the common task of prescribing medications, again, by comparing to a KB and EHR, these systems can prevent adverse effects from drug interactions, overdosing, drug-diseases, drug-intervals and allergies to specific medications [60]. Effectiveness of these systems is promising with Evans [79] stating that 5% of patients and 0.8% of orders produced alerts and clinicians edited their therapy in 77% of cases which heeded an alert.

2.3.2.5 Information Retrieval Systems (IRS)

IRS aid clinicians by locating supporting evidence of clinical cases on the Web. Greens [46] stating these systems are a basic form of CDS. Intelligent IRS can, for example, help find determining information about laboratory test results or evidence appropriate to clinical questions. In addition, they can act as 'filters' reducing the amount of hits produced by Web search engines [60]. PubMed [80] made available to the public in 1997, is an example of a simple IRS. PubMed stemmed from MEDLINE, developed in 1964, later evolving to an online resource in the 1970's [81].

There are two methodologies of IR, taxonomy/ontology-based searching or text-based searching [46]. With taxonomy and ontology-based searching, users navigate terms and relations to select ones relevant, taxonomy referring to the hierarchical classification where entities are organised from one or more downward roots, a child-descendant relationship [82].

This methodology relies on use of controlled vocabularies, like MeSH (Medical Subect Headings) [83] used in PubMed, or SNOMED CT [84] used by the NHS. Both terminologies encompass hundreds of thousands of concepts and millions of semantic relationships consisting of upper-level ontology, exposing lower-levels of ontology [46] (fig. 5). The purpose of ontology tools is for institutions to share a common terminology base for health care, with SNOMED CT said to be the most promising candidate, however, adoption in the US is slow with only widespread use in the UK [66].

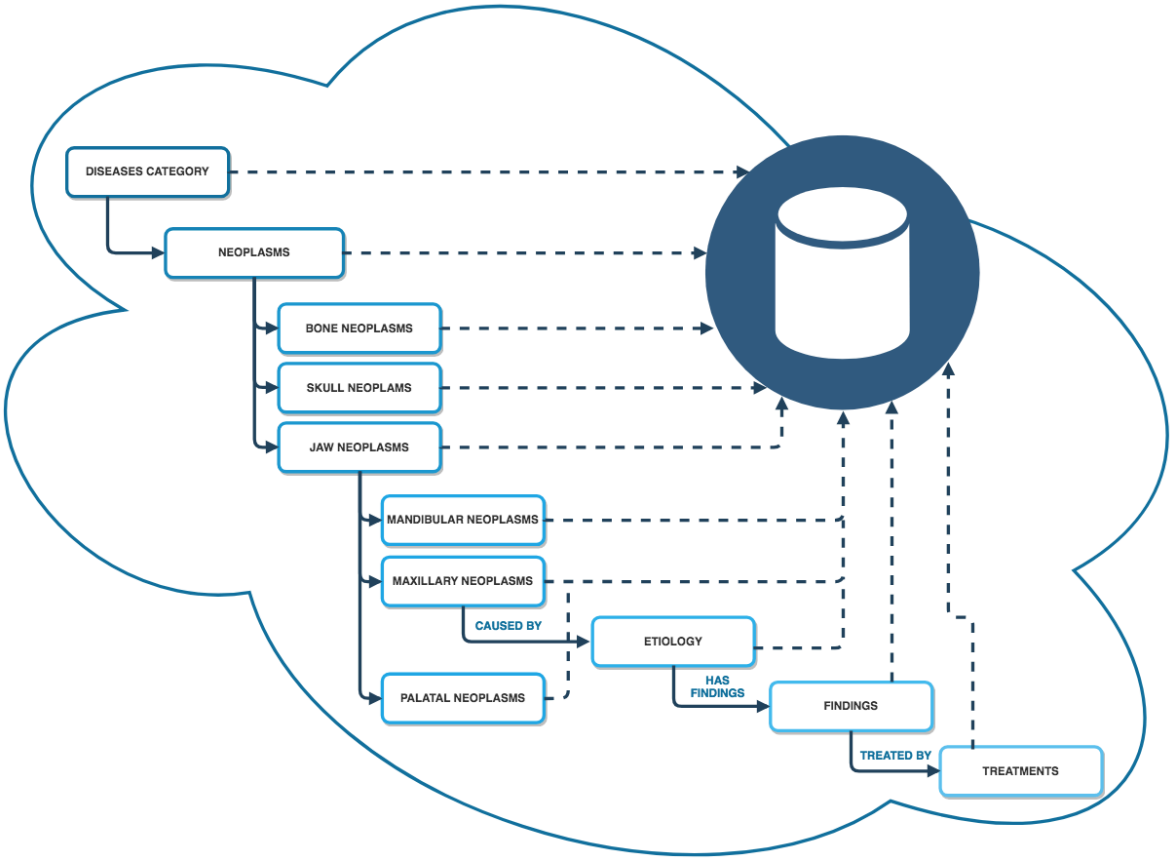


Figure 4 - Ontology Based Information Retrieval [46]

Text-based searching is the most common, and simplest way to search electronic documents: search engines Google and Yahoo! etc. use this method. It is familiar with users and requires the least amount of thinking or learning. Users can repeat searches, alternating keywords to provide different results. Text-based search is especially useful where the corpus is large, and users aren't concerned in finding 'all' of the answers, only 'some' of the answers. However, text-based search has disadvantages: users are unaware of potential hits of interest omitted due to searches conducted using incorrect or ambiguous terms or retrieval of false positive results due to keywords searched being homonyms [46].

2.3.2.6 Image Recognition and Interpretation

With capabilities to automatically interpret clinical imagery such as x-rays, angiograms, CT, MRI and even complex PET scans, systems for interpreting large amounts of imagery are both time and financially beneficial. Clinical practices worldwide perform 1000s of scans daily, each one needing human attention.

With image recognition systems, physicians are only required to examine imagery if abnormities are flagged [60].

2.3.3 Usefulness of Clinical Decision Support Systems

The uses of CDSS are clearly vast, and as previously mentioned, DSS and CDSS can prove beneficial in theory, however, more in-depth evaluations of these systems provide mixed results.

In 1974, de Dombal *et al.* [85] tested a knowledge-based abdominal pain CDSS, proving accuracy 91.5% of the time, compared with 81.2% clinician accuracy, just 10.3% positively. In 1994 Berner *et al.* [86] compared four CDSS, DxPlain [62], Iliad [87], Meditel and QMR [88], finding these systems produced a correct diagnoses range of 52%-71%. Friedman *et al.* [89] in 1999 evaluated two diagnostic assistance systems, reporting rises in correct diagnoses with CDS in 45.4% of patients, compared to 39.5% without. With the costs of developing and implementing CDSS high and the gains small, the question of worthiness arises, however, even small gains will save lives, demonstrating worth after all.

General studies into CDSS effectiveness have also been performed. Garg *et al.* [90] reviewed 100 CDSS evaluations which looked at diagnostic, reminder, disease management, drug-dosing and prescribing systems, finding that CDSS improved practitioner performance in 64% of the studies. Kawamoto *et al.* [91] also reviewed 70 papers, adding that DSS improved clinical practice in 68% of trials. Jaspers *et al.* [12] adding that there is significant evidence to support a positive impact on clinicians' performance but notes that the most effective examples of CDSS are drug-ordering and reminder systems.

In 2005, 2007 and 2013, Haynes *et al.* [92], Hung *et al.* [93] and Hunt *et al.* [94] respectively, published findings that information retrieval from online CDS resources, like MEDLINE, needed optimising. Hung *et al.* [93] concluding their research shows a need for intelligent search agents to improve IR. Evidence again pointing towards minor usefulness in actual clinical settings.

Guideline-based CDSS uses have also come into question, Sintchenko *at al.* [95] reporting information support does not affect confidence of the clinician in making decisions, insinuating that guidelines may not be useful. Heselmans *et al.* [96] and Cresswell *et al.* [97] agree, stating there is little evidence for effectiveness of CPG, but add that an effective implementation strategy is lacking and future systems should be tailored to the needs of users, meaning, with correct development of systems they could prove useful. Berner and Lande [47] also report that guideline-based DSS in GP surgeries had little impact on health outcomes.

Evidence suggests that guideline-based CDSS and CPG do not provide improvements to patient care, however, Shiffman *et al.* [98] state this is due to practitioners ignoring guidelines. Eccles et al. [99] adds that practitioners simply do not use them and a study tracking the use of guideline-based CDSS by medical students showed little to no use, especially surprising given their inexperience [47], however, this is possibly because clinicians report disruptions to their workflow [47], [97].

Sintchenko *et. al.* [95] state that, on average, 245 seconds was taken on decision-making using DSS compared with 113 seconds without, although, this may indicate increased care and thought from clinicians before making decisions. Another study by Keefe *et al.* [100] showed that clinicians simply did not agree with the advice given by the guidelines, and therefore did not follow it. These cases add weight to the Heselmans' theory that CDSS need the correct development and implementation to be useful.

Damiani *et al*. [101] agree, their 2010 study building on Shiffman's early work. Review of 45 studies on CPG effectiveness found evidence demonstrating overall significant improvements to process of care, although they add the effective model of a CPG consists of good accessibility and integration into the clinician's workflow, and that the increased probability of positive effects of CPG might be related to more advanced automated systems.

This equivocal supporting evidence for the use of CDSS as a whole may be the reason that even today, widespread adoption of CDSS does not exist [66][69][102][103].

2.3.4 Conclusion of Section 2.2 & 2.3

The client, Newport MIU has requested a computerised system of their current paper CPG, however, the complexity of computerised decision support and its definitions ask questions of the proposed system; *"Is it really a CDSS at all?", "If it is, what type of system is it?"* and *"Is there a need for such a system?".*

Berner, Lande and Spooner [28], [29] state that programs which perform searches of literature databases or guidelines are not generally considered CDSS, however, they also state that these systems clearly support physicians with decisions. However, Greens [46] supports the notion that these systems should be classed as CDSS, stating that guidelines embody best practice by physicians, improving many areas, such as care quality, efficiency and workflow whilst reducing diagnoses variation.

Osherhoff et al. [104] of the HIMSS, a global advisor of ICT in health adds the following statement:

> "Clinical decision support is a process for enhancing health-related decisions and actions with pertinent, organised clinical knowledge and patient information to improve health and healthcare delivery. Information recipients can include patients, clinicians and others involved in patient care delivery; information delivered can include general clinical knowledge and guidance, intelligently processed patient data, or a mixture of both; and information delivery formats can be drawn from a rich palette of options that includes data and order entry facilitators, filtered data displays, reference information, alerts and others".

This statement classifies the system planned as a CDSS, fitting the criteria Oserheroff *et al.* speak of in this statement. Osheroff *et al.* [105] also state a valuable dimensional concept, the *"CDS Five Rights Framework".* The dimensions state: the right information must be presented to the right people, in the correct formats, through the right channels at the right point in a physician's workflow.

Section two has identified the proposed system being defined as a data-driven, rule and knowledge-based, passive *"Computerised Clinical Practice Guideline"* (CPG) system, a variety of *"Guideline-Based Clinical Decision Support System"*.

i. **Data-Driven**

The system will be accessing and handling evidence-based clinical data from a database which will be targeted at MIU staff, aiding with specific questions and answers.

ii. **Knowledge-Based**

KB systems have been identified to comprise of three parts [section 2.3.1.1]. The MIU system will be simpler than the aforementioned systems, however, the three core components exist:

a. **Knowledge-Base** (KB) – The paper CPG provided contains the data (knowledge) to be inputted into the system. Data inputted will need to be constructed using correct taxonomy/ontology to preserve relationships between the information to form the inference engine logic. The KB also contains the information which users will input to the system, in the form of links and buttons.

b. **Inference Engine** (IE) – The information architecture (IA), navigation and flow through the system form the IE, where, the algorithms are the flowcharts which the system will be designed around. The IE contains the if-then rules which are encoded into the IA and

navigation throughout the existing paper guidelines, which will need to be extracted to form algorithms to design the path through the IA and navigation of the computerised system, thus making it a 'rule-based' CDSS [106].

c. **Input/Output Mechanism** – A GUI makes up the I/O mechanism, where the metadata in the form of links and buttons provides input to the system via the user and the resulting guideline information displayed being the output.

iii. **Passive**

Requiring users to initiate requests for information by interacting with the IA by navigating through the system using the GUI, via the taxonomy or text-based search function make the system passive in nature.

With the proposed system and its key features now identified, the following section looks at CPG, in more detail, focusing on systems which utilise flow-chart style paradigms for semantic execution of multi-step processes for information retrieval.

2.4. Guideline-Based CDSS Paradigms

The remainder of this paper will refer to a 'Guideline-Based Clinical Decision Support System' simply as a CDSS or CPG, and the terms will be used interchangeably, unless otherwise stated.

2.4.1 Definition of Clinical Practice Guidelines

CPG are documents or systems which encompass all available knowledge on diseases, conditions and their symptoms. CPG can be defined as statements developed in a systematic way to assist medical practitioners and patients in making decisions by clearly describing appropriate and inappropriate methods of care [107].

CPG render the best evidence-based medicine into the best medical practices. Well-constructed guidelines promote practitioner quality by improving accuracy of diagnoses, effectiveness of therapy and discourage ineffective and possibly detrimental procedure. Although an overabundance of CPG exist, methodologies vary greatly and are commonly designed poorly [108].

The main objective of CPG is to standardise healthcare to improve overall quality of the care service offered by medical institutions. They aid collaboration between clinicians and promote sharing and extending of expert knowledge as well as being an integral part of medical training. CPG, if followed correctly, may also protect clinicians against possible legal action [109].

2.4.2 Flow-chart Paradigms and Clinical Algorithms

CPG, along with most CDSS, use sequential execution, except at decision steps, in the form of simple flow-chart paradigms for the execution semantics of the multi-step process. In fact, most CDSS comprise of multi-step processes based on logical or computational processes, or other methods such as assessing probabilities, or heuristics. The common element between these systems being an implicit or explicit *'execution semantics'* which directs flow through systems from one step to another. Flow-charts are a familiar model of representing execution semantics of the multi-step process as they execute steps sequentially, until a decision stage, where alternative choices are offered and the flow through the model changes based on conditional evaluations [46].

This paradigm underlies most interactions between users and CDSS, where responses to questions presented are evaluated to determine the next output by the computer, based on logical conditions associated with alternative answers. The process continuing until the system responds with appropriate counsel or when users end their session or begin a new one [46].

In 1965, Warner S. *et al.* [110] developed a computerised medical history system to support physician's diagnostic choices, using a more comprehensive patient history. Importantly, the rule-based system developed was the first to use sequential execution and flow-chart paradigms (fig 5).

In Warner's system, users are sequentially asked questions, until a decision step is reached, then the system displays either a qualifying question or skips to the next necessary question. Warner's system provides the basis for many systems which use a question and answer dialogue and evaluation of a user's responses to branch to subsequent questions, thus controlling the flow of execution. System's like the Swedlow *et al.* [111] 1972 system, also for gathering patient history, a note taking system (PEN-Ivory) by Poon and Fagan [112], in 1994, and van Mulligen's *et al.* [113] clinical data entry system.

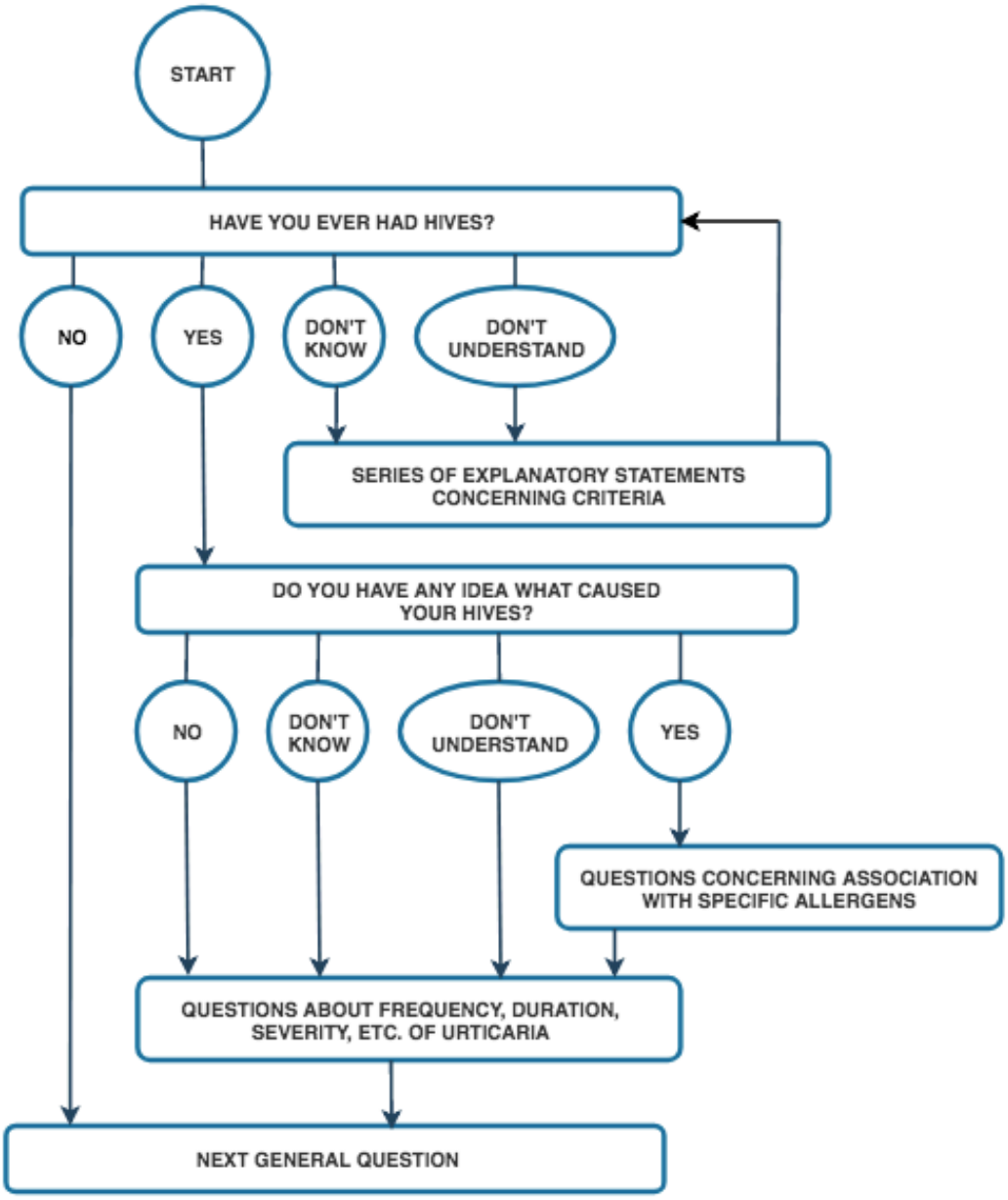


Figure 5 - Example of Warner's Clinical Flow Chart [110]

Greenes [46] states that systems of this nature usually require a designer to specify an underlying step-by-step control structure for conditional branching at each step, adding that CPG make underlying flow-charts explicit when used to drive human-computer interactions. Meaning that flow-charts or clinical algorithms can be designed from information in clinical guidelines and used to develop a structured, semantic information architecture for a computerised system, where users control the flow of information presented to them by answering clearly stated questions for each step of the process, where, different results are shown through different inputs.

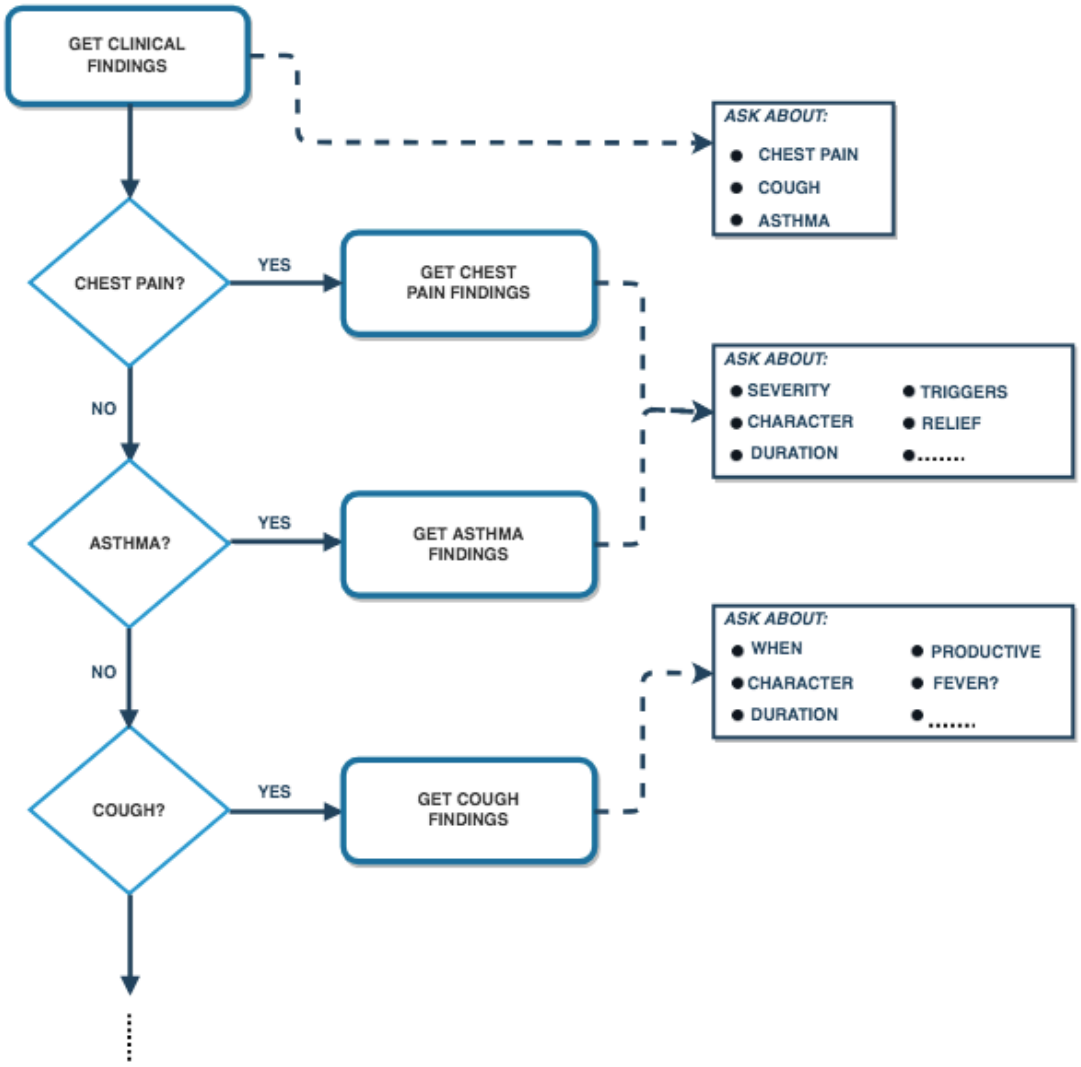


Figure 6 - Interactive Dialogue Guided by Clinical Algorithm (Flow-Chart) [46], [114]**.**

A simplified clinical algorithm based on Shiffman's 1994 Asthma CPG (fig.6) shows how flow-charts underlie systems with interactive dialogues. Clinicians are sequentially guided through the diagnostic process, with results displayed offering reminder advice to ensure clinicians investigate symptoms correctly.

2.4.3 Creation of Clinical Algorithms and Computerising Clinical Practice Guidelines

Translating paper guidelines into clinical algorithms and computerised versions presents a more difficult task than would be expected. Shiffman and Greenes [115] developed formal methods of creating clinical algorithms with decision tables in 1991, their work a foundation for Shiffman [114] in 1994, however, Shiffman encountered many unanticipated problems (table 1) during computer translation due to the exhaustive analysis and extraction of clinical decision and action variable relevance.

Problem	*Explanation*
Incomplete Logical Expressions	Guidelines failed to show all possible decision branches.
Ambiguous Definitions	Interpretation of words such as 'mild', 'moderate', or 'severe' are not clearly defined.
Target Audience	Doctors, nurses or students need data to be presented in different ways to be useful.
Decision Points	Decision points were required to present only useful decision information to provide valuable reminders.
Workflow Integration	Presentation of relevant information on the correct device is required.

Table 1 - Computerising CPG Problems

Peleg and Gonzalez-Ferrer [106] report that to avoid incompleteness and ambiguous definitions, the knowledge gaps throughout guidelines are completed by designers based on expert opinion, and they often need to be written for each clinician speciality (e.g. doctors and nurses) to be useful. To present adherence to all decision points and integrate these into workflow, an interface can be designed as shown in fig. 8 [section 2.4.4].

Most organisations who publish paper-based guidelines which include algorithmic flowcharts do so in an orientation specific to their stakeholder [116], this creates many of the problems which Shiffman encountered. Zielstorff [117] agreed and called for defining guideline knowledge in standardised interchangeable formats which could be installed in differing technical infrastructures.

To eliminate ambiguity of CPG paradigms, Shiffman *et al.* [116] developed the GEM (Guideline Elements Model) hierarchy containing 110 elements relating to a guidelines identity, developer, purpose, target

audience, development method, target population, knowledge components (including recommendations, definitions and algorithms), testing and review plans [106]. Many elements addressed some of the problems Shiffman encountered in his earlier work. The XML (Extensible Mark-up Language) used allowing humans and computers to access and extract a documents information for modification or reuse [118] (fig.7). 'GEM Cutter' software was also developed to mark-up guidelines for translation into XML [119].

```
<guideline.document>
    <identity>
        <title>The Diagnosis, Treatment and Evaluation of the
        Initial Urinary Tract Infection in Febrile Infants and
        Yound Children</title>
        <citation>American Academy of Peadatrics. Practice
        Parameter. The diagnosis, treatment and evaluation
        of the initial urinary tract infection in febrile
        infants and yound children. Peadatrics 1999;103:843
        <guideline.length>9 pages</guideline.length>
        <citation>
            <release.date>1999</release.date>
                <availability>
                    <electronic>http://www.pediatrics.org/cgi/con
                    tent/full/103/4/e54</electronic>
                    <print>Pediatrics(Journal)</print>
                    </contact>
                </availability>
        </status>
        <companion.document>A detailed description of the
        methods by which the parameter was derived is
        available in a technical report from the American
        Academy of Pediatrics
        <patient.resource/>
        </companion.document>
        <adaptation/>
    <identity>
```

Figure 7 - Example of XML Mark-up for GEM CIG [116].

Representations of guideline knowledge which allows execution through computers whilst supporting automatic inference are known as CIG (Computer Interpretable Guideline) formalisms or CIG methodologies [106]. CIGs aim is to create a '*common model'* which standardises guideline representation

to allow better sharing of formats, knowledge and implementation on different platforms [46], [75]. Despite working towards a *'common'* model, many CIG models exist; Arden Syntax [120], EON [121], GLIF [122], GUIDE [123], Prodigy [124] and PROforma [125]. Peleg *et al.* [75] finding that all of these CIG use components which could be adopted for one standardised model under HL7 (Health Line Seven) [126] standards.

2.4.4 Humans and Clinical Decision Support

With the exception of *'closed-loop'* systems, like pacemakers, which act without human interference, humans will always remain at the centre of the decision-making process: even the most complex AI systems still lacking nuance. These systems are designed, for now, to focus on *support* of decisions and not to *make* decisions [127]. With CDSS, and, in particular, CPG being confirmed to significantly improve care processes [91][101][128]–[130], it is important to look into why, as previously mentioned, application of CPG as CDSS is not widespread [131].

Greenes [127] argues CDSS have been somewhat a *'disruptive innovation'* adding that some clinicians consider the use of automated guidelines *'cookbook medicine'* which do not aid with diagnoses due to lack of nuances with patients, or the advice given does not match what the physician believes is best practice. Others see their lightning-fast information retrieval from vast databases useful. Positively for CDSS, patients' attitudes have also changed with a greater willingness to question practitioners and take-part in their diagnoses through their own research using CDSS [127]. Evidence also supports that the quick retrieval of knowledge through CDSS is regarded desirable by patients and practitioners, whereas past evidence suggested practitioners referring to textbooks or computers constituted a lack of knowledge [132][133].

Practitioner reluctance through viewing CDSS as disruptive is just one of many reasons for low adoption rates. Understanding the complexity of tasks required when designing CDSS and implementing them broadly is a challenge, as systems need to be integrated with existing IT infrastructure, clinicians' workflow, be user specific and fit with current business and health care practices. On top of this, regular updates and adaptation are required as the field changes [127].

When comparisons are made between the UX of paper-based guidelines and computerised guidelines there is overwhelming evidence, that, when designed properly, clinicians favour electronic platforms to conventional print. Khodambashi *et al.* [134] finding that 83% of clinicians preferred information retrieval

through a computer system. Evidence which provisions the need for computerising guidelines and well a designed GUI.

When considering clinicians' workflow requirements, the HCI (Human Computer Interaction) between clinician and computer are paramount: systems which are poorly designed and hard to use will not be exploited. A sentiment echoed by Sheehan *et al.* [135] when they report clinicians would appreciate CDSS provided they integrated into workflow, were easy to use, modifiable with patient needs and refrain from interfering with professional judgement. Isern and Moreno [136] provide evidence: stating that CDSS are not integrated into workflow and therefore, not used. Reasoning for non-user-focused and poorly designed CDSS is presented by Miller *et al*. [137], they suggest that CDSS are being designed and implemented with inadequate understanding of clinical work or effects of clinical decisions, and, Lyng [138] adds CPG are technology driven rather and user-driven.

Some experts do recognise the importance of HCI and GUI design. Shiffman [114] [section 3.3] recognised the need for a computer platform which was mobile, low-cost and user-friendly, with an intuitive GUI, when he designed his system for use on Apple's Newton PDA (fig. 8).

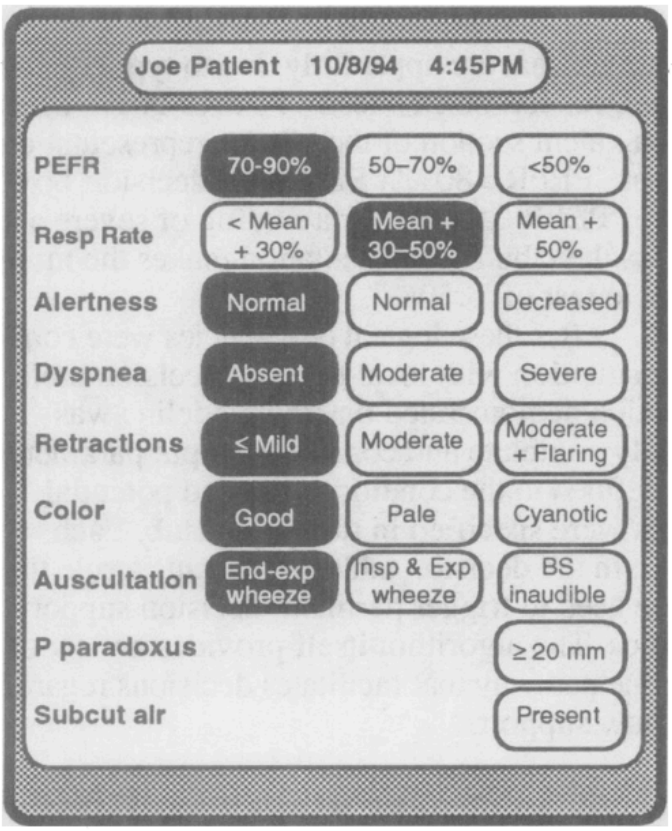


Figure 8 – Shiffman's Asthma Guideline Interface [114]**.**

It can be considered that a major factor in clinicians' lack of adherence to using CPG is due to poor interactions stemming from poor interaction, usability, and user experience design. Horsky *et al.* [139] concur, affirming that poor usability is a fundamental impediment and preventive factor to CDSS periodic use. Miller *et al.* [140] and Genes *et al.* [141] agree, adding that CDSS are mainly ineffective because of sub-standard usability.

This proves the importance of understanding users of CDSS by taking a user-centred approach to development where expectations, preferences and needs are assessed early, along with usability testing throughout the development lifecycle [142]–[144]. This approach will place emphasis on prioritising interaction design, user experience, and human computer interaction principles, as these areas are considered critical to the success of CDSS [139], [140].

2.4.5 Conclusion of Section 2.4

Section three firstly defined CPG and provided explanations of their underlying structure through flow-charts and medical algorithms. CIG theories were briefly discussed as were the challenges of successfully implementing guidelines into a computerised form.

Finally, the role the computer plays with the human in a clinical setting was researched, along with the challenges encountered in attempts to broadly implement CPG. It can be concluded that although many factors exist as barriers to this aim, a fundamental element is that of poor design through a non-user centred approach to interaction design, user experience, and usability.

It is for this reason that the following section will concentrate on the latest theories surrounding UX, IxD (interaction design), and usability theories to, not explicitly, aid in the design of a front-end graphical user interface for use in a clinical setting.

2.5 User Experience and Clinical Decision Support Systems

UX and HCI, considered the precursor to UX and its subsets [145], IxD, information architecture (IA), visual design and usability have all been acknowledged as important scientific aspects imperious to the success of CDSS.

The MIUs proposed CDSS will be used in a high-pressure A&E environment: statistics from the Royal Gwent Hospital A&E, show attendances of 7,101 patients, in June 2018 alone [146]. This high turnover of patients

highlighting pressures faced by MIU staff when trying to perform triage quickly and accurately. These statistics, coupled with evidence from section three, emphases the need for excellent UX design of their CCPG to ensure staff can access potentially lifesaving information quickly and accurately.

2.5.1 User Experience

Defining UX could be considered as difficult as defining CDSS. It represents an equally ambiguous field. ISO and the dictionary, respectively, define user experience as:

> "user experience is a person's perceptions and responses resulting from the use and/or anticipated use of a product, system or service" [147][148].

> "the perception and response of a person towards design elements of software or digital media while interacting with it" [149].

Defining that UX isn't focused on what products do, but on how they work and interact with users. Garret [150] agrees, stating UX is how externals of things work when users connect with a product. Guidelines from *usability.gov* [151] state that UX focuses on having a deep understanding of users, their needs, values, abilities and limitations. The IxD [152] foundation adding that UX is the overall experience users have when using a product.

Norman [153], considered the father of UX, first coined the term *'User Experience'*. In emails exchanged with Merholz [154] he explains how terms *'Human Interface'* and *'Usability'* didn't satisfy his intricate understanding of the subject, adding UX should cover all aspects of a user's experience with a system, supporting the theory that UX cannot be defined simply. Norman's [155] theories date back to 1988: UX, then called *'User-Centred Design'* is the focus of the needs of users, rather than that of the system, something which has been disregarded with development of CDSS [138].

Today, UX still remains an ambiguous, complex field, encompassing many disciplines of interaction with digital products. IxD, usability, IA and design of interfaces, visuals and sounds etc., all fall under the UX umbrella and current experts in the field, Saffer [156], Bacon [157] and Morville [158], have attempted to illustrate understanding of UX and its subsets.

These visualisations help with understanding UX and its complexity. Saffer [159] first publishing his visualisation in 2006, followed by an updated version in 2010 (fig. 9), highlighting the complexity of UX design and, ultimately why it is so difficult to execute.

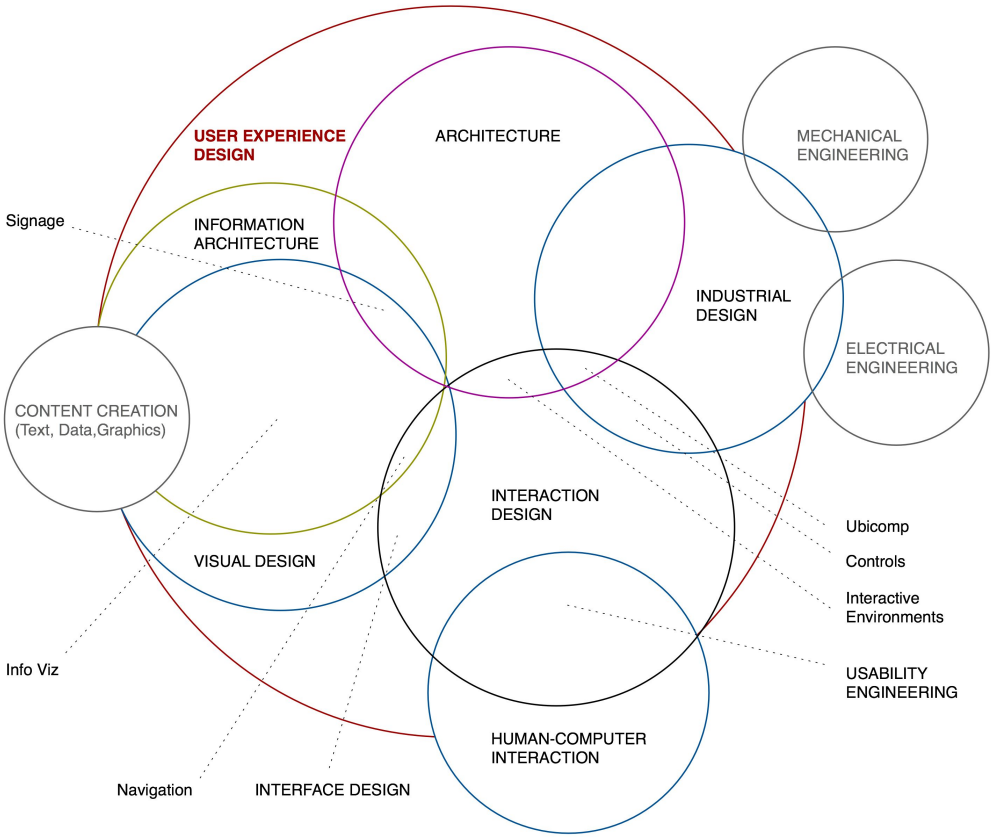


Figure 9 - Saffer's Disciplines of User Experience [160].

Many other infographics attempt to visualise UX, from simple diagrams like Bacon's [157] sundial model and Seo's [161] umbrella graphic, to the extremely complex mega Venn's by Gläser [162] and Envis Precisely [163]. However, it is Morville's [164] UX honeycomb (fig. 10) which provides the most relevant infographic to explain the differing facets of UX which are applicable to every digital project, including CDSS.

2.5.2 User Experience Honeycomb and CDSS

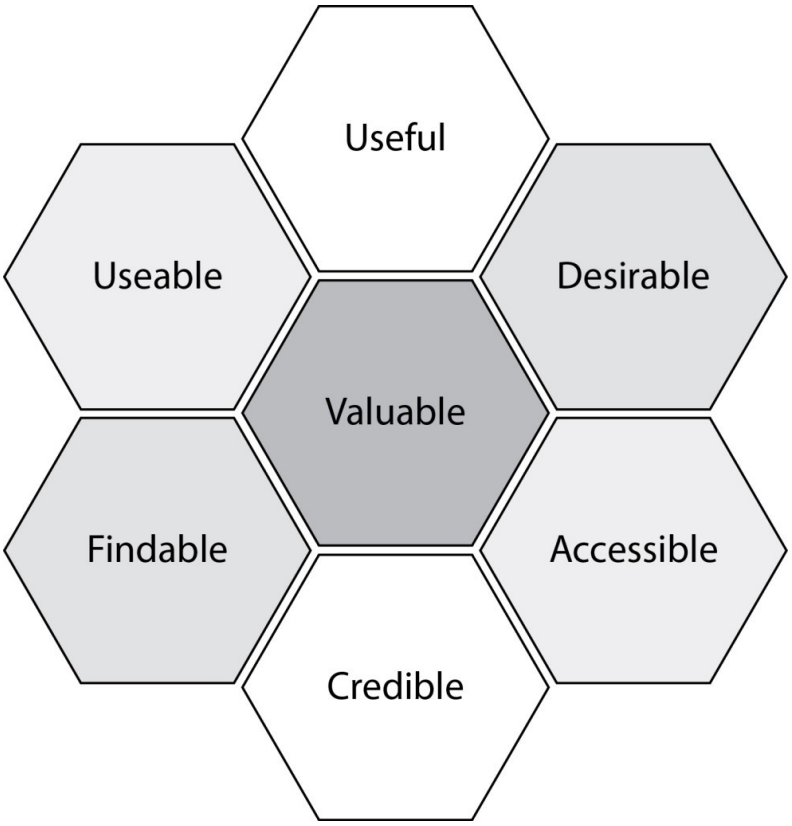


Figure 10 - Morville's User Experience Honeycomb [165]**.**

Morville's [164] conceptual framework consists of seven UX facets (fig 10). It is best suited to CDSS UX research as it addresses key areas for design of CDSS by combing emotional factors of UX with the main aspects of usability and usefulness [166]. Additionally, it provides a UX framework which will aid in delivering a CDSS which fits into Osherhoff's *et al.* [105] CDS five rights framework [section 2.4].

The effectiveness of Morville's honeycomb for CDS development has at present, only been documented in a few studies: each documenting its value. Rosenbaum et al. [167] applied it to testing of a web-based, information retrieval CDSS in 2008. Rosenbaum [166] used this research and the honeycomb to help design and test evidence-informed healthcare systems for her 2010 PhD thesis. In 2011, Giguere *et al.* [168] used it to develop a decision box CDS and in 2016 Fearns *et al.* [169] applied its qualities to improve the UX of CPG. Each study finding that the honeycomb aids in discovery of compatibility issues between users and systems by testing throughout the development process, which, when used in conjunction with

an Agile FDD [170] (Feature Driven Development) method can, in theory, drastically improve the CDSS chances of adoption.

The seven honeycomb facets relating to the development and testing of CDSS accordingly:

Useful – CDSS must have practical value for the user. Usefulness of a system has already been noted as key determinant of CDSS success in section 2.3.3, and by Bates *et al.* [171] and Rousseau *et al*. [172]. Slawson and Shaughnessy [173] state to ensure a CDSS usefulness, the goal is to present the most useful information in the shortest amount of time, adding three attributes: relevance to everyday practice, correctness and obtaining information through little effort.

$$\text{Usefulness} = \frac{\text{Relevance x Validity}}{\text{Work}}$$

Figure 11 - Formula of Usefulness for Medical Information [173]**.**

Relevance – the type of information presented, and the frequency of the problem presented. The aim is to present POEM (Patient Orientated Evidence that Matters).

Validity – the probability of the information being fact.

Work – the factors relating to how much energy is expended to find the relevant information.

Development of CDSS must consider the first two parts of this equation, however, for CCPG, the information should already be relevant and valid. The important UX factor is *work*. Slight variances in this denominator will either lead to an increase or decrease in a systems usefulness [166], which ties in with a UX theory by Pirolli and Card [174], *'Information Foraging'* which states that people (users) modify their habits to maximise valuable gain of information. However, the TAM (Technology Acceptance Model) accentuates importance of a user's perceived usefulness, which can offset perceived ease-of-use [175]. Therefore, these factors must be considered when developing and testing the CDSS.

Useable – CDSS must be easy and satisfying to use. Evidence from Horsky [139] and Zhang [176], [177] shows that CDSS are largely ineffective due to poor usability and their interfaces so badly designed they often cause user error. However, through a user-centred approach to usability testing in the early stages of development, usability can be enriched [142], [178].

Nielsen [179] defines usability through 5 quality components:

Component	*Directive*
Learnability	How easy is it for users to accomplish basic tasks the first time they encounter the design?
Efficiency	Once users have learnt the design, how quickly can they perform tasks?
Memorability	When users return to the design after a period of not using it, how easily can they re-establish proficiency?
Errors	How many errors do users make, how severe are these errors, and how easily can they recover from the errors?
Satisfaction	How pleasant is it to use the design?

Table 2 - Nielsen's Five Quality Usability Components [180]

Employing these fundamental design principles from the beginning of CDSS development will increase its appeal to users. Additionally, Nielsen created a taxonomy of 10 design heuristics which can be used to inspect and evaluate systems of any specific nature [181].

In 2018, both Miller [140] and Taft [182] adapted and matched Nielsen's design heuristics to CDSS usability testing to identify usability problems and discover deficiencies in the interfaces. To do this, Nielsen's heuristics are applied to a product, with violations of the heuristics identified and the severity of violations assessed, subsequent changes are then made to a system [183]. Nielsen recommends, testing with 3-5 users for initial and follow-up tests, which can include interviews, *'think aloud studies'* and observations [184]–[186].

The mapping of Nielsen's heuristics to CDSS by Miller [140] was found to be proactive in the strive for improvements in CDSS design and implementation, however, Miller identified some of Nielsen's heuristics which did not match, identifying her own: *integration into work flow*, which ties in with the 5 CDS five right framework and earlier findings from section 2, which state that successful CDSS must integrate into clinicians workflow.

Findable – Information must be findable and through easy navigation. If users encounter problems, a solution should be able to be found quickly. Bates [171] stresses that many clinicians have concerns about speed of completing tasks within a CDSS, meaning that guidelines need to rapidly present information at convenient points in the workflow without extraneous effort, again, linking to the CDS 5 rights.

Horksy [139] adds that the acceptable screen transition time is under a second and the perceived difficulty of the interactions with a CDSS are directly related to the number of clicks required to retrieve information, the complexity of navigation menus and the cognitive effort required to find required information on the screen once the correct page has been located. Krug [187] agrees, stating that when users don't find what they're looking for, they get frustrated and abandon the system. He adds that navigation is a consideration for users when they perceive the quality of a system.

The underlying structure of information to be presented through the navigation is of paramount importance. Known as IA: the theory of organising information to enhance access to it has been briefly discussed in section 2.3.4 and 2.4.2. Rosenfeld and Morville [188] note that the main components of IA are:

- *Organisation Schemes and Structures* – how information is categorised and structured.

  Similar information should be categorised together and have a hierarchical structure with each layer representing abstractions from the preceding layer [189].

- *Labelling Systems* – how information is represented through labels and buttons.

  Labels represent larger chunks of information in a system, for example, SNOMED uses broader terms such as 'body structure' to house smaller, relating labels like 'cell structure' or 'gland structure', each larger label expanding to reveal more specific information.

- *Navigation Systems* – how users move through the information in the system.

  Navigation can be through form of a clickable buttons in a menu, gestures on a trackpad or touchscreen device or, for best integration into work flow, voice controlled or hands-free interaction [190].

- *Search Systems* – how users look-up information.

  Search functions can be either text-based retrieval or keyword based.

To create the IA for CDSS an understanding of the interdependent nature of users, content and context [191], or 'information ecology' [188], is required; defined and visualised in fig. 12.

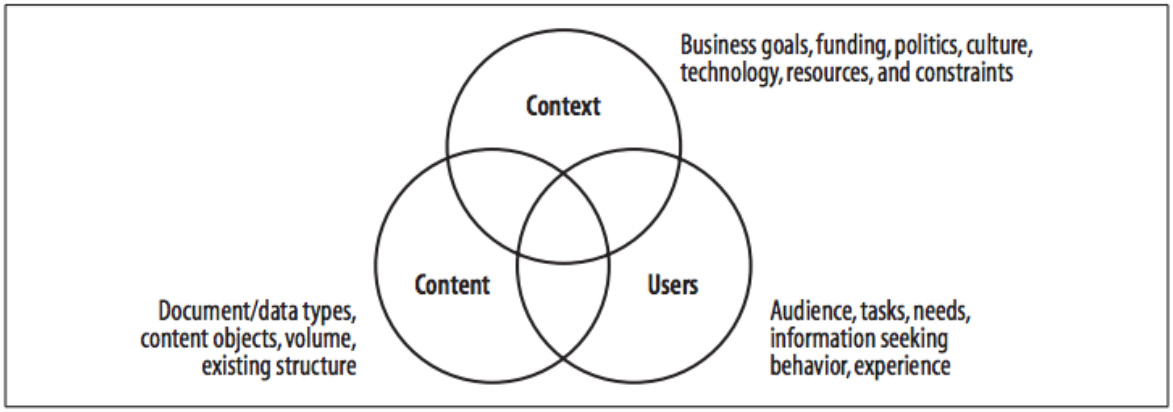


Figure 12 - Information Ecology Venn [188]**.**

Manually testing IA will discover whether information is grouped well and that labels are good. Testing consists of asking users to look for specific information or perform a set task, a technique which works best for a hierarchy pattern IA. Online tools such as '*TreeJack*' [192] can help structure IA tests and provide valuable statistical results. Just as IA structure can be designed using the '*card-sorting'* technique, *TreeJack* is known as *'reverse card sorting'* or card-based '*classification*'.

Desirable – CDSS main purpose is usefulness and usability. However, aesthetics of the system must be attractive and translate easily through minimal, to the point, design [165]. Desirability is conveyed through branding, identity and image [193], something which may not be considered relevant to a practical system, however, if the front-end design of a system is in keeping with current systems and follows existing conventions, in turn, the system becomes more desirable to users, thus encouraging use. Krug [187] adding that conventions also allow users to learn the use of a system quicker, adding desirability.

UX testing using the honeycomb by Rosenbaum [166] for The Cochrane Library [194] found that the medical library was *"crowded"*, *"busy"* and *"cluttered"* and left users feeling *"overwhelmed" and "stupid".* One nurse commented that the site was maybe *"more for doctors"*. Such emotional responses to a system show how important desirability is in respect to potential use. Rosenbaum concludes that existing usability conventions should be applied to ensure repeat use of CDSS.

Accessible – This segment of the honeycomb addresses the discriminatory features of website/system design, ensuring that users of a system with disabilities can access content on a website/system, including but not limited to images, text and sound [195], [196]. Accessibility of systems will one day become law.

CDSS will be used by health professionals, some of which may possess disabilities, however, given the professional nature of health care, people with severe learning or other disabilities will not fill a role where CDSS use is required. However, visual impairment may affect clinicians use of a system. Guidelines to help developers design inclusively are available from W3C [197].

Credible – CDSS must be perceived to be credible, meaning that users must trust and believe the information which is displayed to them. Section 2.3.3 states that information provided in CDSS is usually provided by medical professionals and peer reviewed for accuracy, thus making the information credible. However, other factors also aid in earning a system's credibility, such as site navigation and visual design [198].

Valuable – Value, in respect to the honeycomb, equates to value for the business which creates it and the user who buys and uses it [193]. Users will gain value from this system if all 6 other facets of the honeycomb are addressed and tested. Ultimately the main value in a CDSS is delivering the 5-right framework.

2.5.3 Conclusion of Section 2.5

Section four firstly defined UX through its history and identification of the current theories surrounding the scientific field: identifying Morville's UX honeycomb as a perfect framework of which to guide development of CDSS. Each segment of the honeycomb has been mapped to relevant practices required for development, finding that for a CDSS to be successful five of the segments hold vital importance.

Useful – Speed of information retrieval is paramount in clinical settings for a CDSS usefulness.

Usable – Interfaces must be designed with a user-centred approach from conception, through to completion. Adherence to current usability theories by Nielsen and testing from early stages is imperative to ensure maximum integration into workflow, which has been seen throughout the literature review [sections 2.3.3, 2.3.4, 2.4.3, 2.4.4, 2.5.2] as a major stumbling block in adoption of CDSS.

Findable – Navigation must be simple, concise and follow conventions which are socially familiar with health professionals. Underlaying structure of information must contain the main components of IA.

Desirable – Front end design of the system should be simple, uncluttered and aesthetically pleasing to promoting credibility and trust.

Discoveries from section four have also led to the belief that Morville's honeycomb could provide a UX framework which could aid in delivering CDSS which adhere to the 5-rights frame work. The following discussion will look to map the honeycomb to the 5-rights to develop a framework for future developers to follow, ensuring CDSS of the future finally reach the potential recognised throughout this research.

2.5.4 Discussion

The *CDS 5 Rights* framework was conceived in 2006 by Jerome Osheroff, who built on the conceptual foundations of the *'five rights of medication use'*, published in a 1997 ISMP (Institute for Safe Medication Practices) newsletter [199]–[202]. Osheroff's theory was first published in his 2009 book *"Improving Medication Use and Outcome with CDS: A Step-by-step Guide"* [203]. However, Oserhoff's *et al*. latest publication *"Improving Outcomes with CDS: An Implementer's Guide, Second Edition"* which further describes the *CDS Five Rights* has become a pivotal thesis for successful CDS implementation [199].

Despite the *CDS 5* Rights framework and accompanying guidelines existing since 2012, this paper has provided up-to-date evidence proving that CDSS are still not being implemented successfully, which can be blamed on poor user experience and usability. This unsuccessful implementation of CDSS post *CDS Five Rights* could be considered a failure on the part of developers who implement CDSS, who fail to follow the guidelines, or it could be considered failure because of the framework as there are no specific guidelines for usability and user experience.

The obvious and simple solution to the UX issues which plague CDSS could be to use a UX framework, one which will be employed for this project, however, as Miller [140] has already eluded to [section 4.5.2 – Usable], the use of one framework alone omits important guidance, for example: workflow integration.

This evidence, in addition to findings throughout this paper, have led to the conception of a theory to solve this problem: mapping a UX framework, in the form of Morville's UX Honeycomb to Osheroff's *CDS Five Rights* framework. The aim would be to eliminate some of the omitted UX considerations in Osheroff's theories and provide workflow integration guidelines for future developers wishing to implement a user-centred CDSS with a strong focus on UX using Morville's Honeycomb or other guidelines, such as, Neilsen's heuristics.

The theory, at present, is a recommendation for future research, however, a quick mapping of these two frameworks is provided to highlight the potential usefulness of a combined framework. Sirajuddin *et al.* [199] and Campbell [204] state the following:

1. **The Right Information**

   The right information is evidence-based, derived from recognised guidelines or national performance measures which are suitable to guide actions and are pertinent to each circumstance.

   The right information can therefore be mapped to honeycomb segments ***useful,*** as the information must be of use to the clinicians and ***credible*** as the information must be trusted and believed to be of a certain quality.

2. **The Right People**

   Every member of the care team must be considered, which includes clinicians (doctors, nurses etc.), caretakers and even patients.

   The CDSS therefore must ***desirable*** to each of the separate healthcare professionals, to ensure appreciation for the system.

3. **The Right Intervention Format**

   The different formats of CDSS implementation include alerts and reminders, order sets, reference information, plus many more outlined in section 2.3.2. It is important for implementers to recognise which problem is trying to be solved to enable the best choice of format to provide a solution. In the case of this project, information retrieval.

   Consideration of the ***accessible*** segment will ensure that each format is accessible to all members of the care team with varying levels of skill or disability.

4. **The Right Channel**

   CDSS are delivered through many different channels: though local applications on smartphones, tablets or laptop/desktops computers, to applications accessed over networks like the internet, like the proposed system for the MIU.

   The CDSS must be ***usable*** through familiar, easy to use interfaces.

5. The Right Time in Workflow

The CDSS must deliver its intervention or information at the right point in the clinicians' workflow, whether it be for decision making, action making or general time of need for it. It is common for systems to overlay their technology without consideration for clinicians and their current workflow practices. Hence CDSS poor adoption and a need for a user-centred approach.

Morville's ***findable*** segment ensures that content is navigable and locatable simply and effortlessly which will aid in getting the required information without causing disruption to the workflow of the clinician.

Following the set of combined guidelines will then ensure a CDSS is ***valuable***.

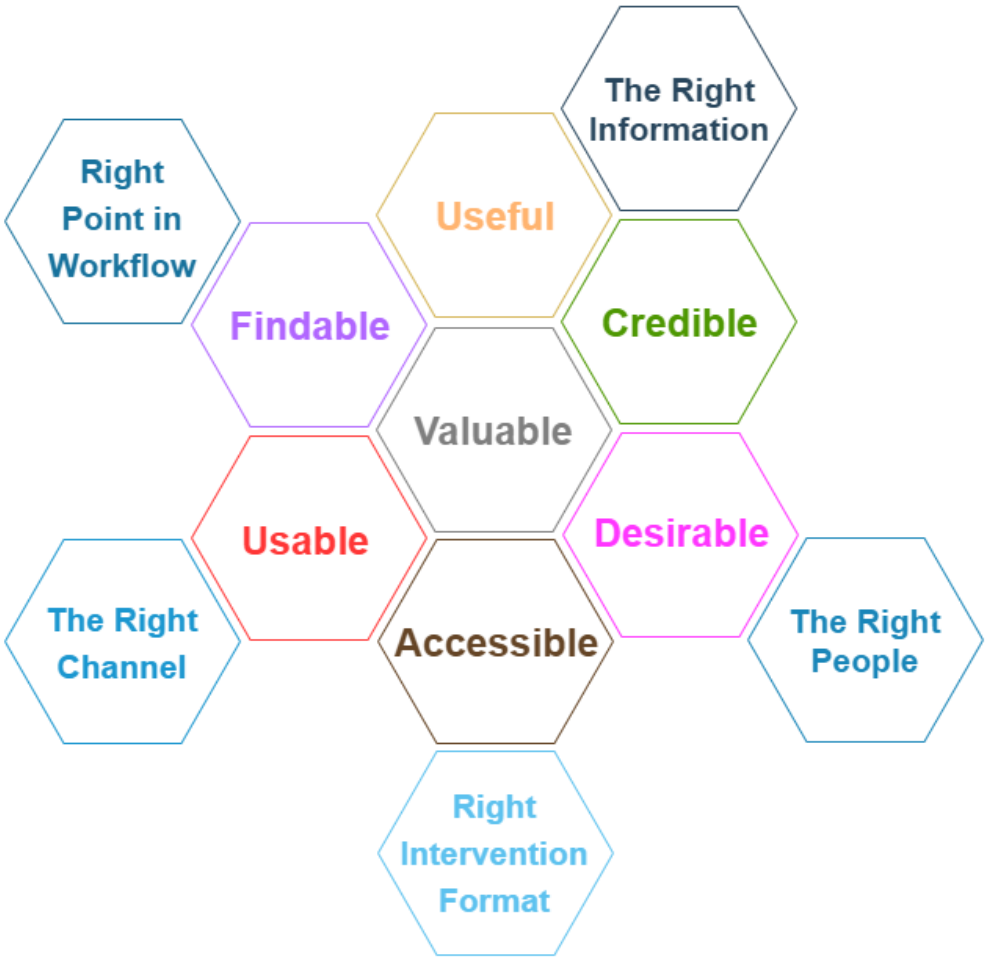


Figure 13 - CDS Five Rights and Morville's UX Honeycomb

3. RESEARCH METHODOLOGY

3.1 Introduction

Section three discusses the research methodologies used throughout this project by looking at research methods on a whole followed by the philosophy used, the approach and the research strategies.

3.2 Research Methodologies

Research is a process of discovering new, trustworthy, solutions to pre-defined problems through planned, systematic collection, analysis and interpretation of data [205]. The process of research involves a research methodology which describes the systematic way a problem is solved: defined as a science which studies how the research is carried out, or, as a study of the methods taken to gain knowledge [206].

There are two main areas of research methodologies: *objectivist* which seeks to research the world's truths, experienced by all social actors, through observable and measurable facts and *subjectivist* research where researchers consider differing opinions, including that of their own and different social actors [205], [207], [208].

Objectivist	***Subjectivist***
Quantitative	Qualitive
Positivist	Phenomenological
Scientific	Humanistic
Experimentalist	Interpretivist
Traditionalist	Constructivist

Table 3 - Objectivist and Subjectivist Philosophies [207]**,**[209], [210]

Table 3 lists the *objectivist* and *subjectivist* research philosophies. Given the nature of the projects proposed by the SOAC (School of Applied Computing) two research philosophies: *positivist* and *phenomenological* are most prevalent, covering *deductive* and *inductive* research approaches. These two approaches allow for the correct selection of three strategies which best relate to the type of project undertaken: experimental, development or survey (fig. 14), allowing for triangulation of results.

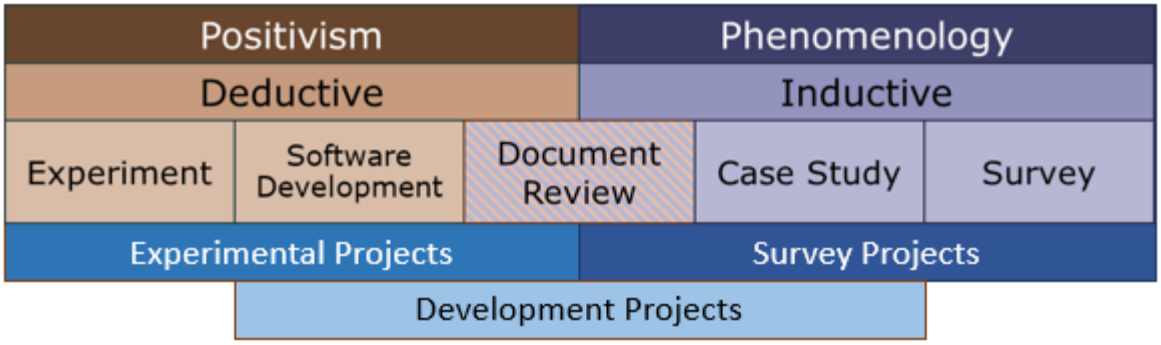


Figure 14 - Research Wall [211]

3.2.1 Research Philosophy

Mora *et al.* [212] state that positivism is considered the traditional paradigm for information technology research as it focuses on objective study from a concrete and measurable reality. However, the research wall (fig. 14) shows that development projects, such as this one, will use mixed philosophies.

The project's philosophy is mainly positivist as from a epistemological point of view the literature review and software development will produce measurable and credible results based on facts and not interpretations [210].

However, the project will also incorporate phenomenological research philosophies which focus on research and results from the perspective of the individual, whilst emphasising the important factors of personal perspective and interpretation [213].

3.2.2 Research Approach

Research has been carried out using both inductive and deductive approaches. Generally, a positivist philosophy favours a deductive approach and *phenomenological* philosophy an inductive [214].

Deductive research for this project is carried out in the form of two strategies: software development and (part of) the literature review as both will work from the 'top-down', beginning with general discussion to form a hypothesis, and end with specific findings based on existing, widely accepted, principles [215], [216].

Inductive research for this project will be carried out using three strategies: literature review (part of), case study and survey. Each strategy starting with the specific (the current system, existing CDSS) and ending with the general (general recommendations for improving the current systems and UX of CDSS) [215][216].

Inductive research is carried out from the 'bottom-up' by utilising a survey to gauge the test participants views to build themes and theories to improve system interfaces and design (paper-prototypes to finished systems) [217].

3.2.3 Research Strategies

The research wall guides to the use of three strategies to enable triangulation of results. The literature review forms a hypothesis whilst the case study collects qualitative data before and after the development of software to allow comparison. This triangulation is then used to prove if the projects aim has been delivered.

3.2.4 Literature Review

The literature review identifies the main theories in the field of DSS, CDSS, and their usage and usability to satisfy the aim. This positivist, deductive research has formed the hypothesis that despite widespread CDSS implementation, due to usability issues, CDSS are not used.

3.2.5 Case Study

The case study looks at the existing system the MIU has in place, as well as existing CDSS, from a phenomenological point of view. The considerations of the personal opinions and interpretations of the usability of current systems is used to gain subjective insights into user's personal motivations and actions which can remove the clutter of assumptions and conventional wisdom, from a statistical (developers) point of view, which may prove that current systems do work, when in reality, users state differently [213].

The case study will utilise usability tests in the form of interviews and SUS (system usability surveys) which aim to collect qualitative data from an individual's perspective to challenge the normative assumptions of CDSS interface design and to inform and support calls for action in terms of design changes.

3.2.6 Software Development

The software development research and methodology will be discussed, in detail, in the following section.

3.3 Conclusion

Section three has investigated research methodologies, philosophies, approaches and strategies. It states that this project will use not only objectivist methods, through positivist, deductive research strategies through part of the literature review and the software development and testing to gather and present

research and results based on fact, but subjectivist, phenomenological and inductive strategies through part of the literature review and usability testing which presents arguments based on individuals' perspectives as well. By covering both methodologies, philosophies and approaches, a well-rounded discussion with measurable results and immeasurable opinions can be presented.

4. DEVELOPMENT METHODOLOGY

4.1 Introduction

The following section discusses the methodologies employed for the development CDSS for the MIU. Firstly, user research and theories surrounding user personas and design patterns are discussed, followed by paper prototyping methods and the chosen development and software testing methods. Finally, the usability and user experience testing methodology are clarified preceding a conclusion. Each of the discussed methodologies will be practiced in section five of this report.

4.2 Interface Design Methodology

4.2.1 User Research & Personas

Designing with a user-centred approach creates the need to understand your users, as designing for everyone results in unfocused systems. Martin and Hanington [218] state that surveys and quantitative methods of research produces dehumanised characters, not useful when designing for specific user groups. They add that user personas provide a solution through relatable profiles which capture common behaviours of a certain user group which are useful in the definition and ideation stage of development.

Cooper [219] introduced the concept of user personas in 1998 through the need to synthesize and communicate design research. Cooper [220] states:

> *"Personas consolidate archetypal descriptions of user behaviour patterns into representative profiles, to humanize design focus, test scenarios, and aid design communication"*

Meaning that research into specific user groups of products can be used to create typical user profiles allowing for the product or system to be designed specifically for them, ensuring the user is always at the centre of design, in turn leading to a greater user experience [221].

Marsh [222] adds that personas encapsulate the goals, expectations, motivations and behaviours of real users of your system. When creating personas, designers need to consider questions like: why do users want to use your product system or website? And what are they looking for? Etc. The answers to these questions should come from user research, and not be made up.

This evidence supports persona use for this project, however, persona do have their weaknesses: they are often created but never used, not seen as important by managers or stakeholders simply do not know how to use them [223].

To overcome these challenges the personas will be used as reference when developing the systems interface and its features from start to finish. In regards to stakeholders, given the UX experience of the project supervisors, their value is already highly acknowledged and the overall stakeholder, the NHS, also recognise their value with all new digital products being developed around personas [224]. Finally, to avoid misuse, the personas for this project will be created from the literature review research [section 2] and their use will be research thoroughly to ensure the greatest value return.

Example personas can be found in appendix B1.

4.2.2 User Stories

User stories help design the IA for a system. They describe possible paths each user could take through an application or website, using the menus. Many user-stories will help describe the whole design of a system and improve the user's flow through the menus [222].

The information architecture for the MIU application is already dictated through the supplied paper document, therefore, no user stories will need to be created, however, this is usually a crucial design phase which should be mentioned.

4.2.3 Design Patterns

Design patterns are proven solutions to reoccurring design problems. The first book on design patterns was written by Alexander [225] in 1977 for architectural work, however, his work inspired developers, most notably, the *'Gang of Four'* [226] who developed reusable patterns for object orientated programming. Alexander's work also inspired UI designers like Tidwell [227], Borchers [228] and Van Duyne [229].

In 1999 Tidwell proposed building an HCI interface pattern language to help designers build better interfaces by capturing collective wisdom and defining a common language. Her work the foundation for the *common* interfaces used today. Most users of applications or websites will testify that they need to be *'intuitive'* to be easy to use, this however, this no mistake, since Tidwell's work, interfaces are designed to be *'familiar'* which makes them *'easy to use'*.

UI design patterns are implemented in many ways, for example, many application or websites will use the same patterns, although the implementation (content, graphical design) will be different. Patterns are the reason users understand that text in blue and underlined is a link or why adding shading to rectangles indicates clickable buttons [229] these visual clues are also known as *'affordances'* [155], [187]. Patterns

are also why users expect menus to be on the left or top of a webpage and why footers are used to signify the end of the page.

This evidence suggests that known design patterns should be used, for the MIU system this will be a modified two-panel selector as it is best suited for presenting the IA in the form of categories and to display selected information. It is a powerful learned convention which is familiar and easy to learn [230]. An excellent example of this is Microsoft's file explorer or Apple's iPhoto.

Additionally, Tidwell [230] states that an interface supporting behavioural patterns helps users achieve their goals effectively. These behaviours are explored, in relation to the proposed system in appendix B2, which will be adhered to when designing the MIU interface.

4.2.4 Paper Prototyping

Paper prototyping was first, sparsely, used by designers in the 1990s, however, it is now considered normal practice in the early stages of development. Sketches or wireframing software is used to produce interface designs matching the ultimate goal of the most important user, as discovered from the user personas [section 4.2.1]. Expected typical tasks for this user are then determined and designs of each window containing, menus, buttons, data, links etc. are drawn up which are required to perform your determined task [231].

Once a prototype has been created, a usability test is undertaken by a user who best matches your created persona. The tester plays the role of *'computer'* manipulating the paper interfaces, simulating how the interface would behave without explanations of how it should work. These initial user tests will be used to identify usability problems and provides evidence that a certain design matches researched user's expectations and delivers a proof of concept to validate further development of an interface design [232], [233].

Despite paper prototypes providing a rapid and iterative process to allowing quick discovery of usability problems and providing proof of concept by using real input from users, Kanpp [234] of Google Ventures views them as a waste of time. He argues that as paper prototypes do not look real, the responses from users will not be real. He continues adding sketches are not quick to produce, and do not evoke honest reactions, but only skewed, possibly dishonest, feedback.

Considering Kanpp's arguments, the paper prototypes used for the first round of user testing will be as close to the actual interface design as possible, ensuring *'real'* responses and reactions from users. The

project's strict time constraints also dictate that only two interface designs will be tested as sketching the interfaces is time consuming. Therefore, paper prototypes still have a value on a development project such as this one to provide an early proof of concept for the UI.

4.2.4.1 Prototype Testing

The paper prototypes will undergo the same usability testing techniques as discussed in section 4.5.3.

4.3 Feature Driven Development

FDD (Feature Driven Development) is a client focused, process orientated, agile development methodology which develops software in-line with the client's most valued features. Developed and first used by Peter Coad and Jeff De Luca in 1997 for a Singaporean Bank's large software project, it was publicly introduced in the 1999 book *'Java Modelling Color with UML'* co-authored by Coad and De Luca along with Eric LeFebvre [235], [236].

Like other agile processes, FDD is a collaborative, incremental and highly adaptive by nature which embodies the effective industry best practices: domain object modelling, development by feature, individual class ownership, feature teams, inspection, configuration, management, regular builds and progress reporting. It does not cover the entire software development process but concentrates on the design and building processes to deliver frequent, tangible results, with a high emphasis on quality [237]–[239].

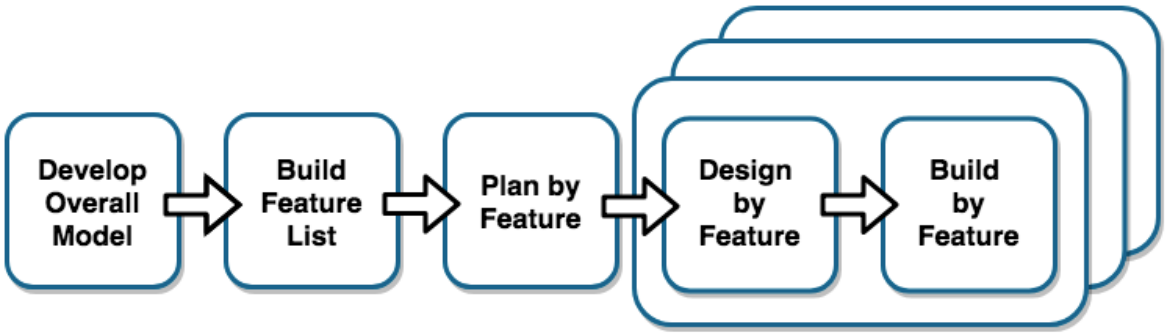


Figure 15 - Feature Driven Development Product Lifecycle [240]

FDD emphasises focus on the planning stages of a project. Palmer [241] states that the difficulty in this process is knowing when to stop, adding that FDD is about doing JEDI (Just Enough Design Initially) and

not BDUF (Big Design Upfront), meaning that FDD planning stages are not for thrashing out every model and requirement but are for creating a broad understanding of a project to create a foundation of which to build on where the plan and features list are not rigid or concrete but living and flexible, staying true to its agile roots.

Through different research strategies a high importance is placed on the planning stages of this project, making FDD a perfect choice as FDD also focuses mainly on the planning stages of software development [237][239][242], however, FDD is manly designed to support large-scale software projects, like the banking application it was designed for [237], and is often deemed unsuitable to small-scale software projects as it designed for teams up to 500 developers [236] and responds slowely to rapidly changing requirements [243], [244].

Despite this evidence, it is justified for a single person team as firstly, FDD feature lists are made up of items small enough to develop in small iterations, meaning that each feature will be implementable by a single developer in minimum time [245]. Secondly, it is suitable for new, start-up projects and is flexible, allowing for certain aspects to be dropped or added gradually when considering the scope of project [239]. Thirdly, it is suited to more novice developers, and developers of all abilities meaning that it fits the developer persona of this project [236][246] and finally, FDD pleases both the customer (MIU) by providing real tangible results are able to be delivered to a customer at the end of each iteration, and managers (lecturers), as the FDD focus on planning means a high level of detailed documentation can be provided to the mangers of the project [237].

A detailed discussion on the FDD processes is documented in appendix B3.

4.4 Software Testing

Beizer [247] states that for every one-hundred programming statements, there will be three bugs with Myers *et al*. [248] adding that, typically, a piece of software requires roughly 50% of development time and 50% of the budget. These figures mean that software testing in any project should play an important role. The main goal of software testing is verify and validate that the software works as desired ensuring that errors are found, it meets its requirements, and is of an acceptable level of quality [249].

Appendix B4 describes the V-model software development process which integrates testing with development, however, FDD, states no formal agile methodology for integrating software tests, therefore, an amalgamation of the FDD and V-models is proposed.

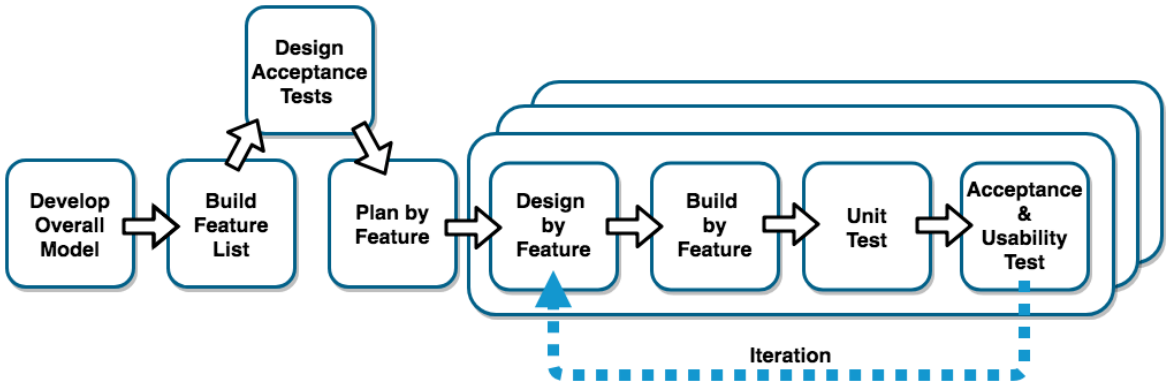


Figure 16 - Proposed Development & Software Testing Model

The proposal consists of utilising two of the test methodologies contained within the V-model, these are: acceptance tests and unit tests. During the planning stage of the FDD, more specifically, the system feature list stage, acceptance tests will be designed as per the V-model system requirements stage. Due to time constraints on the project, the process will then skip to implementation, followed by unit tests. Acceptance testing will then occur during the user testing stage, combing with usability tests. This process will be repeated for every iteration as per the FDD agile methodology (fig. 16).

4.5 Usability & User Experience Testing Methodology

4.5.1 Usability Testing

Usability of a product is defined by the '*absence of frustration'* in using it [250]. Usability should be *invisible* as products should work the way users expect without them bending to the will of the product [251]. The ISO [147] defines usability as:

> *"The extent to which a product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use"*

Barnum [251] highlights the word 'specific' in this definition for encompassing three critical elements of usability: products should be designed for specific users, who have specific goals within a specific context

of use. Products designed *specifically* will provide more satisfaction, be more effective and efficient for the user.

Usability testing is the systematic way of testing products designed in this way, by observing users work with a product whilst under observation [252]. The primary goal of usability testing is to improve the usability, as defined above, of a product, whilst also improving the process through a product is developed to eliminate reoccurring problems in design [253], therefore, it is perfectly suited to deliver a user-centred CDSS.

To conduct user-tests, interviews will be conducted with test participants who will complete a series of tasks on the system; tasks user's usually would look to perform [250][253]. The tasks will also vary depending on the stage of development, for example, paper prototype tasks may differ from that on a real system [187]. The methodology to be used is discussed, in detail, in appendix B5, along with the initial user testing script developed for use in section 5.3.3, in appendix B5.3.

Although usability studies are considered the gold standard of testing, there are several disadvantages, for example, they can be costly and time consuming to conduct, recruitment of the right participants can be difficult, and the resulting data is difficult to analyse. The solution to cost is covered by Nielsen [section 4.5.3] and, for relevance to this project, Krug [254] who designed DIY usability methods which will be employed, and although time consuming, the tests value far outweighs their time-cost, without user-testing it would be impossible to determine whether or not the CDSS produced has delivered on the project aim.

The justification for their use in respect to the other usability testing weaknesses identified are discussed in the following sections.

4.5.2 System Usability Scales

SUS (System Usability Scale) was invented in 1986 by John Brooke [255] to measure usability in reference to its particular context. Known as a *'quick and dirty'* method, it allows for low cost assessments of usability.

Using ten Likert-type scales with fixed 5-point scale responses (fig. 26), the SUS gives a subjective view of usability. It is easy to construct and administer, can be used on small projects and provides validatable results. However, the scoring system can be complex, requiring normalisation to produce percentile rankings and is not considered a diagnostic test, it simply classifies ease of use [251], [256], however, these

tests will produce quantitative data which will be used as supporting evidence when evaluating against the aim and objectives stated.

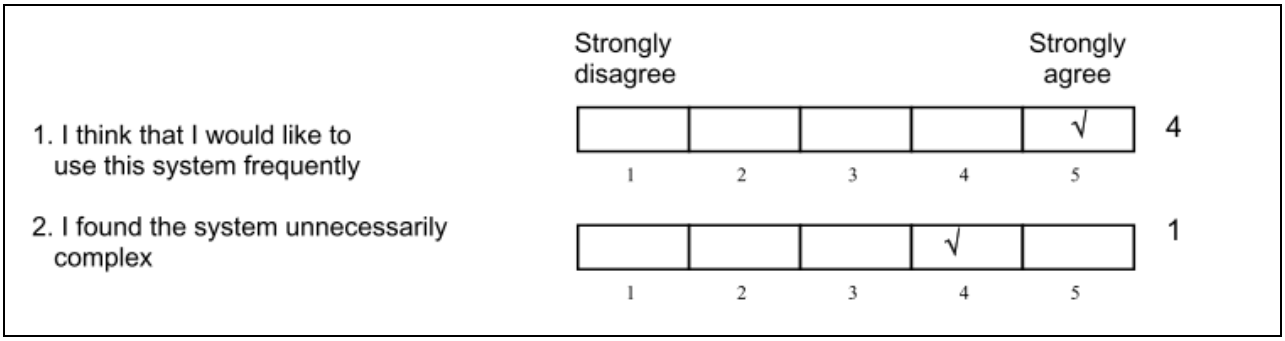


Figure 17 - Sample System Usability Scale [255]

For each question, the scores are converted to a number between 0-4. The scoring formula ranges for each question, for example, question 1. in figure 26 will be scored on the scale position minus 1, giving a score of 4 and question 2. will be scored as 5 minus the scale position, giving a score of 1. The scores are then multiplied by 2.5 to obtain the system usability value [255], Bangor [257] et al. interpreting the final score, shown in figure 18. The above example would have a system usability score of 12.5/100; however, it is worth noting that this is just an example calculation. For the SUS to be accurate, a ten-item scale should be used.

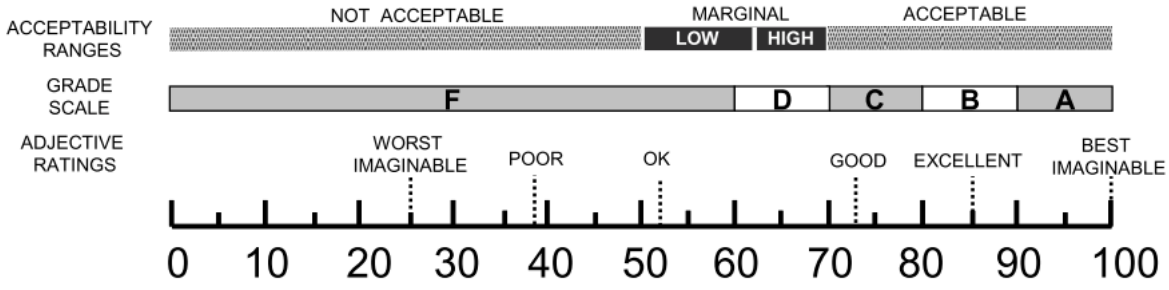


Figure 18 - System Usability Scale Grading [257]

The SUS used for this project is Brooke's original template, obtained from *measuringux.com* [258] and modified accordingly, which is found in appendix B5.5.

4.5.3 Test Participants

Until the 1990s usability testing was considered an expensive, time consuming and rigorous process, conducted by cognitive scientists, psychologists or HCI engineers. Due to its expense and complicity, usability testing was sparse [251]. However, In 1993, Nielsen and Landauer [259] changed how usability

testing was conducted by publishing research showing that the best balance of cost and benefit could be achieved, inexpensively, with just 5 participants and as many small tests as possible.

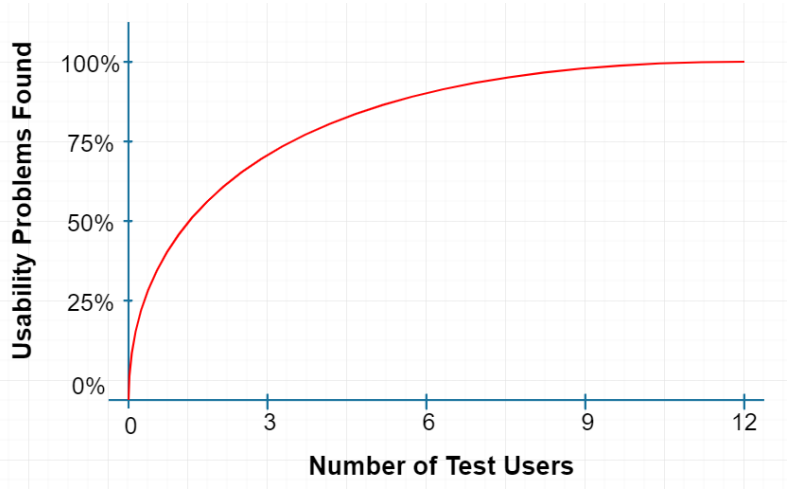


Figure 19 - Nielsen & Landauer's Usability Testing Curve [260]

The curve, derived from the formula, N (1-(1- L) n),where N is the total number of usability problems and L is the proportion of problems found with a single user, shows that 31% of all usability insights can be found with one user and that testing with anything above 5 users wastes resources as the as the optimal 85% of findings has been returned and the same problems will be repeated.

Krug [187], [254] further argues that three participants is enough for DIY testing, it is for this reason that user tests on the prototypes of the system will be conducted with 3-5 participants, however, recruiting 3-5 participants to match the user personas will prove difficult due to several reasons; mainly that highly trained NHS professionals are time constrained.

Dumas and Redish [253] state that participants must be from the group of users who will use the product, however, testing with MIU staff is not an option, therefore the next best thing is considered: first-aid trained participants. Krug [187], [254] agrees, stating *"recruit loosely and grade on a curve"* meaning that an attempt should be made to recruit users who reflect the audience, but is it not that important: testing with any users is better than none. By following this methodology, it is possible to avoid another usability test weakness presented in section 4.5.1.

The UWTSD student's union was contacted to enquire about communicating a social media post through their accounts to help recruit first-aid trained students to perform usability tests with. The correspondence

sent is found in appendix B5.6, but unfortunately, no response was received from the union, therefore, recruitment of friends and family who were first-aid trained commenced.

As participants would be recorded to allow for analysis of each test, a consent and recording release form has been designed for permissions, which is based on Krug's [254] form and is found in appendix B5.7.

4.2.4 Analysis of Results

Testing generates a large amount of data in the form of a problem list, questionnaire results and participants comments, and facilitator observations. Dumas and Joseph [253] present triangulation of sources as a useful technique.

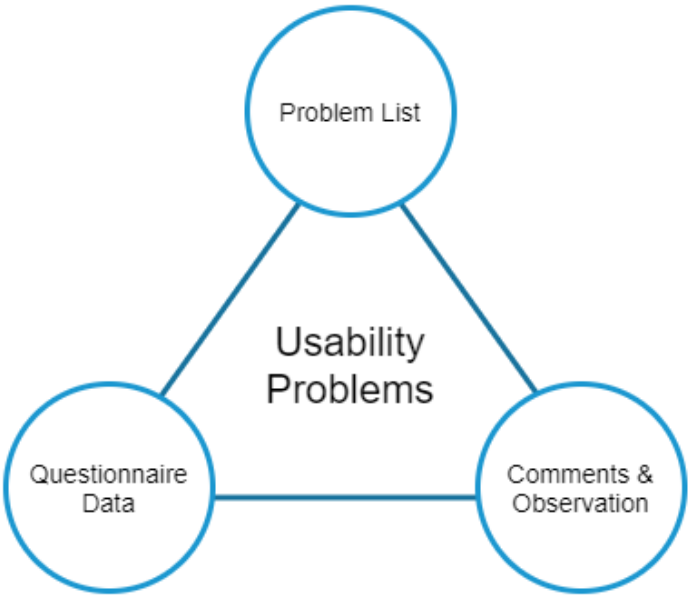


Figure 20 - Triangulation of Usability Test Results

The collected data is looked at together, discovering which data set supports another. For example, comments and observations made on a certain task may match up with frequent errors the user encountered and scores from the questionnaire. By seeing all three areas highlight a specific problem it can be considered a serious usability issue which needs addressing, which should be rectified and tested again in the following round of tests.

This triangulation can be used for each task asked of the participant, the data can be used to formulate a list of usability problems in order of severity. Krug [254] argues that there are always more problems than resources to fix them and focus should be on fixing the most serious first. Given the limited resources and

time for this project, the triangulation technique allows for the most serious problems to be identified and fixed accordingly as well as addressing the weakness raised in section 4.5.1.

4.5.5 Conclusion

The user testing methodology discussed in section 4.5.3 aims to discover the most prevalent usability problems with the system, however, through the results, a gauge on how the user feels about the system in terms of experience will also be measurable to discover whether the system covers all facets of the UX honeycomb [section 2.5.2].

4.6 Tool & Technologies

The following section lists the software and hardware tools, furthermore, the current development technologies used within the project are also discussed.

4.6.1 Software Used

1. **Visual Studio Code**

   VS code has been chosen for this project as it is a free, open-source, cross-platform code editor which integrates debugging, Git control, intellisense (Intelligent Code Completion) and syntax highlighting [261]. It permits this project to be developed on macOS and Windows.

2. **Azure Data Studio**

   A cross platform, SQL database tool incorporating intellisense and Git source control for use with local and Azure cloud-based database servers [262]. Allows the project to be portable by connecting to cloud-based database servers. Integrated analytical dashboard also allows for database analytics.

3. **GitKraken**

   GIT version control client which allows tracking and editing of changes [263]. Free 1-year subscription through the GitHub student pack [264].

4. **Balsamiq**

   GUI for mock-up/wireframe prototypes for website UI through a desktop or web-based client. Chosen for its ease of use and drag and drop WYSIWYG interface [265].

5. **Draw.io**

   Open-source diagram application used for figures, UML and ERD [266]. Easy to use interface and range of diagram templates.

6. **Azure DevOps**

   Web application for team planning and collaboration of software projects. Chosen for its extensive agile planning tools: sprint/iteration trackers with interactive Kanban boards for task planning and assigning, back log lists and organisation tools for planning. Also incorporates free Git repositories with Azure pipeline services which build, test and deploy software, in any language to Azure cloud hosting [267]. A professional web application used by professional development teams around the globe.

7. **Azure Portal**

   Online development hub offering free student access to web application hosting, cloud SQL databases, virtual machines, networks, and analytical services, automatic database tuning and security [268].

8. **Microsoft Excel**

   Microsoft Excel [269] is a cross platform spreadsheet tool used to test the relational integrity of the database used.

9. **Silverback 3**

   Silverback [270] is simple recording software which records video and voice as well as user's screen movements. A perfect tool for post-interview analysis.

4.6.2 Technologies Used

1. **.NET Core**

   A free, cross-platform and open-source software framework and class library for C# and F# languages. Developed from the successful, Microsoft-only, .NET Framework, it is openly maintained by developers on GitHub [271].

   Development for this project will be split between macOS and Windows, therefore, .NET Core is used for cross-platform capabilities. Additionally, .NET Core offers MVC and Web API frameworks. It is the third most popular framework and C# the fourth most popular web development language [272], therefore, there will be plenty of documentation to support this project and perfecting these languages will increase employability after university.

2. **Dapper ORM**

   Dapper [273] is a free, open-source and lightweight ORM tool developed by stack overflow. Allows for SQL queries to be written in .NET applications in their native syntax.

3. **Git Version Control**

   Git version control was created in 2005 by Linus Torvalds [274]. It is a distributed VCS (Version Control System) tracking and records changes to a file(s) over time, allowing developers to recall previous versions of software and revert to a previous state of file. It endorses collaboration between developers, allowing modifications to be tracked to a specific person, date and time. It encourages experimental programming through easy recovery of original versions of files, if mistakes are made [275]. Given the experimental nature of the proposed solution to the MIU's problem, Git version control is a must when implementing each feature.

4. **Bootstrap**

   Free and open-source HTML and CSS front-end web framework [276]. Chosen for its wide range of typography, forms, buttons, navigation and associated interface components and flexible, responsive, grid layout.

4.7 Conclusion

Section four has described, in detail the methods, tools and technologies to be employed for development of the MIU system. Initial interface designs will be produced using the balsamiq mock-up tool using user personas created from research in section two and common interface design patterns. The paper mock-ups will then undergo user tests as described in section 4.5, discovering if the proposed interface design is an acceptable UI foundation on which to build.

Once the UI foundation is laid, the FDD process will begin, starting with the detailed planning stages followed by the development, with the stated tools, following the FDD processes of design, build, unit test and usability test for each feature or set of features. Each round of usability tests will subsequently improve the system to deliver a useful, usable system to the MIU.

5. DESIGN & IMPLEMENTATION

5.1 Introduction

Section five focuses on the problem to be solved and how it will be solved through, firstly, looking at the requirements needing to be met to deliver the updated aim and objectives. The process of implementation is documented to explain how the problems have been solved.

5.2 Problem Formulation

The following section outlines the system's requirements using the MoSCow method and shows the updated (from section 1.1) aims and objectives to be met to address the problem the NHS MIU has presented, discussed in section one.

5.2.1 System Requirements

The system requirements were discovered in section 2 and the user research in section 5.3.3. A list of features to be implemented are derived from this section and the overall model. The feature resides in section 5.6.2. Concluding each timebox in section 5.6.4 will be a feature list updated with findings from the acceptance and usability tests.

5.2.2 MoSCow Requirements List

The system requirements are organised into functional and non-functional requirements, where, functional requirements describe the systems behaviours or functionality which should be provided for users, and non-functional requirements describe how the system *'should be',* or how it *'should work'* in terms of the environmental conditions under which the application needs to remain effective [277], [278].

The requirements are prioritised using the MoSCow method, a process which adheres to the following principles [277], [279]:

Must Have – Unnegotiable requirements deliverable features. The minimum requirements which should be delivered to prevent project failure.

Should Have – Requirements which should be included within the time constraints of a project, if possible. The project's success does not hinge on these requirements.

Could Have – *'Wish List'* requirements*:* advantageous to be included if time and cost permits.

Won't Have – Requirements of low importance which the stakeholders requested. Will not be included in this version of the project.

Key	*Description*
	Usability
	Performance
	Features
	Processing

5.2.2.1 Functional Requirements

i. ***Must Have***

Key	*Requirement*
	The system must display current MIU ENT guidelines.
	The system must be functional on desktops and tablets.
	The system must link related guidelines together.
	The system must work across all operating systems & web browsers.
	The system must hold & display information on each department in the Hospital.
	The system must have a secure login system

ii. ***Should Have***

Key	*Requirement*
	Database should be auditable.
	Users should be able to perform CRUD operations on the database.
	The system should be extendable.
	The system should have contrast control.
	The system should have font size control.
	The system should have a comprehensive search function.
	The system should have voice navigation.

iii. ***Could Have***

Key	*Requirement*
	The system could have customisation for each user.
	The system could have BLE Bluetooth Beacon integration.
	The system could have printing/exporting of guidelines.

iv. ***Won't Have***

Key	*Requirement*
	The system won't use SNOMED or alike clinical vocabulary.

5.2.2.2 Non-Functional Requirements

i. ***Must Have***

Key	*Requirement*
	The system must be easy to use.
	The system must load and display information quickly.
	The systems information must be easy to find.
	The system must follow known NHS/GOV design patterns.
	The system must have a structured ontology.
	The system must allow multiple users access simultaneously

ii. ***Should Have***

Key	*Requirement*
	The systems databases should not have any downtime.
	Admins should have elevated rights to perform CRUD operations on system.
	The system should have a comprehensive search function.
	The system should have a RESTful service layer.

iii. ***Could Have***

Key	*Requirement*
	The system could be aesthetically pleasing.
	The system should be available in English and Welsh
	The system could support different orientations on tablets.

iv. ***Won't Have***

Key	*Requirement*
	The system won't have AI technology.

5.2.3 Aim & Objectives Updated

Post literature review, the initial aims and objectives for the project stated in section 1.1 have changed. This section outlines these updated aims and objectives.

5.2.3.1 Project Aim

To develop and deliver a user-centred Computerised Clinical Practice Guideline system, as a web app, using an MVC framework with a RESTful web service layer and an SQL data service with a usable, intuitive interface.

5.2.3.2 Project Objectives

1. Investigate, through a literature review, current CDS technologies and current user experiences with these technologies.
2. Design and build the CDSS using an agile, FDD approach and the latest available software and technologies.
3. Conduct software and usability tests throughout the project to ensure system will deliver a good user experience.
4. Evaluate the system to conclude whether the aim has been met and to propose future recommendations.

5.3 Design

Prior to writing code, design planning must take place on the design of the database and the interface. Section 5.3 discusses each design stage through two *design* timeboxes. Each timebox will aid in the implementation shown in section 5.6 where the database model is used to develop the overall model and the interface designs are used as reference when developing the front-end interface.

These timeboxes differ slightly from the implementation timeboxes found in section 5.6 as neither the database design or front-end interface design will have feature sets or feature designs, however, the database design will be tested by scrutinising the relationships between the tables, and the prototype interface designs subjected to usability and user experience tests.

5.3.1 Design Timebox One - Database Design

Date	*Duration*	*Completion Date*
11/03/19	*7 days*	17/03/19

5.3.1.1 Formulation of Database Design One

Version one of the database was drawn following the documents structure, in terms of the sections, sub-sections, sub-sub sections and the guidelines and images. The guidelines themselves were organised into 6 different resource groups for categorisation.

Designing the database model following the guideline document produces a semantic data model which adds basic meaning to the data and relationships between entities, the advantage being usability, interoperability and effectiveness [280].

Figure 21 shows the different document sections, which would be described in the *Sections* table, ordered by the priority 2, as it is the second section in the document and each section highlighted in the screenshot would belong to the orthopaedics department, therefore, would be referenced to this department in the *Department* table.

SEC_ID	SEC_NAME	*SEC_DEPT*	PRIORITY
S002	Hand Injuries	D001	2

DEPT_ID	DEPT_NAME	DEPT_HEAD	CONTACT_NO
D001	Orthopaedics	Dr. Orth	4111

Contents	**Page**
Clinical assessment	**2**
Hand injuries/conditions	**10**
Wrist injuries/conditions	**31**
Elbow injuries/conditions	**41**
Shoulder injuries/conditions	**51**
Foot injuries/conditions	**58**

Figure 21 - Document Sections in Section Table

Figure 22 shows the main section heading of the Hand Injuries section and the level-two heading *Anatomy,* stored in the *Sub Section* table, which resides under it. Also displayed is an image of the hand's anatomy, which would be stored in the Image table and reference the *Sub-Section* heading Anatomy's ID to ensure correct placement in the system when querying the database.

IMG_ID	IMAGE	IMG_DESC	CAPTION	IMG_DATE	*SUBSEC_ID*
I001	Hand_Anatomy	Annotated skeleton of hand	NULL	01/02/2010	SS001

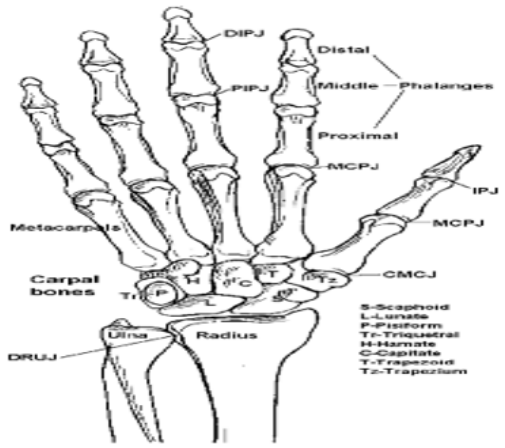
This also applies to the guideline on display below the image which would be stored in the *Guideline* table and reference the same sections as the image with an additional reference to the Resource table as it is an observation resource.

GL_ID	GUIDELINE	*SUBSEC_ID*	*SSH_ID*	*RES_ID*
GL001	NUMBER the metacarpals (i - v) & NAME the phalanges (ie. Thumb, Index)	SS001	NULL	R004

RES_ID	RES_GROUP
R004	Observationes/Notes

HAND INJURIES

ANATOMY



N.B. You NUMBER the metacarpals i.e. I – V but you **NAME** the phalanges i.e. thumb, index etc

Figure 22 - Section and Sub-Section

Figure 23 shows the stress testing section where the stress testing heading would be stored in the *Sub Section* table referencing the *Section* table's *Hand Injuries ID* and ordered by priority 5 as it is the 5th *Sub Section* in the document.

SS005	Stress Testing	S002	5

Underneath this heading the sub-section headings stored in the *Sub-Section Headings* table are shown, e.g. *Ulnar Collateral Ligament* or *Collateral Ligaments of the Fingers* which reference the *Stress Testing* sub-heading ID in the *Sub-Section table*.

SH004	Ulnar Collateral Ligament	SS005	4
SH005	Collateral Ligaments of Fingers	SS005	5

Underneath these 3rd level headings are the guidelines, stored in the *Guideline* table which reference the *Stress Testing ID* in the *Sub-Section* table, the Ulnar Collateral Ligament heading ID in the *Sub Section Headings* table and the action *resource ID* in the *Resource* table.

GL_ID	GUIDELINE	*SUBSEC_ID*	*SSH_ID*	*RES_ID*
GL011	To test Ulnar Collateral Ligament of thumb, isolate metacarpal and stress thumb laterally	SS005	SH004	R002

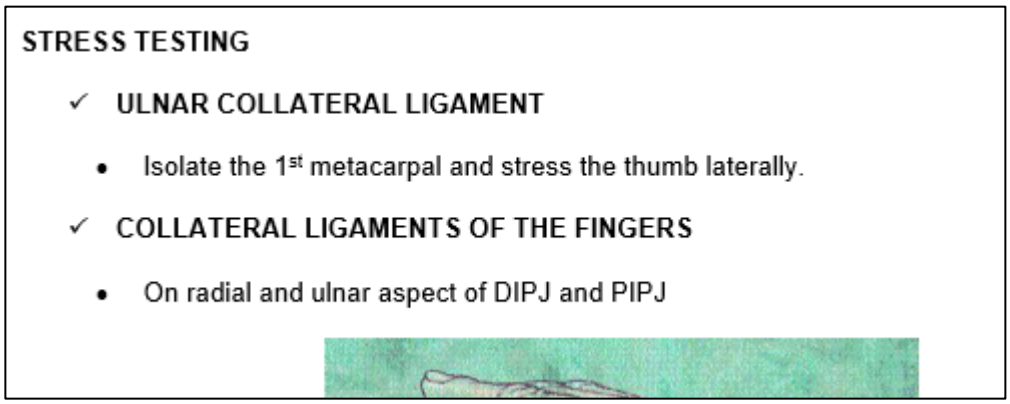


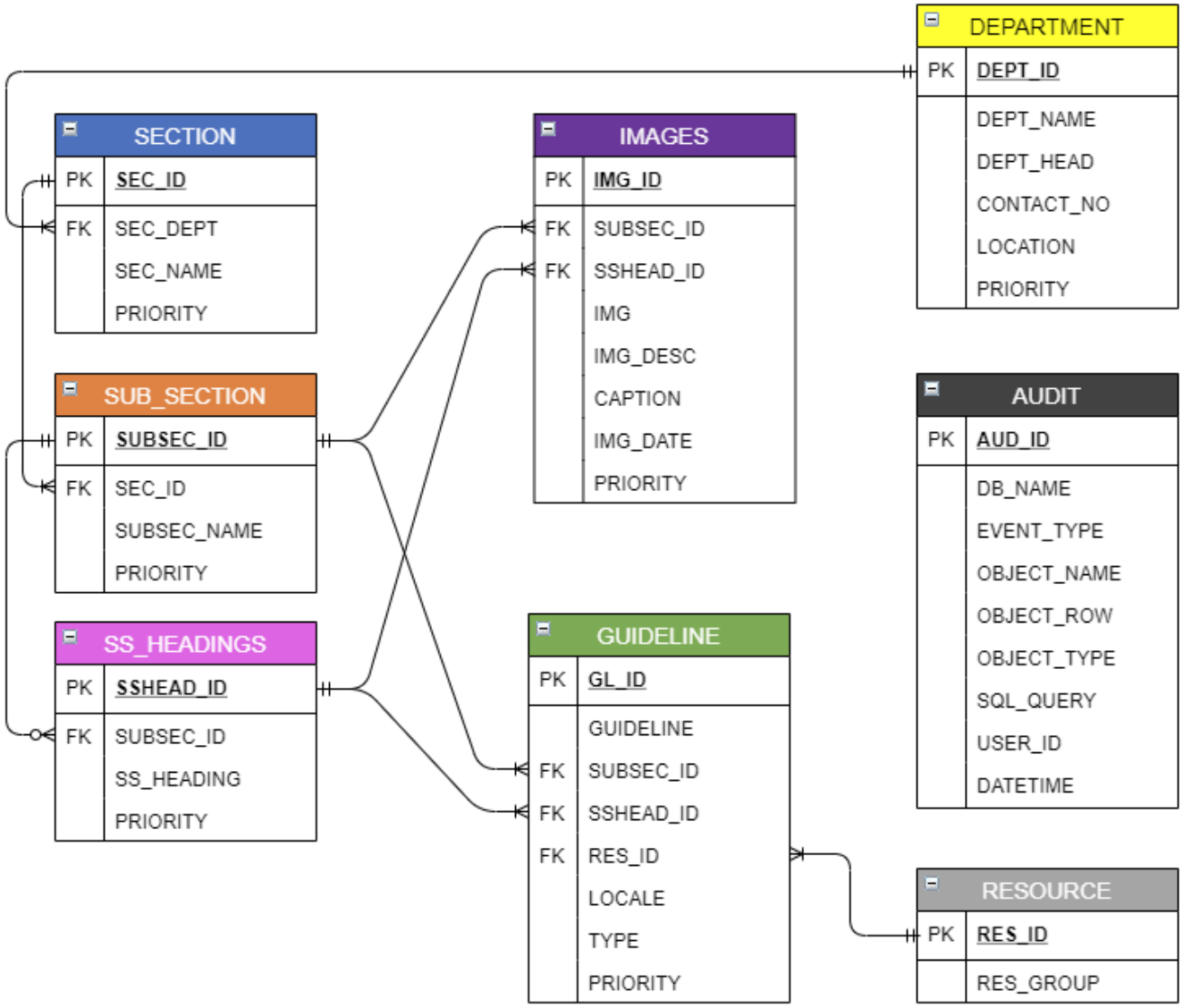
Figure 23 - Sub-Section & Sub-Section Headings

i. ***Table & Column Descriptions***

Table	*Description*
Department	Contains the department contact details each page relates to, for example, Hand Injuries is part of the Orthopaedics department.
Section	Contains the highest-level headings stating the sections in the document: Hand Injuries, Ankle Injuries, Throat Problems etc.
Sub-Section	A repository containing the 2nd level headings in the document, these are: Anatomy, History, Examination or Thumb Movements, Bennett's Fracture, when using the Hand Injuries section as an example.
Sub-Section Headings	A repository containing the 3rd level headings in the document, these are: Look, Feel, Move, Treatment or Radial Nerve or Mallet Deformity, again, for the Hand Injuries section.
Guideline	Contains every guideline text throughout the document, for example, '*examine the elbow'.* Also contains a reference to the Sub Section and Sub Section Headings tables to ensure each guideline is displayed in the correct area in the document. Also references the Resource table to categorise each guideline.
Resource	Contains each resource for reference, for example, *'examine the elbow'* is an *'action'* resource or *'localised tenderness'* is a symptom resource.
Image	Much the same as the guideline table, contains the images to be displayed under the relevant, sub-section & sub-section headings.
Audit	Auditing table which logs any activity, made by any user, throughout the database.

Table 4- Database Model Tables Version Two

ii. ***Entity Relationship Diagram***



iii. ***Testing of Database Version One***

Version one of the database model was tested by entering Hand Injuries data into an Excel spreadsheet, testing the referential integrity of the database. The following problems were discovered:

Within each section, the document contains different headings, of which the guidelines reside under, therefore a table was created to house these level two headings which would reference the *Section* table so each heading would have a relationship with the correct section (Figure 24). However, as every section in the document contains the headings *Anatomy, History and Examination* this violates database First Normal Form (1NF) practices which state that databases should not store multiple fields of the same data in the same place. As there are 21 sections in the document, each containing these sub-headings, each one would be repeated 21 times meaning a total of 189 repeated rows which would affect performance.

SUBSECTION			
SUBSEC_ID	SUBSEC_NAME	*SEC_ID*	PRIORITY
SS001	Anatomy	S002	1
SS002	History	S002	2
SS003	Examination	S002	3
SS004	Thumb Movements	S002	4
SS005	Stress Testing	S002	5
SS006	Neurovascular	S002	6
SS007	Fractured Neck of Fifth Metacarpal	S002	7
SS008	Fractured Metacarpal Shaft	S002	8
SS009	Metacarpal Base Fractures	S002	9
SS010	Phalangeal Fractures	S002	10
SS011	Bennett's Fracture	S002	11
SS012	Volar Plate Injury	S002	12
SS013	Interphalangeal Joint Dislocation	S002	13
SS014	Epiphyseal Injuries in Children	S002	14
SS015	Nail Bed Injuries	S002	15

Figure 24 - Sub-Section Table V1

Unnecessary repetition was also discovered in the *Sub Section Heading* table which contains the level-three headings which reside under different level-two headings. (Figure 25). The headings *Look, Feel* and *Move* are repeated in every section, again meaning 189 repeated rows, furthermore, the majority of the sub-sections in the table are headings for each illness, of which, each has a *Treatment* heading meaning that *Treatment* would be repeated in the *Sub-Section* Heading table for every sub-section which had a treatment sub-sub heading, as shown in Figure 25. Again, this is violating database normalisation.

SUBSECTION HEADING			
SSH_ID	SS_HEADING	*SUBSEC_ID*	PRIORITY
SH001	Look	SS003	1
SH002	Feel	SS003	2
SH003	Move	SS003	3
SH004	Ulnar Collateral Ligament	SS005	4
SH005	Collateral Ligaments of Fingers	SS005	5
SH006	Median Nerves - Motor Function	SS005	6
SH007	Ulna Nerve - Motor Function	SS005	7
SH008	Radial Nerve	SS005	8
SH009	Treatment	SS007	9
SH010	Treatment	SS008	10
SH011	Treatment	SS009	11
SH012	Treatment	SS010	12
SH013	Treatment	SS011	13
SH014	Treatment	SS012	14
SH015	Treatment	SS013	15

Figure 25 - Sub-Section Headings Table V1

Remaining tables in this design worked well and adhered to relational database best practices. This initial design, although flawed, would work, however, should the application be scaled up, this design would cause problems, as similar data would be stored in more than one place, increasing the possibility of redundant data, additionally, mapping the database to an object-orientated program would be more difficult, furthermore, performance would suffer [281][282].

The test spreadsheet can be found in the appendix C1 of this report. The spreadsheets will also accompany the code submission for this project.

5.3.1.2 Formulation of Database Version Two

Using the same data as V1, a semantic model was formed with each section in the document following the same four level heading structure which the guidelines and images reside under. The guidelines have been categorised into six resource categories.

Version two uses a further normalised schema to avoid repetition. To do this the *Section* table was replaced with a *Page* table containing all the Page headings which were previously found in the *Section* table. By renaming the table *Page*, it denotes the real-world relationship better. Therefore, referring to Figure 21 section 5.5.1.1, each section in the document is now a page on the system.

PAGE					
PAGE_ID	PageName	PageDescription	PageDate	*DEPT_ID*	Priority
H000	Review Clinic	General clinic overview	02/01/2019	D005	PR000
P001	Clinical Assessment	General Clinical Asses	02/01/2019 15:00	D005	PR001
P002	Hand Injuries	Page for breakages, etc.	02/01/2019 15:00	D001	PR002

Figure 26 - Page Table

Sub-Section and *Sub-Section* Headings tables are also replaced with one *Headings Repository* table (Figure 27) which holds headings present throughout the document, regardless of their hierarchy. Furthermore, a new *Heading Date* column has been added allowing reference to when each heading was created, important when considering the findings that for CDSS to be successful they should be kept up to date [section 1].

Headings(Repository)		
HEAD_ID	HeadingText	HeadingDate
H003	Anatomy	DATE&TIME
H004	History	DATE&TIME
H005	Examination	DATE&TIME
H006	Look	DATE&TIME
H007	Feel	DATE&TIME
H008	Move	DATE&TIME
H009	Thumb Movements	DATE&TIME
H010	Stress testing	DATE&TIME
H011	Ulnar Collateral Ligament	DATE&TIME
H012	Collateral Ligaments of the Fingers	DATE&TIME
H013	Fractured neck of fifth metacarpal	DATE&TIME
H014	Treatment	DATE&TIME

Figure 27 - Headings Repository Table

To bring the correct headings into the correct pages at the right level and order throughout the system a new Guideline Heading table was created, acting as central look-up table which breaks up the one-to-many relationship, shown in the ERD, which was present in version one between the sub-headings (*Sub Heading Table*) and sub-sub-headings (*Sub Section Headings Table*) and the guidelines in the *Guideline* table and images in the *Images* table.

GuidelineHeading				
GLH_ID	*HEAD_ID*	*PAGE_ID*	Level	Priority
GLH001	H003	PG002	2	1
GLH002	H004	PG002	2	3
GLH003	H005	PG002	2	4
GLH004	H006	PG002	4	5
GLH005	H007	PG002	4	6
GLH006	H008	PG002	4	7

Figure 28 - Guideline Heading Table

Now when a page contains the same headings as another, the Guideline Heading table is simply referencing the column in the *Headings Repository* table, adhering to 3NF normalisation rules. Figure 28 shows how this table references each heading to each page, shown in figure 29. The *Guideline Headings* are ordered firstly by level and secondly by priority, for example: heading H003 represents *Anatomy* which is the second level heading on the Hand Injury page and is the first heading in terms of priority on the Hand Injuries page.

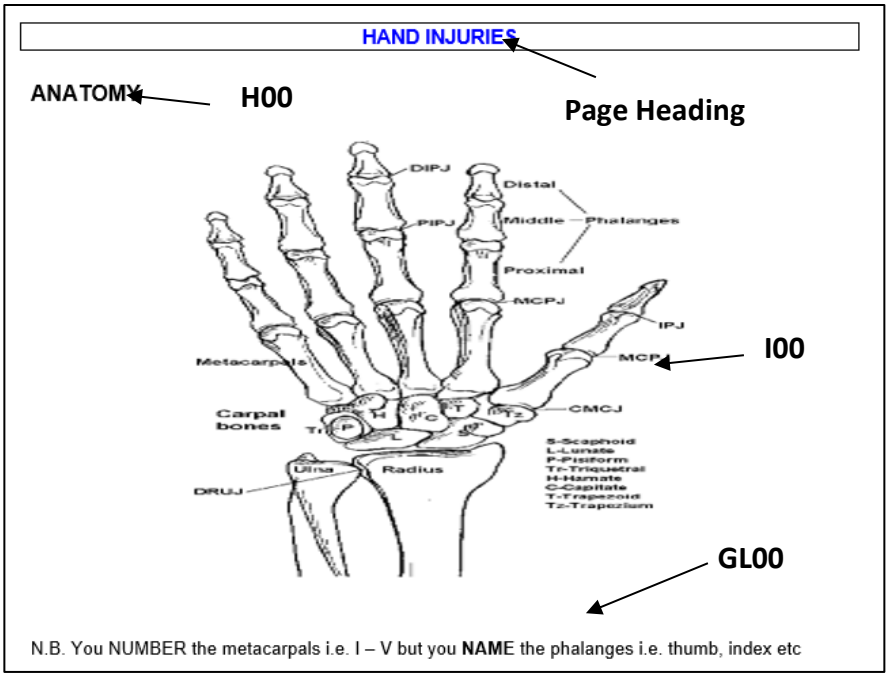


Figure 29- Hand Injuries Section Version Two

Now, each *Page* and *Heading* has their own unique ID which the *Guideline* and *Image* table reference to know what page they will be displayed on, and under what heading. For example, the hand image in in Figure 37, is referenced under *Anatomy* (GLH001) and is the first item on the page so is ordered by priority 1.

IMAGE						
IMG_ID	*GLH_ID*	Image	ImageDesc	ImgCaption	ImgDate	Prioirty
I001	GLH001	Hand_Anatomy	Annotated skeleton of hand	NULL	01/02/2010	1

Similarly, the guideline on this page follows the same references; it resides under *Anatomy* (GLH001) and is the second item on this page, therefore it is ordered by priority 2.

GUIDELINE						
GL_ID	GuidelineText	GLH_ID	GuidelineDate	*RES_ID*	LOCALE	Priority
GL001	NUMBER the metacarpals (i - v) & NAME the phalanges (ie. Thumb, Index)	GLH001	03/01/2019 15:00	R004	gb-EN	2

When looking at the 3rd and 4th level headings in the document the *Stress Testing* section is again used as an example, shown in Figure 30.

Headings(Repository)		
HEAD_ID	HeadingText	HeadingDate
H010	Stress testing	DATE&TIME
H011	Ulnar Collateral Ligament	DATE&TIME
H012	Collateral Ligaments of the Fingers	DATE&TIME

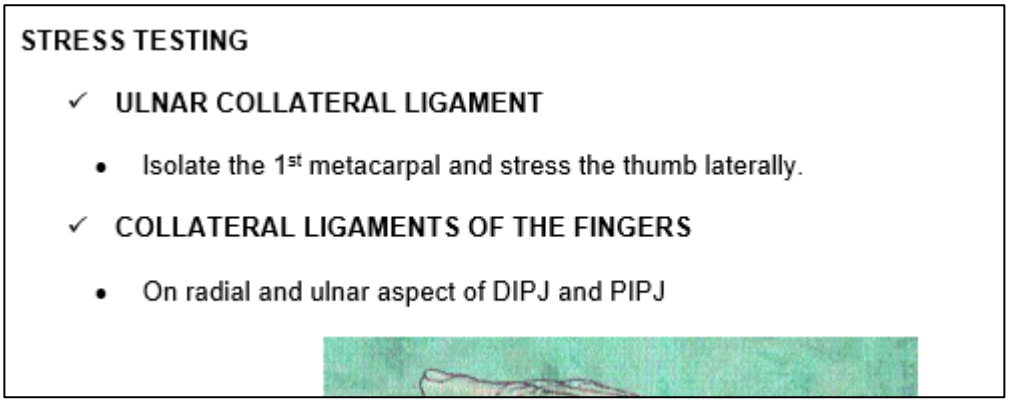


Figure 30 - Level 3 & 4 Headings

The three headings displayed in the document have ID's of H010, H011 & H012 respectively and are ordered sequentially with the *Stress Testing* heading (H010) being a higher, 3rd level heading. This is represented in the *Guideline Heading* table as:

GuidelineHeading				
GLH_ID	*HEAD_ID*	*PAGE_ID*	Level	Priority
GLH007	H010	PG002	3	8
GLH008	H011	PG002	4	9
GLH009	H012	PG002	4	10

Where, *Stress Testing (*H010*)* is located on the *Hand Injuries* (PG002) page and is a 3rd level heading and is the 8th heading on this page. Following this pattern, the *Ulnar Collateral Ligament* (H011) heading is a 4th level heading and is the 9th heading on this page. This pattern continues for every heading in the system.

Now, the 4th level headings know what position on the page they will be, the *Guideline Heading ID* associated to these headings can be referenced in the *Guideline* table. For example:

GUIDELINE						
GL_ID	GuidelineText	GLH_ID	GuidelineDate	*RES_ID*	LOCALE	Priority
GL011	Isolate metacarpal and stress thumb laterally.	GLH008	13/01/2019 15:00	R002	gb-EN	PR011
GL012	Located on radial and ulnar aspects of DIPJ and PIPJ	GLH009	14/01/2019 15:00	R004	gb-EN	PR012

Guideline GL011 references GLH001 which is the *Ulnar Collateral Ligament* heading and GL012 references GLH009 which is the *Collateral Ligaments of the Fingers* heading, now each guideline knows which location in the document it should be displayed. Also, in this example, is the reference to the *Resource* table where R002 is an *Action* as it instructs the practitioner to perform an action and R004 is an *Observation* as it denotes observations made by previous practitioners about the location of the *Collateral Ligaments*.

Also, worth noting in this table is the use of the LOCALE field. At present the guidelines are written in English, however, with Welsh Government initiatives to implement the Welsh language in every sector, this column provides future proofing of the system in this respect. New guidelines in Welsh would be added to the same table, however, the LOCALE would be *'gb-CY'* allowing for the data driven interface to switch between languages programmatically with minimal changes to the database structure.

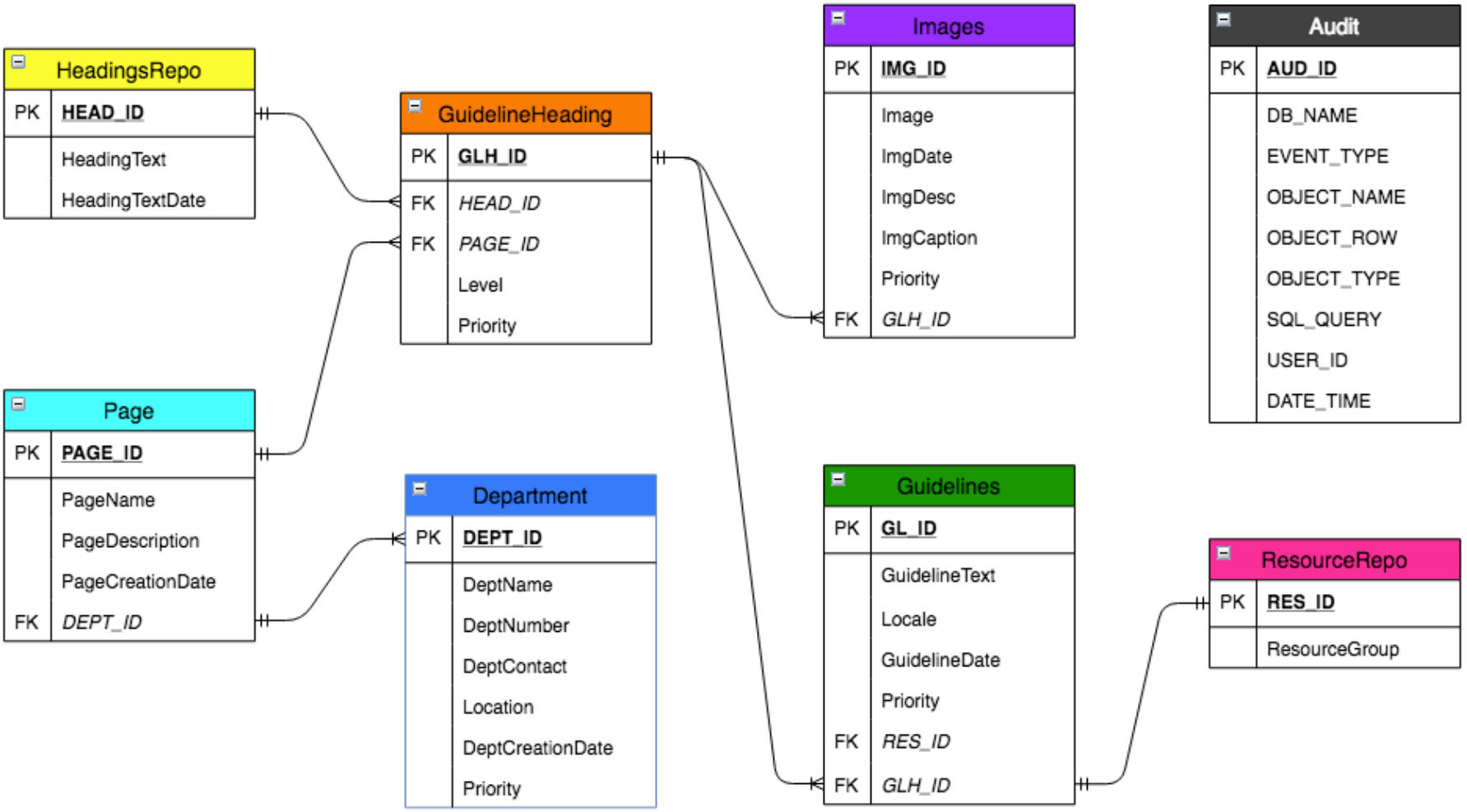
The examples shown in the screenshots denote that the ID's will start with different letter prefixes, however, as these ID's will auto-increment upon insertion, the prefixing will be dropped. The test spreadsheet is in appendix C2.

*i. **Table & Column Descriptions***

Table	*Description*
Department	Contains the department contact details each page relates to, for example, Hand Injuries is part of the Orthopaedics department.
Page Table	Contains the highest-level headings stating the sections in the document: Hand Injuries, Ankle Injuries, Throat Problems etc.
Headings Table	A repository containing the 2nd, 3rd & 4th level headings in the document, some are 2nd level Injury headings: Thumb Movements, Bennett's fracture etc. & some are 3rd & 4th level headings appear in each section: Anatomy, Look, Treatment etc.
Guideline Heading Table	References the headings to the correct page. For example, Anatomy & Feel are referenced to the Hand Injuries page.
Guideline	Contains every guideline text throughout the document, for example, '*examine the elbow'*. Also contains a reference to the Guideline heading table to place each guideline under the correct heading and references the resource table.
Resource	Contains each resource for reference, for example, *'examine the elbow'* is an *'action'* resource.
Image	Much the same as the guideline table, contains the images to be displayed under the relevant, referenced guideline heading.
Audit	Auditing table which logs any activity, made by any user, throughout the database.

Table 5 - Database Model Tables Version Two

ii. ***Entity Relationship Diagram***



iii. ***Testing of Database Version Two***

The tests have shown no errors and theoretically prove the proposed database design will be suitable. The test spreadsheet is found in appendix C2 and accompany the code submission.

5.3.2 Audit Table, Metadata & Data Governance

Thomas [283] states that data governance is:

> *"The exercise of decision-making and authority for data related matters. It is a system of decision rights and accountabilities for information-related processes, executed according to agreed-upon models which describe who can take what actions with what information, and when, under what circumstances, using what methods"*

The database will contain sensitive information in two tables: *Department* and *Audit* (figure 29). The department table holds data on each hospital department and its location, the names of department staff and their contact details. The audit table will hold metadata, required for demonstrating compliance to GDPR article 30 [284], on the who, when, how and where information was created, updated or deleted; data about the data.

Therefore, a data governance policy is required to manage this data in a *governed* state. Meaning that for every data element, the following must be known [285]:

- The standardised business name, definition and physical location.
- For calculated or derived data: the calculation/derivation rule.
- The data quality rules, *in context.*
- Rules for creating the data element.
- Usage rules for the data element.
- The data Governor/Owner and Business Data Steward for the data element.

5.3.2.1 Data Governance Policy

The data governance policy found in appendix C3 outlines how data used will be stored in a *governed* state. The policy has been adapted from NHS Wales' [286] and UWTSD's [287], [288] current policies, following a template by the University of New South Wales, Australia [289].

5.3.3 Design Timebox Two - Interface Design

The following timebox implements the user interface design methodologies researched in section 4.2 to produce initial wireframe models which are subjected to user tests to provide a proof of concept.

Date	*Duration*	*Completion Date*
18/03/19	*7 days*	24/03/19

5.3.3.1 User Personas for MIU

The literature review has researched the users of CDSS to gain enough insight to create goal-directed personas [290], which will focus on what the typical user of CDSS wants.

i. ***Persona One***

Abbie Jones is a trainee nurse who is interested in passing her nursing exams and becoming a fully qualified nurse on the MIU ward meaning she needs access to a wide range of information from reputable sources. As a trainee she references the guidelines often but is time limited so needs to read and find information quickly. Abbie is slightly visually impaired and wears glasses so needs to zoom in on most web pages. She likes to email herself guidelines of interest for her exams and sees herself as becoming a sister one day.

Persona one is created from the findings in section 2.4.4 which finds that students do not adopt CDSS as they do not integrate into their workflow, despite their inexperience and thirst for reputable knowledge.

From this persona can conclude that Abbie needs a system which:

- Can be accessed from anywhere on any device.
- Has accurate, up to date reputable information.
- Has a clear to read font with possible adjustment of font size.
- Is easy navigable to find information quickly.
- Enables her to save guidelines for viewing later.
- Allows her to email guidelines to herself or medical friends for viewing later.

User's	*Details*
Name	Abbie Jones
Demographic	18-25, single, no children.
Description	Abbie Jones is a trainee nurse in the MIU at Royal Gwent Hospital.
Goals	Having access to a wide range of reputable guidelines. Keep up to date with the latest guidelines for each ailment. Learn the medical terminology. Be seen as very knowledgeable to her class peers and to impress her senior nurses.
Pains	Not having time to search through the guidelines. Not knowing the medical terminology for certain guidelines. Not being able to read small text. Not being able to access enough reputable information to revise for her exams.
Device Preference	Laptop, smart phone.
Responsibilities	Has a pet dog. Is a student rep for her course. Lives in shared house with 3 other medical students from a range of professions.
Tasks	Accessing a wide range of reputable guidelines. Finding information regarding ailments quickly. Saving or emailing guidelines for review later. Being able to read the guidelines quickly and clearly. Accessing the guidelines from many devices and locations.

Table 6 - User Persona One

ii. ***Persona Two***

Dr Victoria Jenkins is a Junior Doctor, qualified for 3 years, who works in the A&E department at the Royal Gwent Hospital. As Dr Jenkins is fairly experienced, her usage of the system is for quick reference only. The A&E dept is extremely busy so Dr Jenkins needs information to be displayed quickly and often asks nurses to find and read out guidelines she requires whilst she tenders to patients. Dr Jenkins also prefers to read off dark screens and all her devices in 'dark mode' due to tiredness from long hours straining her eyes. As Dr Jenkins is more qualified than the nurses, she regards herself a leader when she is called to the MIU ward to assist.

Persona Two is created from literature review sections 2.3.3, 2.4, 3.3, 3.4, 4.1.2 which highlight that CDSS are not used due to lack of integration into the clinicians' workflow. Dr Jenkins finds it difficult to find the time to find guidelines herself as it interrupts her flow with patients.

From this persona can conclude that Dr Jenkins needs a system which:

- Has a wide range of up to date, reputable guidelines.
- Displays most common reference information quickly.
- Has a UI which is dark in contrast.
- Has voice recognition so she doesn't have to ask nurses to find information for her.
- Can recite guidelines to her so nurses don't have to and her workflow remains intact.

User's	*Details*
Name	Dr Victoria Jenkins
Demographic	25 - 35, in a relationship, no children.
Description	Dr Jenkins is a junior doctor of 3 years at the Royal Gwent's A&E dept.
Goals	Treating patents as accurately as possible. Seeing as many patients as possible. Qualifying to be a consultant in emergency medicine. Be seen as a leader and someone the nurses can trust for help.
Pains	Not having time to search through the guidelines herself. Feels cheeky asking nurses to read out the guidelines but has no time. Reading from bright screens which strain her eyes.
Device Preference	Desktop pc at work only.
Responsibilities	Responsible for 1000's of patients each month, often is unsupervised as her lead consultants are busy.
Tasks	Accessing a wide range of reputable guidelines. Finding information for reference quickly. Having someone or something access and recite the guidelines to her. When she has time, being able to read the guidelines on a low contrast screen.

Table 7 – User Persona Two

iii. ***Persona Three***

Sister Claire McCarthy is the ward Sister for the Royal Gwent MIU. Claire is highly experienced in all minor injuries and she often uses the system for quick reference for herself but mainly to guide, teach and advise her less experienced colleagues. As head of the department, Claire's time is less focused on patients and more on the running of the ward, allowing her more time to find information, however, she often discovers guidelines which are out of date, misspelt, in the wrong order or misleading. Claire sees herself as a mother figure to her staff and wants to make the best equipment and resources available to them to make them the best they can be.

Persona three has been created from the initial brief for this project as well as section 2.3.3 which finds a beneficial use for computerised guidelines for improving patient outcomes and reducing staff stresses.

From this persona can conclude that Claire needs a system which:

- Is easy to use to reduce her staff stresses.
- Transfers her paper guidelines to computer.
- Allows her to update, create, and delete guidelines as an admin.
- Is easy to navigate for a novice PC user.

User's	*Details*
Name	Claire McCarthy
Demographic	55 - 65, married, three children.
Description	Claire McCarthy is a senior sister nurse at the Royal Gwent Hospital's MIU
Goals	Looking after her staff. Ensuring the ward has the best available equipment. Advising her staff in the best way possible. Ensuring her department offers the best possible care.
Pains	Seeing her staff suffer through poor equipment and resources. Not being able to update or change guidelines herself easily. Having to use out of date, paper guidelines. Not being 100% computer literate.
Device Preference	Books and desktop pc at work only.
Responsibilities	Responsible for 100's of staff nurses and trainees and the general running of the MIU.
Tasks	Accessing a wide range of reputable guidelines for teaching and advising. Finding information for reference quickly. Being able to add, delete and amend guidelines in the document.

Table 8 - User Persona Three

5.3.3.2 Initial Prototype UI Designs

Using these user personas, initial designs are drawn up using the balsamiq wireframe tool. The prototypes are inspired from two web applications: *GOV.UK* and *NHS 111* which should offer familiarity to the users of the prosed system given their context.

Sharp [291] states that NHS digital's user research led to finding a need for a strong, shared, reusable, design pattern across the NHS's digital services, meaning that utilising the design pattern from NHS111 will tie in with any existing NHS digital products, offering the user familiarity whilst supporting their behavioural patterns.

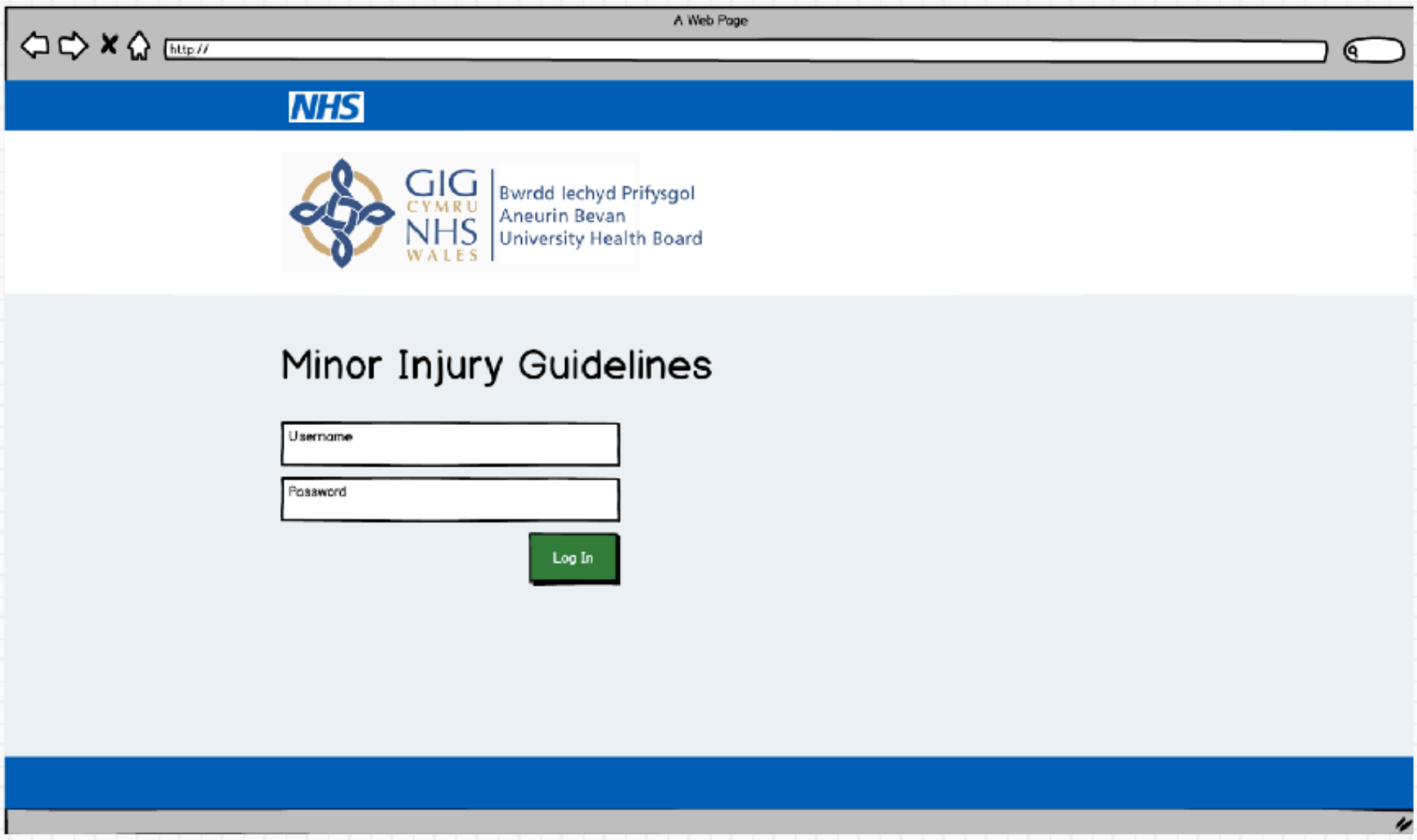
Additionally, Noakes and Hupe [292] state the UK government has introduced its design styles, components and patterns to be used across all of the government services which include typography, layout, colours, checkboxes, forms and buttons. Furthermore, the two-panel selector used is a classic, instantly recognisable, easily learnt, design pattern employed by many existing systems Added evidence that following these heavily researched and tested design patterns will prove successful for the MIU system.

The first designs are shown in section 5.2.2.2 (i - iii) and are discussed in tables 12-14 in relation to Tidwell's [230] behavioural patterns. The three main interface screens will be discussed to avoid repetition. The remaining prototype design can be found in appendix C4.

i. ***Login Screen***

Behavioural Pattern	*Details*
Safe Exploration	The simple, familiar login interface is instantly recognisable, inviting safe exploration. Also follows Tidwell's basics of form design.
Instant Gratification	User knows exactly what they will accomplish from this screen.
Satisficing	No need to learn or study this interface, it does exactly what users expect.
Changes in Midstream	N/A as this is the gateway to the main UI.
Deferred Choices	N/A as interface does not answer unnecessary questions.
Incremental Construction	N/A
Habituation	If users hit return or click the login button the expected behaviour ensues.
Spatial Memory	Form and button will always remain in the same place on any device.
Perspective Memory	N/A
Streamlined Repetition	N/A as shared system, often public facing when patients are being seen, the option to 'stay logged in' is removed.
Keyboard Only	Users can hit return to login without the use of the mouse.
Other People's Advice	N/A

Table 9 - Login Screen Behavioural Patterns

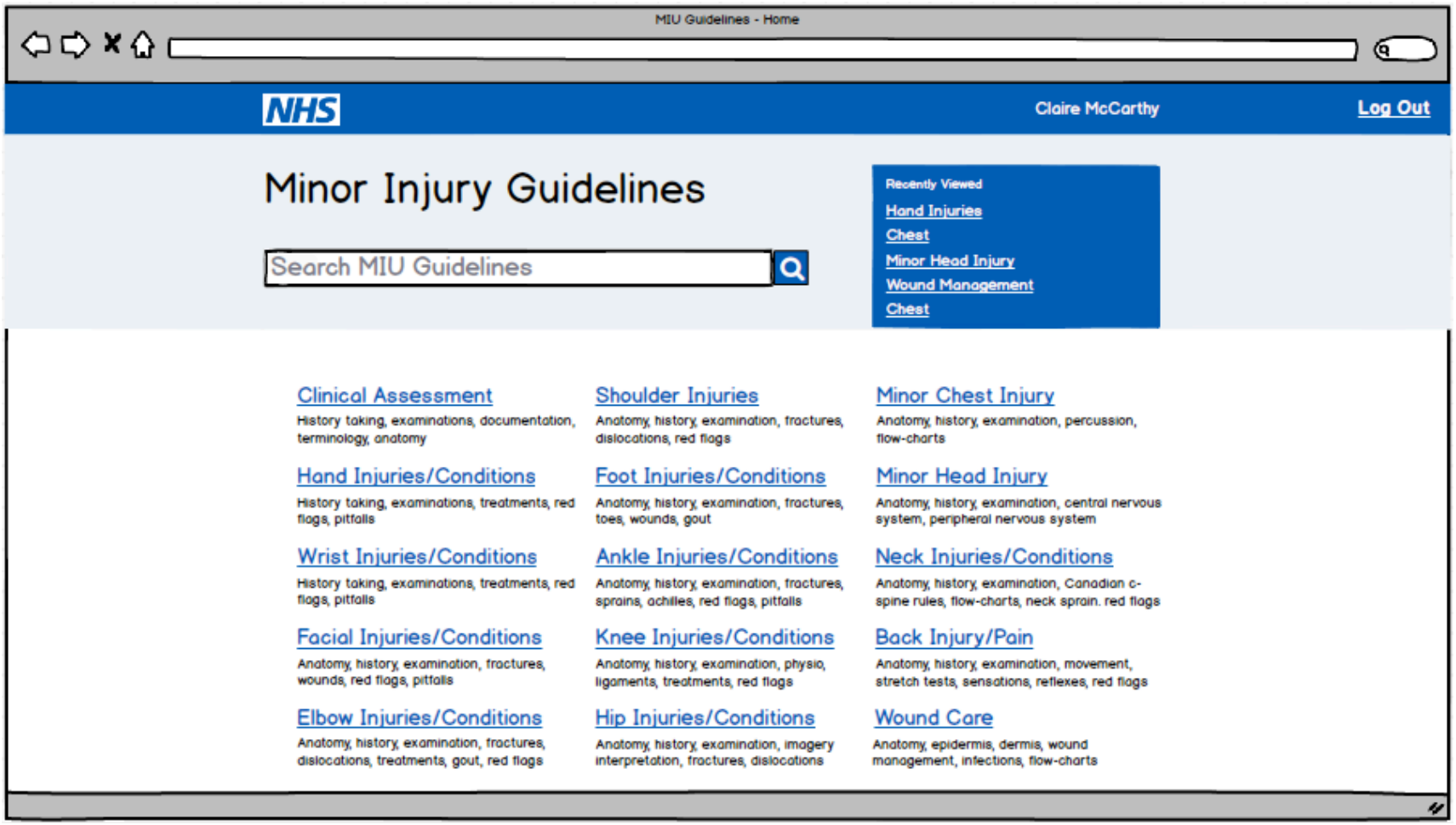

A Web Page
http://
NHS
GIG CYMRU NHS WALES
Bwrdd Iechyd Prifysgol
Aneurin Bevan
University Health Board
Minor Injury Guidelines
Username
Password
Log In

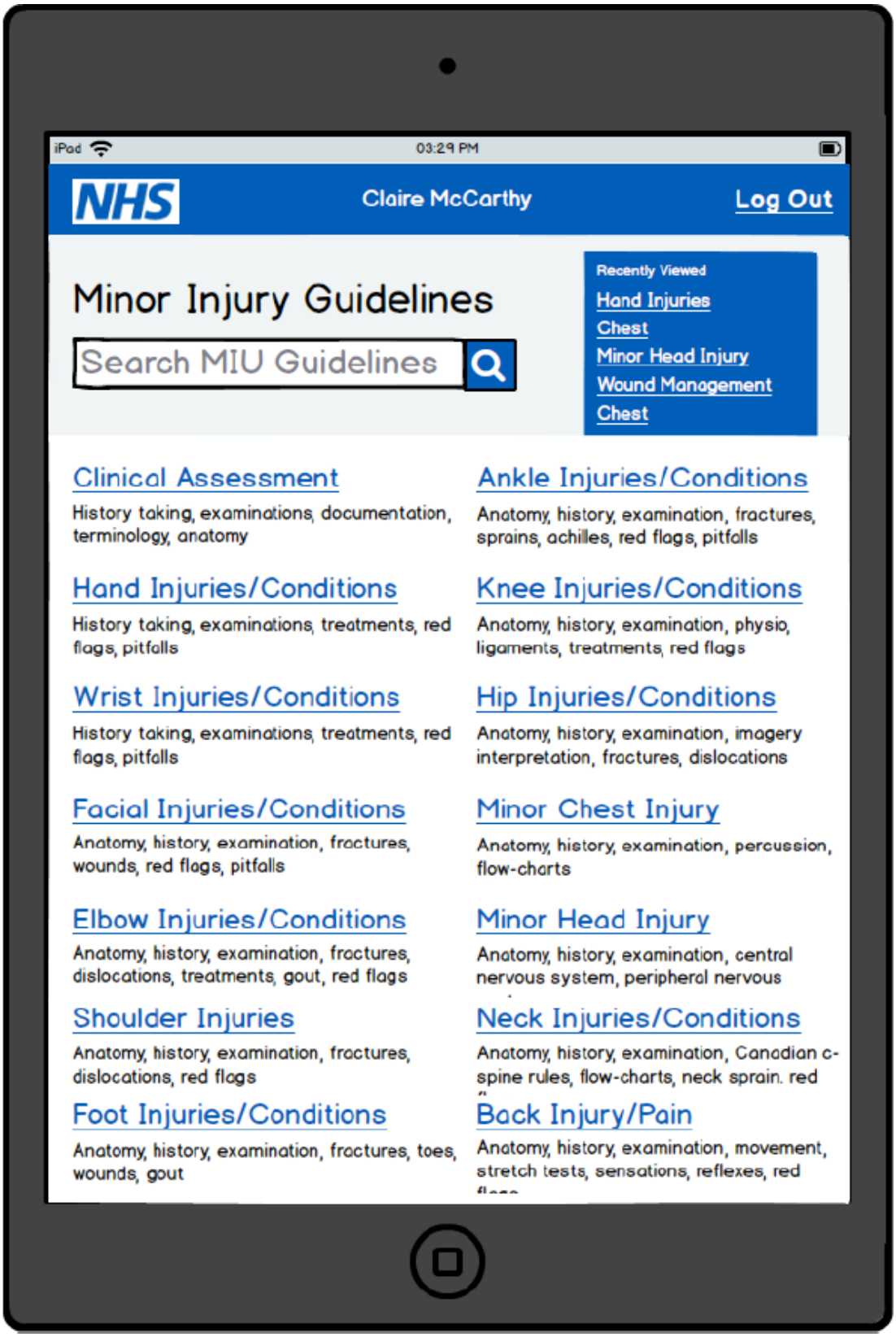

iPad
03:29 PM
NHS
GIG
CYMRU
NHS
WALES
Bwrdd Iechyd Prifysgol
Aneurin Bevan
University Health Board
Minor Injury Guidelines
Username
Password
Log In

ii. ***Home Page***

Behavioural Pattern	*Details*
Safe Exploration	The simple design following the Gov.uk & NHS digital design patterns invites safe exploration though instantly recognisable links, clear text, labels and recognisable buttons and entry boxes.
Instant Gratification	Recognisable links, buttons & search bars indicate to the user they will accomplish their goal of finding information quickly.
Satisficing	Design pattern used does not require learning, 'F' pattern layout allows user to rapidly scan interface for what they want.
Changes in Midstream	Log out button clearly visible in expected location allowing users to change their mind about using the system. Browser will save recently search items searched through the search box for quicker access next time.
Deferred Choices	N/A as interface does not answer unnecessary questions.
Incremental Construction	Each link instantly takes user to their desired location, giving instant feedback.
Habituation	If users hit return or click the search button the expected behaviour ensues.
Spatial Memory	Buttons, labels, search bars will remain in the same place, enabling easy recollection of location.
Perspective Memory	N/A in prototype. A recommendation to add feature which saves user preferences and favourite guidelines or ones to view later.
Streamlined Repetition	Recently viewed items provides an easier path for users to a guideline the use repeatedly.
Keyboard Only	Users can hit return to search without the use of the mouse. No other keyboard features available yet – recommendation for future.
Other People's Advice	Using the GOV & NHS design patterns may have users discussing the familiarity and ease of use of these designs.

Table 10 - Home Page Behavioural Patterns

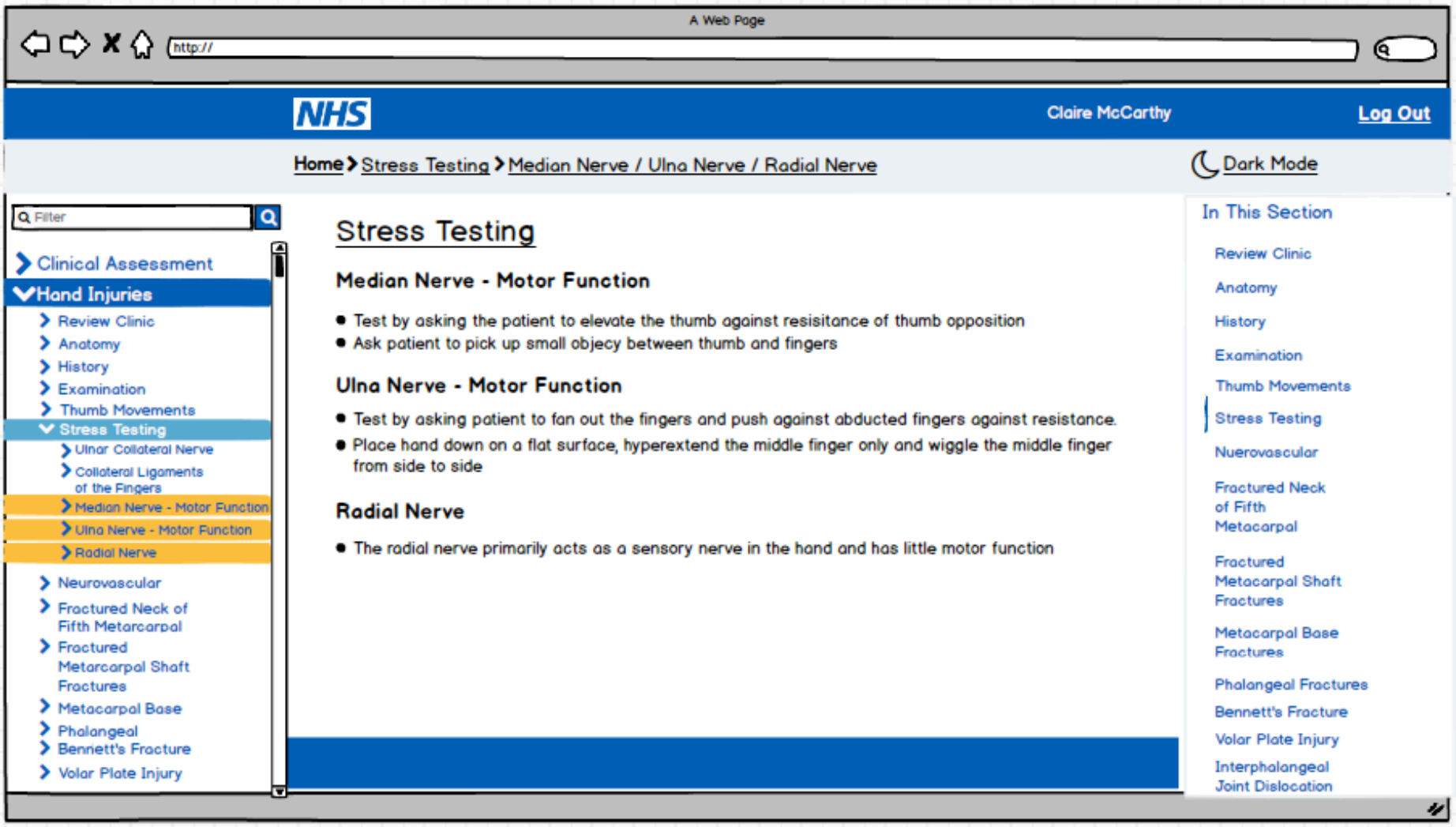

MIU Guidelines - Home
NHS
Claire McCarthy
Log Out
Minor Injury Guidelines
Search MIU Guidelines
Recently Viewed
Hand Injuries
Chest
Minor Head Injury
Wound Management
Chest
Clinical Assessment
History taking, examinations, documentation, terminology, anatomy
Shoulder Injuries
Anatomy, history, examination, fractures, dislocations, red flags
Minor Chest Injury
Anatomy, history, examination, percussion, flow-charts
Hand Injuries/Conditions
History taking, examinations, treatments, red flags, pitfalls
Foot Injuries/Conditions
Anatomy, history, examination, fractures, toes, wounds, gout
Minor Head Injury
Anatomy, history, examination, central nervous system, peripheral nervous system
Wrist Injuries/Conditions
History taking, examinations, treatments, red flags, pitfalls
Ankle Injuries/Conditions
Anatomy, history, examination, fractures, sprains, achilles, red flags, pitfalls
Neck Injuries/Conditions
Anatomy, history, examination, Canadian c-spine rules, flow-charts, neck sprain. red flags
Facial Injuries/Conditions
Anatomy, history, examination, fractures, wounds, red flags, pitfalls
Knee Injuries/Conditions
Anatomy, history, examination, physio, ligaments, treatments, red flags
Back Injury/Pain
Anatomy, history, examination, movement, stretch tests, sensations, reflexes, red flags
Elbow Injuries/Conditions
Anatomy, history, examination, fractures, dislocations, treatments, gout, red flags
Hip Injuries/Conditions
Anatomy, history, examination, imagery interpretation, fractures, dislocations
Wound Care
Anatomy, epidermis, dermis, wound management, infections, flow-charts

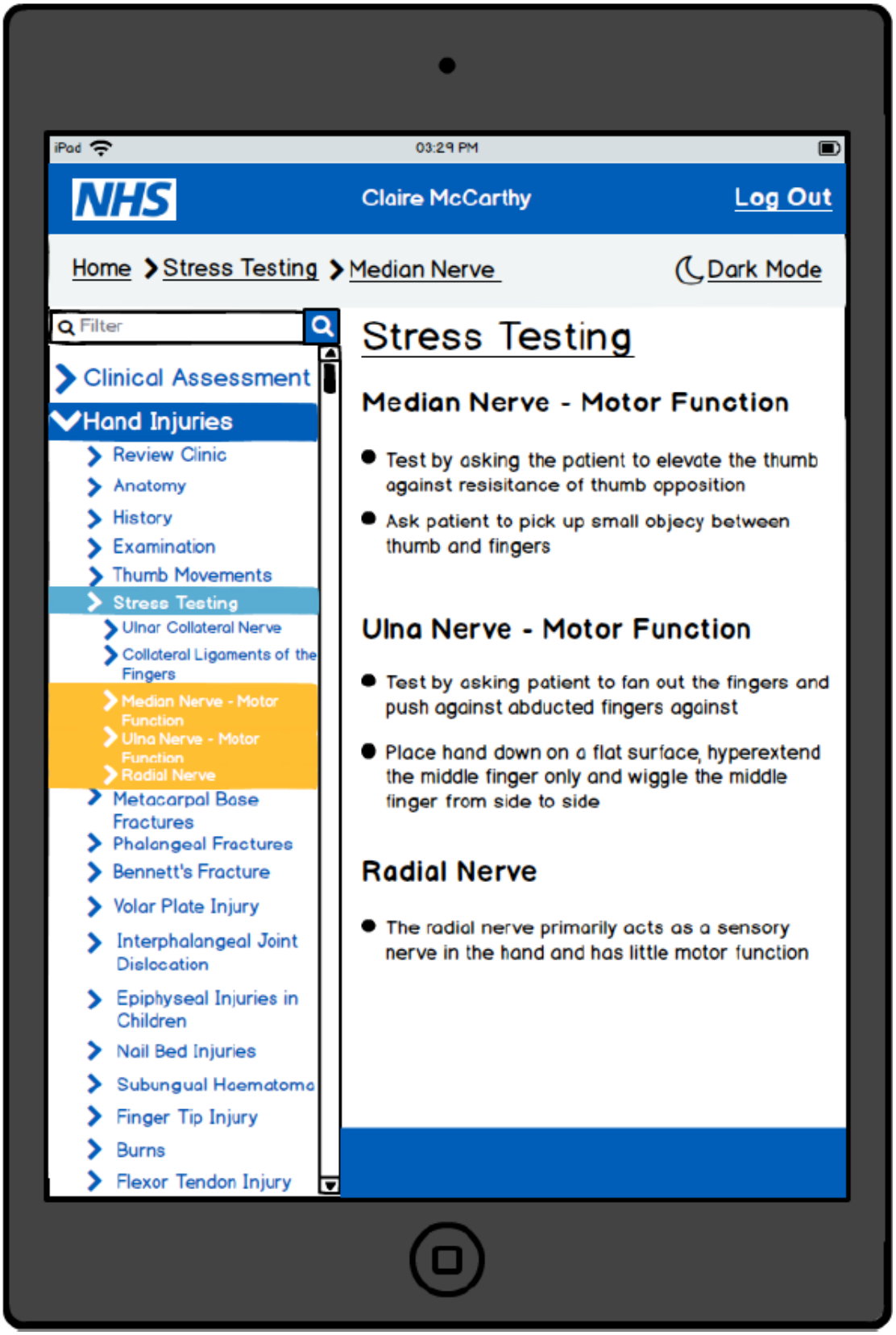

iPad
03:29 PM
NHS
Claire McCarthy
Log Out
Minor Injury Guidelines
Search MIU Guidelines
Recently Viewed
Hand Injuries
Chest
Minor Head Injury
Wound Management
Chest
Clinical Assessment
History taking, examinations, documentation, terminology, anatomy
Ankle Injuries/Conditions
Anatomy, history, examination, fractures, sprains, achilles, red flags, pitfalls
Hand Injuries/Conditions
History taking, examinations, treatments, red flags, pitfalls
Knee Injuries/Conditions
Anatomy, history, examination, physio, ligaments, treatments, red flags
Wrist Injuries/Conditions
History taking, examinations, treatments, red flags, pitfalls
Hip Injuries/Conditions
Anatomy, history, examination, imagery interpretation, fractures, dislocations
Facial Injuries/Conditions
Anatomy, history, examination, fractures, wounds, red flags, pitfalls
Minor Chest Injury
Anatomy, history, examination, percussion, flow-charts
Elbow Injuries/Conditions
Anatomy, history, examination, fractures, dislocations, treatments, gout, red flags
Minor Head Injury
Anatomy, history, examination, central nervous system, peripheral nervous
Shoulder Injuries
Anatomy, history, examination, fractures, dislocations, red flags
Neck Injuries/Conditions
Anatomy, history, examination, Canadian c-spine rules, flow-charts, neck sprain. red
Foot Injuries/Conditions
Anatomy, history, examination, fractures, toes, wounds, gout
Back Injury/Pain
Anatomy, history, examination, movement, stretch tests, sensations, reflexes, red

iii. ***Guideline Page***

Behavioural Pattern	*Details*
Safe Exploration	Two-panel selector pattern is familiar, inviting safe exploration: many users have used before. The IA and menu are instantly recognisable as a menu through the chevrons used. Font sizing denotes hierarchy which offers a clear path back to previous pages in addition to the breadcrumbs and location in document menu on the right of the screen.
Instant Gratification	Recognisable links, buttons & search bars indicate to the user they will accomplish their goal of finding information quickly.
Satisficing	Design pattern used does not require learning, two panel selector and 'F' pattern layout allows user to rapidly scan interface for what they want.
Changes in Midstream	IA menu on left, location menu on the right and breadcrumbs offer many options allowing users to change their mind quickly.
Deferred Choices	N/A as interface does not answer unnecessary questions.
Incremental Construction	Each link instantly takes user to their desired location or opens a lower-level menu, giving instant feedback.
Habituation	Menu is follows already learnt patterns, if new to users it is easily learnt and will become habitual.
Spatial Memory	Buttons, labels, search bars will remain in the same place, enabling easy recollection of location.
Perspective Memory	N/A in prototype. A recommendation to add feature which saves user preferences and favourite guidelines or ones to view later.
Streamlined Repetition	N/A in prototype. A recommendation to add recently viewed items to this screen Is offered.
Keyboard Only	N/A. No keyboard shortcuts, except for keyword search, are used. Recommend future keyboard shortcuts be added for future.
Other People's Advice	Using the two-panel selector design pattern may have users discussing the familiarity and ease of use of these designs.

Table 11 - Guideline Page Behavioural Patterns


A Web Page
http://
NHS
Claire McCarthy
Log Out
Home > Stress Testing > Median Nerve / Ulna Nerve / Radial Nerve
Dark Mode
Filter
Clinical Assessment
Hand Injuries
Review Clinic
Anatomy
History
Examination
Thumb Movements
Stress Testing
Ulnar Collateral Nerve
Collateral Ligaments of the Fingers
Median Nerve - Motor Function
Ulna Nerve - Motor Function
Radial Nerve
Neurovascular
Fractured Neck of Fifth Metacarpal
Fractured Metacarpal Shaft Fractures
Metacarpal Base
Phalangeal
Bennett's Fracture
Volar Plate Injury
Stress Testing
Median Nerve - Motor Function
Test by asking the patient to elevate the thumb against resisitance of thumb opposition
Ask patient to pick up small objecy between thumb and fingers
Ulna Nerve - Motor Function
Test by asking patient to fan out the fingers and push against abducted fingers against resistance.
Place hand down on a flat surface, hyperextend the middle finger only and wiggle the middle finger from side to side
Radial Nerve
The radial nerve primarily acts as a sensory nerve in the hand and has little motor function
In This Section
Review Clinic
Anatomy
History
Examination
Thumb Movements
Stress Testing
Nuerovascular
Fractured Neck of Fifth Metacarpal
Fractured Metacarpal Shaft Fractures
Metacarpal Base Fractures
Phalangeal Fractures
Bennett's Fracture
Volar Plate Injury
Interphalangeal Joint Dislocation


iPad
03:29 PM
NHS
Claire McCarthy
Log Out
Home
Stress Testing
Median Nerve
Dark Mode
Filter
Clinical Assessment
Hand Injuries
Review Clinic
Anatomy
History
Examination
Thumb Movements
Stress Testing
Ulnar Collateral Nerve
Collateral Ligaments of the Fingers
Median Nerve - Motor Function
Ulna Nerve - Motor Function
Radial Nerve
Metacarpal Base Fractures
Phalangeal Fractures
Bennett's Fracture
Volar Plate Injury
Interphalangeal Joint Dislocation
Epiphyseal Injuries in Children
Nail Bed Injuries
Subungual Haematoma
Finger Tip Injury
Burns
Flexor Tendon Injury
Stress Testing
Median Nerve - Motor Function
Test by asking the patient to elevate the thumb against resisitance of thumb opposition
Ask patient to pick up small objecy between thumb and fingers
Ulna Nerve - Motor Function
Test by asking patient to fan out the fingers and push against abducted fingers against
Place hand down on a flat surface, hyperextend the middle finger only and wiggle the middle finger from side to side
Radial Nerve
The radial nerve primarily acts as a sensory nerve in the hand and has little motor function

These initial designs have been formulated to cater for the needs of the user, found through the user research and personas. They achieve this by offering a familiar interface which allows for quick information retrieval, which showed to be the main feature required by users. The personas will be referenced throughout the development process to implement other features required, such as voice recognition for greater integration into work flow and dark mode to ease strain on the eyes.

5.3.3.3 Testing of initial Design

The prototype was subjected to the user testing methodology [section 4.5]. First, a 6-task list was drawn up and written into the test script [section 4.5.1] with 5 questions asking users how they feel about the pages. A SUS questionnaire was completed at the end of the test. The users were asked to sign a consent form to allow the test to be recorded using silverback. The relevance of the questions and tasks are explained in the following section.

The test script, write up of results and questionnaire, complete with notes can be found in appendix C5. The silverback recordings file size is 1.4GB, too large to upload to Moodle, therefore, it is available upon request.

5.3.3.4 User Test Script Explained

The test script and explanations of each question reside in appendix B5.3 and B5.4, respectively, discussing why certain questions have been asked and what is the hoped outcome.

5.3.3.5 Analysis of Results

The results of the user tests are triangulated as discussed in section 4.2.4. Firstly, the results have been tabulated into problem list and compared with comments to extract more detailed information about each problem. Thirdly, the SUS questionnaire results are averaged to produce quantitative data which can be compared to the problems and comments made. Finally, recommendations are made from the results. Each problem is numbered with the observations, comments and recommendations corresponding to the written results in appendix C5.

i. ***Problem List***

Problem	*Test*	*Point*
1.	*1 & 3*	Home page is cluttered with too much information.
2.	*1, 2 & 3*	All menus are not ordered in any way.
3.	*1 & 3*	The font size is too small and text too close together.
4.	*1 & 3*	Menu on the right is useless.
5.	*2*	iPad menu on the screen is too busy and unusable.
6.	*1,2 & 3*	NHS logo as home button is useless.

ii. ***Comments & Observations***

1. Participant 1 and Participant 3 both found difficulty with the busyness of the homepage; however, they had no problems in locating the page required. And 2/3 three participants commented that the labelling under the links helped.
2. All three participants commented that all the menus should be ordered in some way, the most popular choice being alphabetically. Participant 3 also commented that having 'Wrist' next to 'Hand' injuries could be confusing.
3. Participant 1 commented that the text on the page was too small and should be spaced at a minimum 1.5 lines, whilst Participant 3 commented that the text was too small on all the menus and in the main body text.
4. Participant 1 and Participant 3 both stated that the right-hand menu is useless and should only tell you what is in the current document, not the whole system.
5. Point 5 corresponds with the iPad test (Participant 2) where the right menu is condensed on the page due to the small screen size, the participant struggled to find the required link.
6. All three tests proved that the NHS logo was not suitable for a path 'Home'. Participant 1 commented that it may take them to the main NHS website, Participant 2 was unsure where it

would take her and Participant 3 did not use it at all, even when asked if there were any other ways possible to 'Home'.

iii. ***System Usability Scale Results***

Test	*Participant*	*System Usability Score*
1.	*Participant One*	82.5
2.	*Participant Two*	95
3.	*Participant Three*	87.5
	Average	**88.3**

iv. ***Recommendations***

1. The final menu should consider being taken out of its container to enable the links to spread across the page (where possible with screen width). Additionally, main links and labelling links below them should be further spaced apart. Further testing with greater spacing on the menu items and labels will be required.
2. Ordering of the menus should follow some organisational structure. At present, it follows the provided documentations structure, however, it is recommended that it is reorganised alphabetically or by most used. If the latter, MIU staff will need to be consulted.
3. None of the participants were visually impaired but 2/3 struggled with the text size, therefore it is recommended that the font size is increased across the menus and the body text. If possible, adjustable font sizes should be implemented.
4. The right-hand menu should not be of the whole system but should contain 'quick links' to items on selected pages and point out where the user is on that page.
5. The iPad version could implement feature 4, however, if the selected document is too big the same problem will occur. It is recommended that this feature is implemented and tested further for suitability.

6. The NHS logo can always remain a link to 'Home' however, a more obvious icon should also be provided and test. A 'House' icon is recommended either in the breadcrumbs or the fixed header.

5.3.3.6 Conclusion

Time constraints forced Krug's [187] lowest recommendation of 3 user participants for this stage, however, the tests have shown many positives and the triangulated data has proved the prototype initial interface is suitable for this project, albeit requiring further improvements.

The interface mock-up will now be used to code the front end, whilst fixing problems encountered in these user tests, following the recommendations in section 5.3.3.5 (iv). The interface will then be tested again to prove that the fixes have addressed the issues found.

The questionnaire used for each test was modified slightly after each test as some personal questions were deemed redundant and some system usage questions considered too personal. These changes will be reflected in the script for the next round of user tests. All scripts can be found in appendices B5.3 and C5.

5.4 Implementation

5.4.1 Develop Overall Model

The overall model development follows a different methodology stated in section 4.3 and appendix B3 as there is no *'team'* to collaborate with or to develop models for comparison. Therefore, an overall model is developed solely by the project manager using the data entity models, and the anticipated controller classes. This model is used to develop the initial feature list and feature sets, following FDD conventions stated in appendix B3.

The model shown uses Coad's [240] colour UML, allowing the classes to be split into different roles and grouped using colour. For example, the controllers in the model have a *role* which is to control the requests and responses from the views to the model and vice versa, as per the MVC pattern.

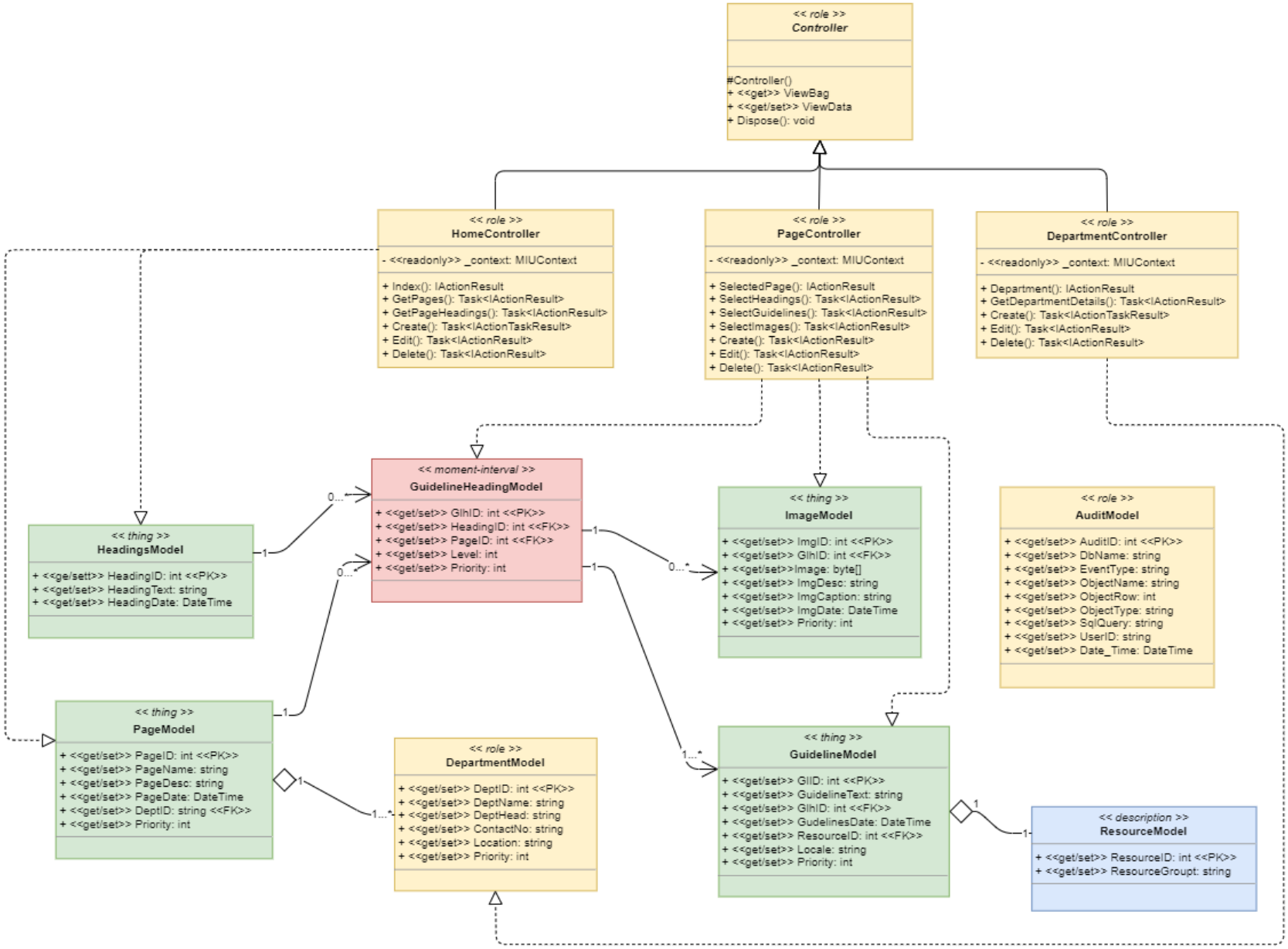
Controllers at this stage are the bare minimum required to display the guidelines, with methods denoted inside each class representing the standard request and response methods. The three-page controllers

inherit from the front-controller (the entry point to the application) which contains common methods shared across the child classes, these child classes also implement their own, page specific methods.

The data domain classes represent the database model which is also grouped using colours and roles, for example, the pages, headings, images and guidelines are all *things* meaning they represent real world entities which help relate the semantic data model to the real world.

The diagram shows their relationship to the controller classes where each controller implements one or more specific models. Each model's relationship is denoted using aggregation or association. For example, aggregation is used for the *Resource* to *Guideline* table as the *Resource* groups are made up of one or more *Guidelines*, the models have a 1 to 1 or many relationship where one *Guideline* has only one *Resource* group. The association between the models shows how the classes interact, for example, the *Headings* model interacts with *GuidelineHeading* model with a one to none or many relationship. This association continues through the *GuidelineHeadingModel* and into both the *Guideline* and *Image* models.

At this stage in the development process the model is conceptual but also contains some specification details which makes the UML somewhat vague, however, Fowler [293] states that interpretation of such models should depend on what is being described. At this stage, the model is describing what the overall system *could* look like, not what it *will* end up like, therefore, this model is likely to morph as the project develops.


<< role >>
Controller
#Controller()
+ <<get>> ViewBag
+ <<get/set>> ViewData
+ Dispose(): void
<< role >>
HomeController
- <<readonly>> _context: MIUContext
+ Index(): IActionResult
+ GetPages(): Task<IActionResult>
+ GetPageHeadings(): Task<IActionResult>
+ Create(): Task<IActionTaskResult>
+ Edit(): Task<IActionResult>
+ Delete(): Task<IActionResult>
<< role >>
PageController
- <<readonly>> _context: MIUContext
+ SelectedPage(): IActionResult
+ SelectHeadings(): Task<IActionResult>
+ SelectGuidelines(): Task<IActionResult>
+ SelectImages(): Task<IActionResult>
+ Create(): Task<IActionResult>
+ Edit(): Task<IActionResult>
+ Delete(): Task<IActionResult>
<< role >>
DepartmentController
- <<readonly>> _context: MIUContext
+ Department(): IActionResult
+ GetDepartmentDetails(): Task<IActionResult>
+ Create(): Task<IActionTaskResult>
+ Edit(): Task<IActionResult>
+ Delete(): Task<IActionResult>
<< moment-interval >>
GuidelineHeadingModel
+ <<get/set>> GlhID: int <<PK>>
+ <<get/set>> HeadingID: int <<FK>>
+ <<get/set>> PageID: int <<FK>>
+ <<get/set>> Level: int
+ <<get/set>> Priority: int
<< thing >>
HeadingsModel
+ <<ge/sett>> HeadingID: int <<PK>>
+ <<get/set>> HeadingText: string
+ <<get/set>> HeadingDate: DateTime
<< thing >>
ImageModel
+ <<get/set>> ImgID: int <<PK>>
+ <<get/set>> GlhID: int <<FK>>
+ <<get/set>>Image: byte[]
+ <<get/set>> ImgDesc: string
+ <<get/set>> ImgCaption: string
+ <<get/set>> ImgDate: DateTime
+ <<get/set>> Priority: int
<< role >>
AuditModel
+ <<get/set>> AuditID: int <<PK>>
+ <<get/set>> DbName: string
+ <<get/set>> EventType: string
+ <<get/set>> ObjectName: string
+ <<get/set>> ObjectRow: int
+ <<get/set>> ObjectType: string
+ <<get/set>> SqlQuery: string
+ <<get/set>> UserID: string
+ <<get/set>> Date_Time: DateTime
<< thing >>
PageModel
+ <<get/set>> PageID: int <<PK>>
+ <<get/set>> PageName: string
+ <<get/set>> PageDesc: string
+ <<get/set>> PageDate: DateTime
+ <<get/set>> DeptID: string <<FK>>
+ <<get/set>> Priority: int
<< role >>
DepartmentModel
+ <<get/set>> DeptID: int <<PK>>
+ <<get/set>> DeptName: string
+ <<get/set>> DeptHead: string
+ <<get/set>> ContactNo: string
+ <<get/set>> Location: string
+ <<get/set>> Priority: int
<< thing >>
GuidelineModel
+ <<get/set>> GlID: int <<PK>>
+ <<get/set>> GuidelineText: string
+ <<get/set>> GlhID: int <<FK>>
+ <<get/set>> GudelinesDate: DateTime
+ <<get/set>> ResourceID: int <<FK>>
+ <<get/set>> Locale: string
+ <<get/set>> Priority: int
<< description >>
ResourceModel
+ <<get/set>> ResourceID: int <<PK>>
+ <<get/set>> ResourceGroupt: string

5.4.2 Initial Feature List

The initial feature list (table 12) is developed from the domain model and divided into feature sets, addressing the *must have* requirements. As the project develops into the *should have* and hopefully *could have* requirements, more features will be added to the feature list from the requirements list, the overall model and the usability testing results at the beginning of each timebox.

Feature Set `<action> <-ing> a(n) <object>`	*Feature* `<action> the <result> <by|for|of|to> <a(n)> <object>`
1. Creating the MIU Database	Write SQL to create table for a MIU database. Write SQL to insert data to a MIU database.
2. Creating the Interface for an MIU System	Write HTML to create views for a MIU system. Write CSS to create styling for MIU views. Write HTML & CSS to create navigation for a MIU system.
3. Create the MVC Application with RESTful service for the MIU	Create MVC Template Application for MIU System Create Model Classes for each Entity Create Controllers for each Page Create Interfaces & Classes for GET/POST methods Implement Repository Pattern for the MIU System Install ORM Tool to query MIU database
4. Performing a Search for the ENT Guidelines	Retrieve the guidelines for an ear problem. Display the guidelines for an ear problem. Retrieve the guidelines for a throat problem. Display the guidelines for a throat problem. Retrieve the guidelines for a nose problem. Display the guidelines for a nose problem.
5. Linking the Guidelines for ENT	Link the pages for ENT guidelines.
6. Performing a search for the Contact Details of a Department.	Retrieve the details for the hospital departments. Display the details for the hospital departments.

Table 12 - Initial Feature List

5.4.3 Acceptance Test Design

As stated in section 4.4, a *Design Acceptance Test* section has been added to the FDD process. Each test will be performed by users in parallel with usability tests.

To save documentation in the report's main body, acceptance test sheets will be printed out for each test and reported in each timebox. Scanned copies are found in appendix D2.

5.4.4 Timebox Feature Plans

This section follows the *plan by feature* methodology (appendix B3.1 (ii)). The initial features are organised into feature sets and prioritised numerically, ordered by importance in table 12, again, due to the project being managed by one person, all feature sets and ownership of classes are assigned to the project manager.

5.4.5 Timeboxes

Timeboxes document development with inclusion of the date, duration, completion date and features to be implemented. Use case descriptions and use case diagrams have been omitted due to time constraints.

4.4.5.1 Implementation - Timebox One

Date	*Duration*	*Completion Date*
25/03/19	*7 Days*	31/03/19

i. ***Timebox Feature Set***

Timebox one feature set is specified in table 16 and outlined below:

1. Create the MIU database tables.
2. Insert ENT data into database tables, adding HTML tags where applicable.

ii. ***Feature Design***

1. *Create the MIU Database Tables*

An ERD used to create the tables is found in section 5.5.1.2.

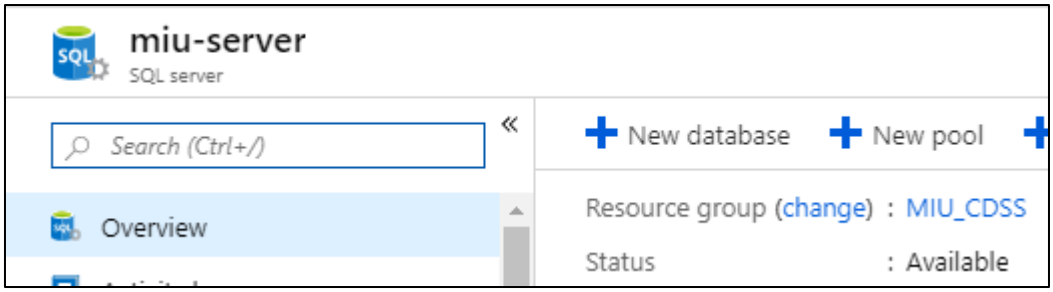
2. *Insert ENT data into database tables, adding HTML tags where applicable.*

To enable text to be displayed in bold, italics etc. or represent hyperlinks to related pages, the data was entered using HTML tags.

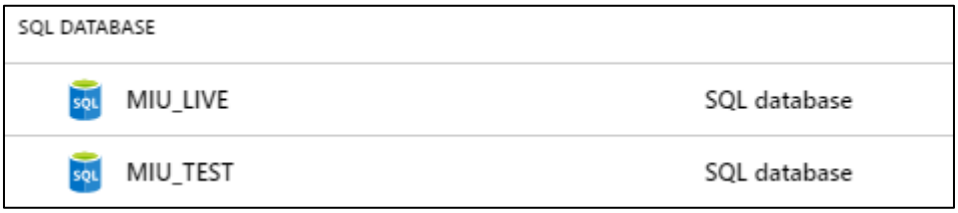
iii. ***Feature Implementation***

1. *Creation of MIU Database Tables*

To create the database tables, an Azure SQL server was setup, following Microsoft documentation [294] , on the MS Azure Portal host.



Two databases were created, one test and one live , enabling test development to take place before migrating any changes to the live database.

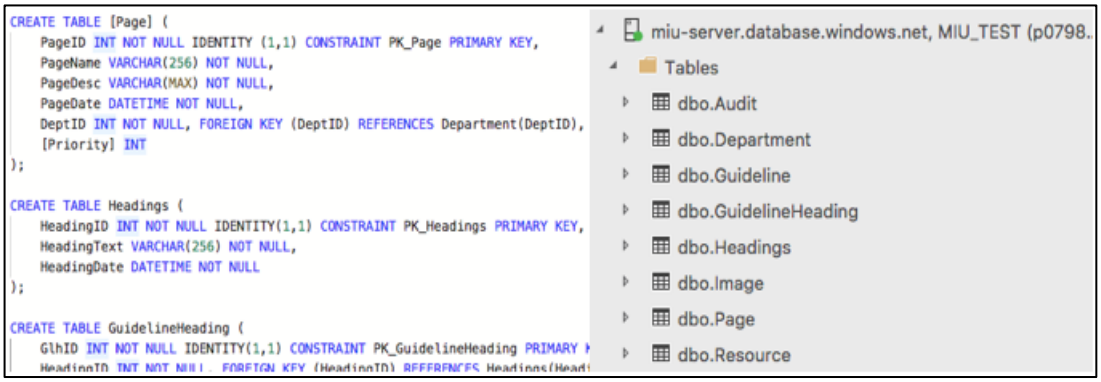


The databases use Microsoft's SQL Authentication (table 13).

Setting	*Value*
Connection Type	Microsoft SQL Server
Server Name	miu-server.database.windows.net
Authentication	SQL Login
User Name	p079868
Password	20miugl19!

Table 13 - Azure SQL Connection Credentials

The tables were created using transact SQL, and Azure Data Studio to connect and query databases on the MIU server.



Notable features of the table creation were, firstly, use of auto-incrementing ID primary key fields using keyword IDENTITY, along with a named PRIMARY KEY CONSTRAINT syntax:

```
CREATE TABLE [Page] (
    PageID INT NOT NULL IDENTITY (1,1) CONSTRAINT PK_Page PRIMARY KEY,
```

Secondly, the foreign-key constraints added for referential integrity:

```
PageDate DATETIME NOT NULL,
DeptID INT NOT NULL, FOREIGN KEY (DeptID) REFERENCES Department(DeptID),
[Priority] INT
```

Thirdly, the check constraint on the Locale column:

```
ResourceID INT NOT NULL, FOREIGN KEY (ResourceID) REFERENCES [Resource](ResourceID),
Locale CHAR(5) NOT NULL CONSTRAINT CHK_Locale CHECK (LOCALE LIKE '[a-z][a-z]-[A-Z][A-Z]'),
[Priority] INT
```

Finally, the use of VARBINARY (BLOB or Binary Large Object) data type to store images. This data type allows for unstructured data, such as images, up to a size of 2GB to be stored [295].

```
CREATE TABLE [Image] (
    ImgID INT NOT NULL IDENTITY(1,1) CONSTRAINT PK_Image PRI
    GlhID INT NOT NULL, FOREIGN KEY (GlhID) REFERENCES Guide
    [Image] VARBINARY(MAX) NOT NULL,
```

2. *Insert ENT data into database tables, adding HTML tags where applicable.*

With the tables created, data entry began using standard SQL INSERT statements. There were several considerations for data entry, firstly, the ENT documents were scoured for headings and other text which would contain HTML `<h1>` or alike tags, any words in each guideline which needed displaying in bold using the `<b>` bold tags and any text needing to link to other pages in the system using `<a>` tags to ensure the flow through the system and classification as a guideline-based CDSS using a flow chart paradigm and clinical algorithms for sequential execution at decision steps [section 2.4.2]. Furthermore, to display the text in lists both the `<ol>` and `<ul>` tags are required along with `<li>` tags.

The sample insert statements below show the *Page* table data, inserted alphabetically, via the Priority column, adhering to usability analysis findings from section 5.5.2.4, containing the relevant `<h1>` tags with added HTML ID's for the anchor links to each page section.

```
INSERT INTO [Page] (PageName, PageDesc, PageDate, DeptID, Priority)
VALUES ('<h1 id="#clinicalAssesment">Clinical Assesment<h1>', 'General clinical assessment guidelines', '2019-03-15', 5, 3);
INSERT INTO [Page] (PageName, PageDesc, PageDate, DeptID, Priority)
VALUES ('<h1 id="#handInjuries">Hand Injuries & Conditions<h1>', 'Hand injuries and related conditions', GETDATE(), 1, 11);
```

Another example from the *Headings Repository* table shows the `<h2>` tags inserted with ID's, along with the SQL *GETDATE();* function which automatically inserts the date and time upon query execution. This feature avoids the need for users to manually insert the date and time through the interface, promoting usability. Furthermore, it is one less feature to implement on the interface.

```
INSERT INTO Headings (HeadingText, HeadingDate) VALUES ('<h2 id="anatomy">Anatomy<h2>', GETDATE());
INSERT INTO Headings (HeadingText, HeadingDate) VALUES ('<h2 id="history">History<h2>', GETDATE());
```

Below is an example of the guidelines inserted with `<ul>`, `<ol>`, `<b>`, `<br>` and `<a>` tags.

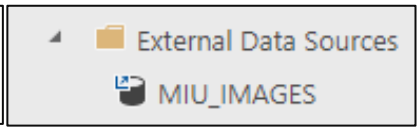
```
INSERT INTO Guideline (GuidelineText, GlhID, GuidelineDate, ResourceID, Locale, Priority) VALUES
('<ul><li><b>Ensure when looking down troat that good light source and tongue depressor is used
(DO NOT USE TONGUE DEPRESSOR IF <a href="pages/troat/#epiglottis">EPIGLOTTIS</a> IS SUSPECTED!)</b></li><br>',
3, GETDATE(), 1, 'gb-EN', 21);
```

The final insert consideration was the images. Inserting VARBINARY data types into the Azure Cloud database proved more challenging than first envisaged. Firstly, a storage account to store the images was set-up on the Azure Portal, within the created MIU resource group, and the images uploaded via the portal UI.



This then was linked to the linked to an EXTERNAL DATA SOURCE in the database which pointed to the Azure BLOB storage account created (miuimages).

```
CREATE EXTERNAL DATA SOURCE MIU_IMAGES
WITH ( TYPE = BLOB_STORAGE,
       LOCATION = 'https://miuimages.blob.core.windows.net',
     );
```



The remote images stored in the Azure BLOB storage could then be inserted using the BULK INSERT command to load the file from the BLOB storage account into the Images SQL table. The OPENROWSET SQL function then parses the image file and returns the content as a set of rows [296]. The complex SQL INSERT query for this process is shown below:

```
INSERT INTO [Image] (GlhID, [Image], ImgDesc, ImgCaption, ImgDate, Priority)
VALUES
(1, (SELECT *FROM OPENROWSET(BULK 'miu-images/throat.png', SINGLE_BLOB, DATA_SOURCE = 'MIU_IMAGES')
 AS AnImage), 'Anatomy of the throat, side view.', null, GETDATE(), 1);
```

Where the image location in the BLOB storage account is specified, along with the SINGLE_BLOB command to return the data as a single row [297], and the external DATA_SOURCE created earlier. Other fields in this table are then added. The results of this insert:

ImgID	GlhID	Image	ImgDesc	ImgCaption	ImgDate	Priority
1	1	0x89504E470D0A1A0A00000...	Anatomy of the throat, side v...	*NULL*	2019-04-09 19:48:31.210	1
2	1	0xFFD8FFE000104A46494600...	View of throat from the mou...	*NULL*	2019-04-09 19:48:32.397	2
3	15	0x89504E470D0A1A0A00000...	Flow chart for guidance for f...	Protocol for Patients Presenti...	2019-04-09 19:50:43.540	24
4	17	0xFFD8FFE117554578696600...	Labelled anatomy of the ear	*NULL*	2019-04-09 19:50:43.600	1
5	3	0x89504E470D0A1A0A00000...	Tympanic membrane	*NULL*	2019-04-09 19:50:43.680	10

Inserting data proved a challenging and time-consuming exercise. The full MIU document contains 20 sections for a range of injuries, however, for this project, just the ENT data was inserted as this allows for three-page sections accessible on the system to demonstrate the flow and sequential algorithms needed for the systems classification as a CDSS. Despite this, over 600 lines of SQL code were written.

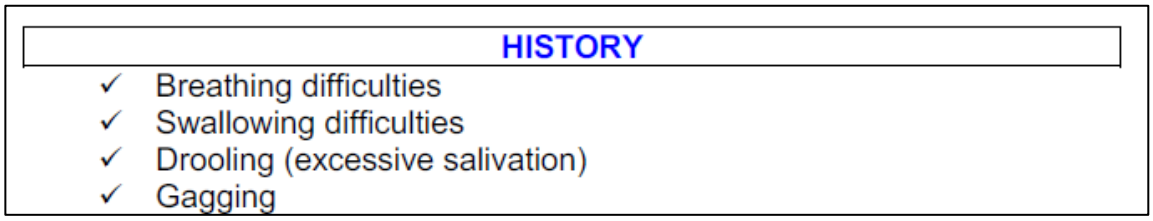
iv. ***Software Testing***

Testing was conducted to prove the theory of the database design [section 5.5.1]. For this a JOIN query was used for each page:

```
/* SELECT ALL HEADINGS, GUIDELINES & IMAGES ON PAGE 15 (THROAT) */
SELECT glh.GlhID, h.HeadingText, i.Image, i.ImgDesc, g.GuidelineText
FROM Headings h
LEFT JOIN GuidelineHeading glh ON glh.HeadingID = h.HeadingID
LEFT JOIN [Image] i ON i.GlhID = glh.GlhID
LEFT JOIN Guideline g ON g.GlhID = glh.GlhID
WHERE glh.PageID = 15
ORDER BY glh.Priority ASC;
```

This query selects all fields needed to prove the theoretical model works. By left joining the tables the query returns all records from the Headings table and any records which match the *Guideline Heading ID* (*GlhID*) in the *Image* and *Guideline* tables, where the page ID is 15 (*Throat Page*) and orders, ascendingly, the results by the *Guideline Heading* tables priority column. As the priority column in this table is ordered sequentially by the order in the document this will ensure the

headings, guidelines and images which reference this table are returned in the correct order. A sample of the results are shown below:



	GlhID	HeadingText	Image	ImgDesc	GuidelineText
1	1	<h2 id="anatomy">Anatomy<h2>	0x895...	Anatomy of the throat, side view.	<b>The pritority is to asses ABC - If the air...
2	1	<h2 id="anatomy">Anatomy<h2>	0xFFD...	View of throat from the mouth.	<b>The pritority is to asses ABC - If the air...
3	2	<h2 id="history">History<h2>	*NULL*	*NULL*	Breathing difficulties
4	2	<h2 id="history">History<h2>	*NULL*	*NULL*	Swallowing difficulties
5	2	<h2 id="history">History<h2>	*NULL*	*NULL*	Drooling (Excessive Salivation)
6	2	<h2 id="history">History<h2>	*NULL*	*NULL*	Gagging
7	2	<h2 id="history">History<h2>	*NULL*	*NULL*	Is the patient PMH? (Immunocompromised)

Ignoring the images for this example, each guideline under the *History* heading has been returned correctly. This is verified throughout the 118 records retuned against the original document provided.

Two more JOIN queries were executed, changing the WHERE clause to return results for different page sections, the results confirming the theoretical model of the database a success.

Although the *first* round of testing executed proved successful, it presented some interesting thoughts into the theoretical design on the database. These questions and their answers reside in appendix D1.

v. Usability Testing

Timebox one addressed the creation of the database tables and the data it will hold; therefore, no *usability* testing will apply.

vi. Requirements Met (Section 5.2.1)

- The system must hold & display all information on each department in the hospital.
- The system should be extendable.
- The systems database should not have any downtime.
- The system must allow access to multiple users simultaneously.

5.4.5.2 Implementation - Timebox Two

Date	*Duration*	*Completion Date*
1/04/19	*7 Days*	7/04/19

i. ***Timebox Feature Sets***

Timebox two feature set is specified in table 16 as:

1. Write HTML to create views for a MIU system.
2. Write CSS to create styling for MIU views.
3. Write HTML & CSS to create navigation for a MIU system.

ii. ***Feature Design***

No use-case diagrams for the front-end, however, feature sets class as user-stories which are split up into smaller tasks to achieve implementation of each feature set.

1. *Write HTML to create views for the MIU system.*

A template [298] was used which contained the basic two-panel selector design pattern required [section 4.3].

2. *Write CSS to create styling for MIU views.*

Bootstrap [276] was used for the grid layout, along with CSS from the template. Further custom CSS was added.

3. *Write HTML & CSS to create navigation for the MIU system.*

Navigation for the two-panel selector left menu was modified accordion CSS from Cody House [298], as was the jQuery for the right side-menu.

iii. ***Feature Implementation***

1. *Write HTML to create views for the MIU system.*

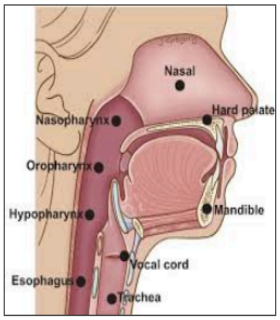
The HTML of note is the structure for the Throat guidelines, following the documents structure. By following the paper throat guidelines), the following is produced:

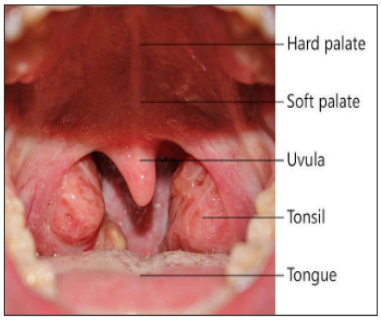
```
<h1>Throat Problems</h1>
  <h3 id="one">Anatomy</h3>
  <br>
  <div class="images">
      <img src="images/throat.jpeg">
      <img src="images/t-palate.jpeg">
  </div>
  <br>
  <br>
  <ul class="ul-bullets">
      <li><b>The priorty is to assess ABC - if the airway is not clear or comprimised transfer t
  </ul>
  <br>
  <h3 id="two">History</h3>
  <ul class="ticks">
      <li>Breathing difficulties</li>
      <li>Swallowing difficulties</li>
      <li>Drooling (excessive salivation)/li>
      <li>Gagging</li>
  </ul>
```

This HTML translates to:

Throat Problems

Anatomy





- **The priorty is to assess ABC - if the airway is not clear or comprimised transfer to resus and refer to senior A&E Dr**

History

- Breathing difficulties
- Swallowing difficulties
- Drooling (excessive salivation)/li>
- Gagging

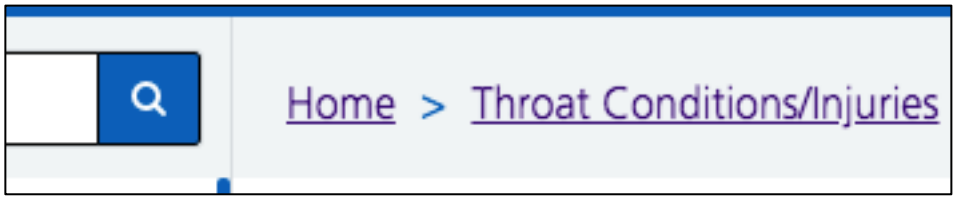
2. *Write CSS to create styling for MIU views.*

To follow the design patterns investigated in section 4.2.3 and used in section 5.3.3, the NHS digital UI design guidelines were followed [298], ensuring the UI was consistent with NHS branding, making it recognisable and usable to MIU staff, promoting habituation.

The first feature of note is the NHS colours. NHS Blue (#005eb8) is used for links, headers and footers, with warm yellow (#ffb81c) used for highlight on hover, along with link decoration. NHS digital state that these colours give a visible focus to interactive elements, which ties in with Tidwell's behavioural patterns: satisficing, incremental construction and safe exploration (appendix B2). Furthermore, it creates affordances which NHS users will instantly recognise.

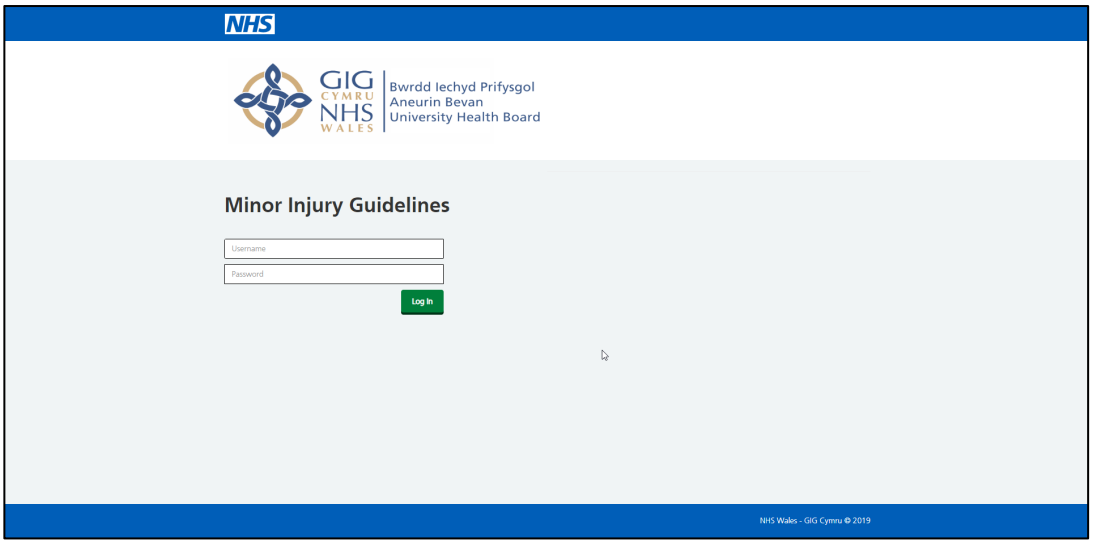


Continuing consistency with NHS patters, the font used is Frutiger [298], which the NHS have used for both print and digital media since 1999. Furthermore, the icons used for the search and chevrons for the breadcrumbs meet the NHS guidelines, as do the visited link colour change on the links.



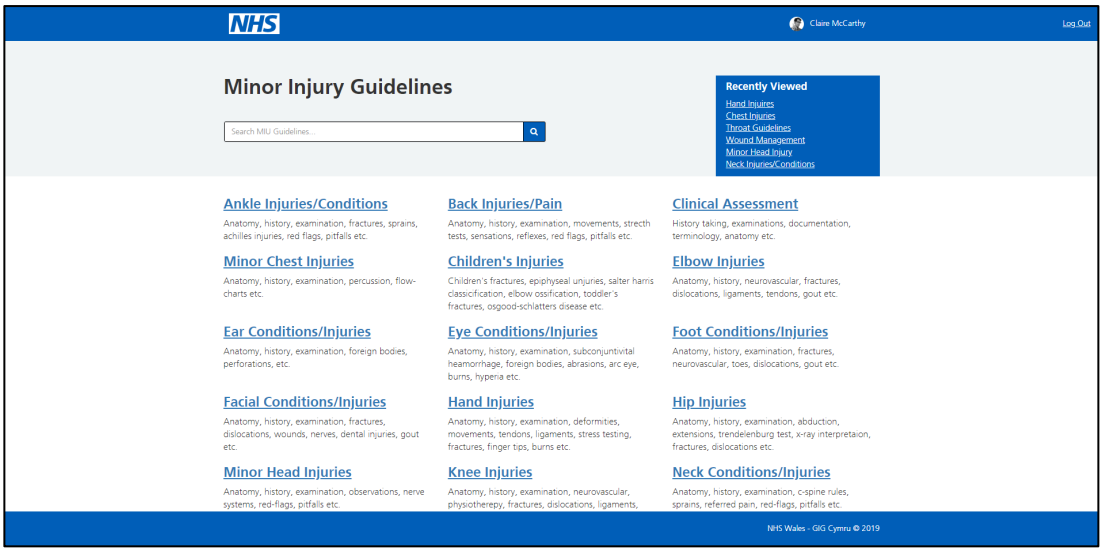
The completed HTML pages which will be user-tested are shown below:

The log-in page:



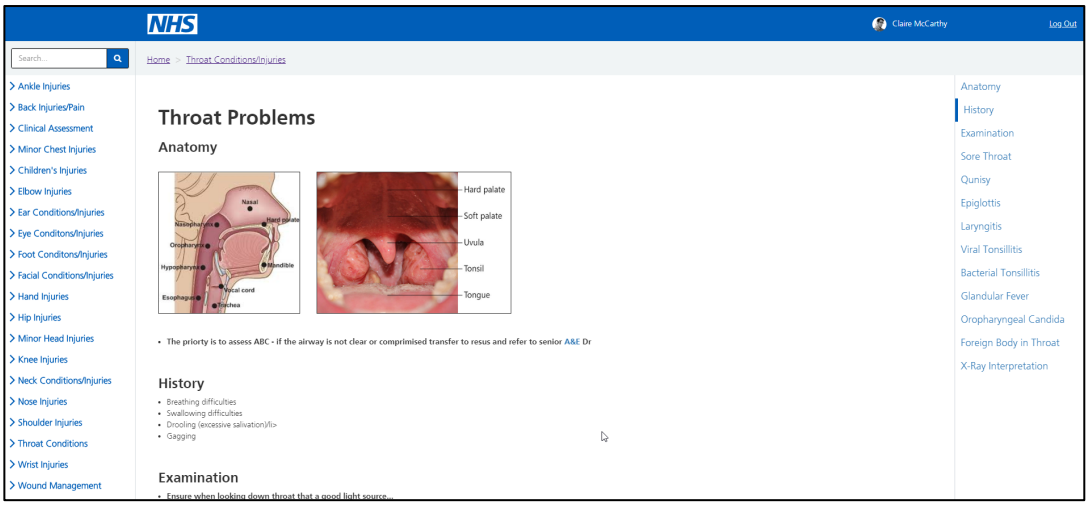
The log-in page is simple, and follows familiar conventions used throughout web applications for access. The log-in button also follows UI button patterns found on NHS digital [299].

The index (home) page:



The index page is uncluttered, and guideline links are alphabetical ordered from left to right, an improvement made from the paper-prototyping tests [section 5.3.3 iv]. The user logged in, is displayed in the header, along with a clear log-out button. The main content is stored inside a container to limit the screen width to 1170px on large screens to avoid user's having to scan the whole screen to find the required guidelines.

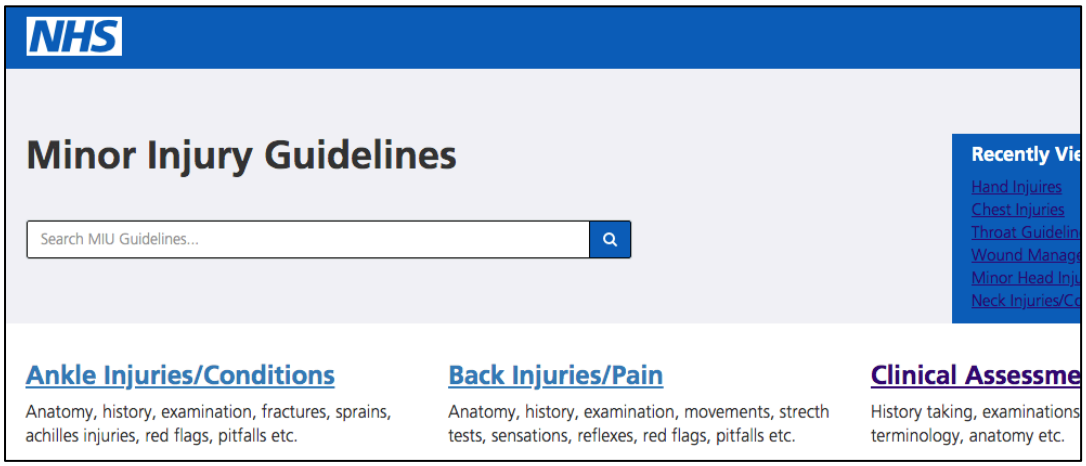
The guideline (throat) page:



The two-panel selector design pattern is clearly visible with an additional locator menu on the right. The components and main body of this page have been removed from the container to ensure the biggest possible viewing area for the guidelines, as some guidelines have large images and flow-charts which fill the page, however, it may be more suitable to scale down the content to avoid stress to the user's eyes. This will be tested in the user tests in section (v) and improved if necessary.

3. *Write HTML & CSS to create navigation for the MIU system.*

Navigation for the home page is a bootstrap grid layout, created by following the tested designs in section 5.5.2 which has been proved to be simple and easy to follow.



The main navigation on the guidelines pages is constructed using an accordion menu, now organised alphabetically following recommendations [section 5.3.3.4 iv], which is achieved by implementing an unordered list to house the menu items, accompanied by an input checkbox and a label for the guideline name.

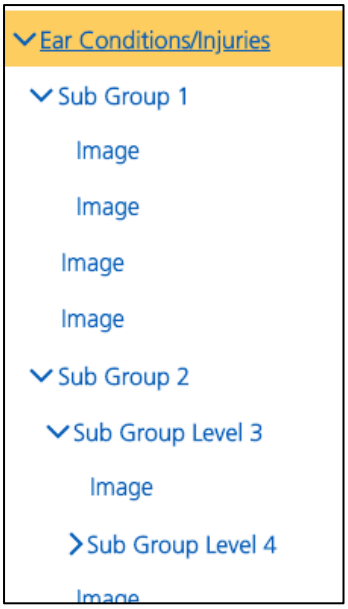
```
<li class="has-children">
    <input type="checkbox" name ="group-1" id="group-1">
    <label for="group-1"><p class="labels">Ear Conditions/Injuries</p></label>
    <ul>
```

To allow for the opening and closing of the accordion, the pseudo-class :checked is used to detect if the checkbox is clicked, this then changes the display of the unordered list elements from 'none' to 'block' to display the child menu items.

```
.cd-accordion-menu ul, .first-ul {
    display: none;
    list-style: none;
    padding: 0px;
  }
```

```
.cd-accordion-menu input[type=checkbox]:checked + label + ul,
.cd-accordion-menu input[type=checkbox]:checked + label:nth-of-type(n) + ul {
  display: block;
}
```

This results in the top-level menu exposing sub-level menus:



The right-menu sidebar, which now only contains sections of the current page, not the whole system, an improvement made from testing [section 5.5.3.4]. This menu highlights which document section the user is in relation to screen position. Furthermore, links here automatically scroll to the corresponding headings on the page, making navigation to a desired section quicker.

To implement this, jQuery was used to target 'anchor' tags in the HTML which are simply id's placed menu list-items and on the corresponding heading tags in the main body HTML.

Menu items:

```
<li><a href="#two">History</a></li>
<li><a href="#three">Examination</a></li>
<li><a href="#four">Sore Throat</a></li>
```

Headings in the body:

```
<h3 id="two">History</h3>
<ul class="ticks">
    <li>Breathing difficulties</li>
    <li>Swallowing difficulties</li>
    <li>Drooling (excessive salivation)/li>
    <li>Gagging</li>
</ul>
<br>
<h3 id="three">Examination</h3>
```

jQuery for scrolling to headings:

```
$(document).ready(function () {
    $(document).on("scroll", onScroll);

    $('a[href^="#"]').click(function(){
        $('html, body').animate({
            scrollTop: $($(this).attr('href')).offset().top - 140
        }, 500);
        return false;
    });
});
```

This function first creates a jQuery object from the page's document and calls the *ready()* function on the object, with the function to be executed passed in. In this case, the function selects the link <a> elements on the page, which have a *href* to an ID. The *click()* function is then called when a link matching the selected elements is clicked which contains another function which scrolls to

the matching attribute by referencing '*this*'. Animation is added ensuring a smooth scroll, and an offset to clear the fixed header.

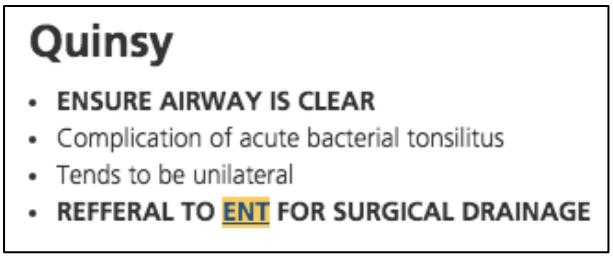
To communicate to the user where exactly they are on the page, each section is highlighted with a blue tab when in focus. This feature adheres to web conventions discovered which state that navigation should convey where users are on page as it avoids users feeling lost [187].



This feature was also implemented using jQuery, however, instead of the click function being called, the scroll function is used to measure the scroll position in the document and add or remove CSS styles when each anchor in the HTML is reached.

```
function onScroll(event){
    var scrollPos = $(document).scrollTop();
    $('#tab-highlight li').each(function () {
        var currLink = $(this);
        var refElement = $(currLink).find("a").attr("href");
        var h3Element = $(refElement);
        var offsetHeight = $("section.content").position().top + $(".spacer").height();
        if (h3Element.position().top  <= scrollPos + offsetHeight && h3Element.position().t
            $('#tab-highlight ul li').removeClass("sb-active");
            currLink.addClass("sb-active");
        }
    });
```

To ensure the flow through the document, creating the CDSS and increasing usability, the NHS digital '*inset text*' pattern is implemented which helps users identify important content and links on the page, without reading the whole text [300]. These links also follow the highlighting conventions discussed [section 2].



This pattern will be seen throughout the implemented ENT pages, ensuring flow through the separate document sections. Departments are also linked, as shown above, for quick access to contact details. However, time limitation may hinder the creation of these pages.

*iv. **Software Testing***

Timebox two developed the front-end using HTML and guidelines for Throat conditions, therefore, limited menu options have been coded. This has resulted in the acceptance test scope being designed to test the following:

1. Displaying Throat guidelines on a laptop/desktop/tablet.

2. Follow in-text links to other pages to check link integrity.

3. Check multi-level accordion menu is working.

4. Check dynamic page location indicator and auto-scroll is working.

The Tests:

1.	1. Open the Throat guidelines page. 2. Return to home page using the NHS logo. 3. Open the Throat guidelines page. 4. Return to home using the breadcrumb 'Home' link. 5. Open the Throat guidelines page.
2.	1. Visit Throat guideline page. 2. Follow ENT department link from in text links. 3. Open Throat guidelines page. 4. Find Throat guidelines in accordion menu. 5. Navigate to Glandular Fever section in document from accordion. 6. Navigate back to Anatomy section from right hand menu.

The Results:

1.	1. Throat guideline page appears. 2. Home page appears. 3. Throat page appears.	1. PASS 2. PASS 3. PASS

	5. Home page appears. 6. Throat guideline page appears.	4. PASS 5. PASS
2.	1. Throat guideline page appears. 2. Coming soon information page appears. 3. Throat guidelines page appears. 4. Accordion menu opens as expected. 5. Page scrolls to Glandular Fever section. 6. Auto scrolls to Anatomy section & highlights.	1. PASS 2. PASS 3. PASS 4. PASS 5. PASS 6. PASS

Conclusion

The results show that the front-end passed all the tests, however, these tests were only performed using the Chrome browser on one operating system. To extensively test the system, it is recommended that testing on different browsers is undertaken in future timeboxes.

The acceptance test sheet for timebox two can be found in appendix D2.

v. Usability Testing

The front-end was subjected to the usability methodologies used in design timebox two, albeit with an updated user-test script to home in on the current systems features. This updated script with full comments is found in appendix D4. Unfortunately, due to time constraints only the desktop version has been tested. Furthermore, as recruiting first-aid trained participants proved difficult, test participant one is not first-aid trained and two participants from the first round of user tests were re-used.

The user test script focuses on finding similar usability problems and users' preferences as the script used and discussed in section 5.3.3.4 (appendix B5.3 and B5.4), therefore, a walkthrough of each question will not be repeated.

Analysis of Results

Good Points

All users commented that the layout of the application was very good, stating it felt very familiar, with one comparing to Facebook. These points provide overwhelming justification that the use of proven design patterns was a good design decision. Furthermore, all users liked the accordion menu, the right-hand quick selector and highlight indicator menu and the highlighted links on hover.

The tests also uncovered an interesting point: 2 users instantly chose the NHS logo to navigate back to the home page, however, in the paper-prototype tests, this was flagged as a problem with all three test participants commenting they would not use it. A reason for such a discrepancy could be the environment the tests were conducted, perhaps the users felt more familiar with a web-page layout when viewed though a computer, rather than paper, meaning that the NHS logo was more recognisable as a path 'home'.

Problem List

Problem	*Test*	*Point*
1.	*2 & 3*	Footer is cutting off content on bottom of page.
2.	*2 & 3*	Discrepancies in the orientation of alphabetical layout.
3.	*1*	Lots of wasted space on main body content when viewed on a large screen.
4.	*1, 2 & 3*	In-text links should be underlined & bolder.
5.	*2*	Links in both menus should allow for whole link container to be clickable.
6.	*2 & 3*	Minor Chest Injuries is not in order.
7.	*2 & 3*	Right hand menu should be in alphabetical order.
8.	*3*	Content on page should have clearer breaks in-between sections.
9.	*3*	Highlight on hover area should be bigger.
10.	*1*	Guideline body text should be larger.

System Usability Scale Results

Test	*Participant*	*System Usability Score*
1.	*Participant One*	97.5
2.	*Participant Two*	100
3.	*Participant Three*	90
	Average	**95.8**

Recommendations

1. At present, the footer is cutting off page content. This could be down to the CSS fixed property being used. It is recommended that a margin is added to offset the fixed footer.

2. The alphabetical ordering is currently horizontal in layout, although one participant suggested it should be vertical. Nielsen [301] states that as user's scan a list of items on a page, they scan only the first few letters in a list, meaning that a vertical alphabetical ordering would allow for quicker location of items as all the items are aligned vertically, meaning when a user scans the first few characters down a page, the order is instantly recognisable. When organised horizontally, the user is forced to read the whole word before skipping to the next column, thus slowing down location of links required. Therefore, vertical organisation is recommended.

3. When viewed on a larger screen (over 1366px) the body content viewable is justified left, meaning a large amount of whitespace on the screen. Furthermore, the content on a whole isn't in a container, meaning the user's eye has to scan across the whole screen area to view menus which violates elements of readability rules [302], meaning that user's will have to move their head as well as their eyes, making the application tiring to use, something which needs to be avoided in an already tiring environment like the MIU. It is recommended that a max container width is set within a media query to contain the main body content on larger screen to a more usable size.

4. The in-text links should be underlined permanently, not just on hover. Furthermore, it is recommended that the padding be increased to increase the highlighted area on hover.

5. On both menus, CSS property *display: block* should be added to the <a> tags, allowing the whole area containing the link text to be a clickable button.

6. Remove the ‘Minor’ on chest injuries as it is not in alphabetical order. This is a typo as it is displayed as ‘Chest Injuries’ in the document.
7. The right-hand menu’s ordering should be investigated. At present, it follows the structure of the document, however, it is unknown if the documents structure is purposely laid out in this order, therefore, it is recommended that the menu be re-organised, but the body content remain the same.
8. The addition of line breaks between each section would provide a clear visual divider.
9. Padding should be increased on all highlighted links on hover to increase the highlighted area.

Conclusion

Some problems listed above could have been discovered through a cognitive walkthrough before user testing, therefore, the improvements recommended will be implemented in timebox four, and a cognitive walkthrough conducted to iron out imperfections in functionality which will allow the user tests to focus on the *usability* of the system, rather than *functionality*.

Although the system to date has scored highly on the SUS, there are many areas that need improvement. These high scores could also be the result of testing with similar users to the paper-prototyping, therefore, for the final round of user tests, best efforts will be made to find new test participants.

vi. ***Requirements Met (Section 5.2.1)***

- The system must display current MIU ENT guidelines.
- The system should be extendable.
- The system must be easy to use.
- The system could be aesthetically pleasing.
- The system must have a structured ontology.
- The system must link related guidelines together.
- The system must follow known NHS/GOV design patterns.

5.4.5.3 Implementation - Timebox Three

Date	*Duration*	*Completion Date*
8/04/19	*7 Days*	15/04/19

i. ***Timebox Feature Sets***

Timebox three feature set is specified in table 16 as:

1. Create API/MVC Application Template for MIU System
2. Create Model Classes for each Entity
3. Create Controllers for each Page
4. Create Interfaces & Classes for GET/POST Methods
5. Implement Repository Pattern for the MIU System
6. Install ORM Tool to query MIU database

ii. ***Feature Design***

1. *Create MVC Application Template for MIU System*

A .NET core web API template [302] was installed using the command line to build a basic web API project containing all the basic dependencies required.

2. *Create Model Classes for each Entity*

As the API will not be using the .NET Entity Framework ORM, the POCO (plain old common objects) were used to create models which are not reliant on any inheritance or attributes. This technique was used as it works well with the repository pattern and dependency injection as POCO do not depend on any frameworks [303].

3. Create Controllers for each Page

The controllers used are implemented using the attribute routing method which places the route URI in the controller directly on the action it will implement [304]. Each controller action returns a different response, dependent on URI set.

4. *Create Interfaces & Classes for GET/POST Methods*

To maintain an OOP approach and increase loose-coupling, organisation and maintainability of the system, as well as making the application more scalable and code reusable, interfaces are used which define the GET/POST methods need to create the RESTful service.

5. *Implement the Repository Pattern for the MIU System*

The repository pattern has been implemented to provide an abstraction of the data layer to the web API by means of interfaces. Database queries are performed using the methods in each IRepository (CRUD), with the details of each method being implemented in the corresponding repository class. This achieves loose coupling by keeping the domain objects ignorant of each other and removes the need to handle the database concerns, meaning the database could be swapped with little or no impact to the system, something which could prove useful should the NHS require the need for another API.

6. *Install ORM Tool to query MIU database*

As POCO are being used, an object mapper is required to map the OOP language to the database. The Dapper ORM tool is used as it operates using the .NET IDbConnection interface and allows for queries to be written without the need for complex Linq syntax, furthermore, it is better suited to the database first approach taken. It is also lightweight, and is considered the fastest ORM tool on the market for .NET [304].

iii. ***Feature Implementation***

1. *Create MVC Application Template for MIU System*

The command line interface in VS Code is used to install the web API template:

```
MacBook:MIU Pet$ dotnet new webapi -o MIU
```

Using VS Codes built in terminal avoids the need to navigate to the specified directory using the ‘cd’ command and installs the required project and dependencies directly into the projects root folder.

2. *Create Model Classes for each Entity*

The model classes are POCO, therefore, implementation isn't particularly interesting, however, although naming does not have to explicitly match the database, implementation has followed the same naming conventions as used when created the database columns to promote consistency and avoid confusion when accessing the properties from each model in the application.

```
public class Guideline
{
    1 reference
    public int GlID { get; set; }
    1 reference
    public string GuidelineText { get; set; }
    1 reference
    public int GlhID { get; set; }
    1 reference
    public DateTime GuidelineDate { get; set; }
    1 reference
    public string Locale { get; set; }
    1 reference
    public int Priority {get; set; }
}
```

As stated, the naming of these properties is not explicit to columns in the DB, meaning that should any columns be updated or removed or the POCO model would be unaffected and could be easily modified to suit, minimising complexity and dependencies on other layers in the application, promoting loose coupling.

3. *Create Controllers for each Page*

The controllers use the .NET attribute routing system, implemented by adding a decorator above the class name to specify the route:

```
[Route ("api/[controller]")]
0 references
public class GuidelineController : Controller
{
```

.NET Core uses a naming convention for its controllers. meaning that whenever a controller class has Controller at the end of the name this is removed. For example, the route here is

specified as api/[controller] but the class is *GuideController*, .NET removes the Controller part of the name, so the API route becomes api/guideline/.

Each method inside the controller returns a different response, depending on the *HttpGet* decorator on the method. For example, to return all the guidelines from in the database, the *HttpGet* is placed on the method containing the *GetAllGuidelinesAsync()* method. The return type of the methods in the controller is Task<TResult> which .NET core automatically serialises in JSON and writes it into the body of the response from the server.

```
[HttpGet]
0 references
public async Task<GuidelineResponse> Get ()
{
    return await _guidelines.GetAllGuidelinesAsync ();
}
```

Should a specific record need to be returned, parameters can be added to the decorators, such as an ID parameter:

```
[HttpGet("{id}")]
0 references
public async Task<GuidelineResponse> Get (int id)
{
    return await _guidelines.GetGuidelineAsync (id);
}
```

Now, when the URI *api/guideline/1* is requested, the method returns the guidelines from the throat page with the ID of 1.

It is worth noting that these methods perform their tasks asynchronously using the async/await keywords. This is done primarily for performance and to allow greater concurrency when multiple users are trying to access the system.

4. *Create Interfaces & Classes for GET/POST METHODS*

To promote loose coupling, interfaces are created for each of the guidelines required. For example, *IGuidelines* contains the methods, defining the behaviour of the classes which implement it:

```
public interface IGuidelines
{
    1 reference
    Task<GuidelineResponse> GetGuidelineAsync (int id);
    1 reference
    Task<GuidelineResponse> GetAllGuidelinesAsync ();
    1 reference
    Task AddGuidelineAsync (GuidelineRequest guidelineRequest);
}
```

However, it does not decide how each object is implemented, meaning that each class which implements a specific interface must adhere to the behaviour specified in that interface but can implement the methods in different ways [305]. For example, the *Guidelines* class which implements *IGuidelines* contains the defined behaviour in each of its methods, in the example below, the implementation of the *GET* method called by the *GuidelineController* class is shown, in turn these methods behaviour is defined in the *GuidelineRepository* class, however, the behaviour could different in another class which implements *IGuidelines*.

```
1 reference
public async Task<GuidelineResponse> GetGuidelineAsync(int id)
{
    GuidelineResponse guidelineResponse = new GuidelineResponse();
    var guideline = await _guidelineRepository.GetGuidelineAsync(id);

    if (guideline == null)
    {
        guidelineResponse.Message = "Page not found!";
    }
    else
    {
        guidelineResponse.Guidelines.Add(guideline);
    }
    return guidelineResponse;
}
```

Using interfaces provides a layer of abstraction meaning that code can be written with a level of ignorance for the details of implementation. It is worth noting that in the supplied code for the web API, there is an interface for each guidelines class, this is because each guideline class returns a different list of guidelines specified in the *Request* and *Response* classes, therefore each interface must contain an asynchronous *Task* method with each specific response/request object passed in:

```
1 reference
Task<ThroatResponse> GetAllThroatGuidelinesAsync ();
```

```
1 reference
Task<NoseResponse> GetAllNoseGuidelinesAsync ();
```

```
1 reference
Task<EarResponse> GetAllEarGuidelinesAsync ();
```

It is understood that there could be considerable refactoring of the submitted web API, however, due to time constraints, this was not possible.

5. *Implement the Repository Pattern for the MIU System*

Implementation of the repository pattern is similar to step 4, where an interface repository class defines the behaviours of the repository class, usually CRUD commands, with each implementation of these being different. The repository class then handles all the database concerns such as the connection information or the specific query details.

IGuidelineRepository

```
public interface IGuidelineRepository
{
    1 reference
    Task<Guideline> GetGuidelineAsync(int id);
    1 reference
    Task<IEnumerable<Guideline>> GetAllGuidelinesAsync();
    1 reference
    Task AddGuidelineAsync(Guideline guideline);
}
```

GuidelineRepository (One Implementation Shown)

```
public async Task<IEnumerable<Guideline>> GetAllGuidelinesAsync ()
{
    using (IDbConnection dbConnection = _connection) {
        string query = @"SELECT
                        [GlID]
                        ,[GuidelineText]
                        ,[GlhID]
                        ,[GuidelineDate]
                        ,[Locale]
                        ,[Priority]
                        FROM [dbo].[Guideline]";

        var guideline = await dbConnection.QueryAsync<Guideline> (query);
        return guideline;
    }
```

6. *Install* ORM Tool to query MIU database

The Dapper ORM tool was installed via the CLI:

```
MacBook:MIU Pet$ dotnet add package Dapper
```

This is used in the project where needed, specifically in the repository classes, with the *using* assembly directive before the namespace and class definitions.

```
using Dapper;
```

This allows for SQL queries to be written directly into C# methods in each repository class. The example below returns the throat guideline dataset. It is worth noting that the Image column has been omitted due to the size of the byte arrays used for the image files.

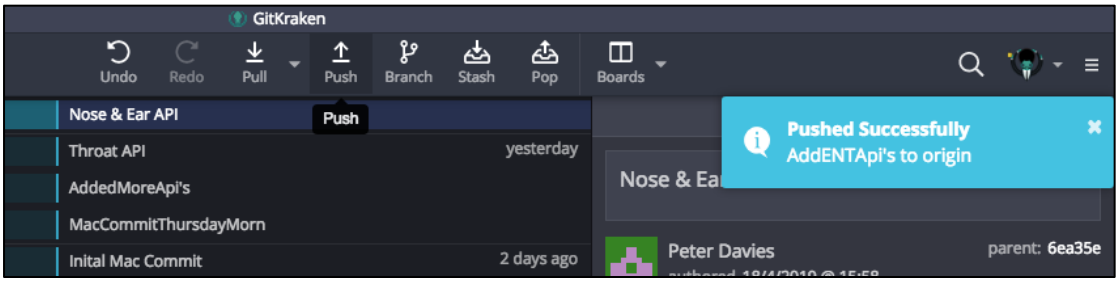
```
public async Task<IEnumerable<Throat>> GetAllThroatGuidelinesAsync () {
    //TODO: Paging...
    using (IDbConnection dbConnection = _connection) {
        string query = @"SELECT
                        glh.GlhID
                        ,h.HeadingText
                        ,i.ImgDesc
                        ,g.GuidelineText
                        ,glh.Priority
                        FROM Headings h
                        LEFT JOIN GuidelineHeading glh ON glh.HeadingID = h.HeadingID
                        LEFT JOIN Image i ON i.GlhID = glh.GlhID
                        LEFT JOIN Guideline g ON g.GlhID = glh.GlhID
                        WHERE glh.PageID = 15
                        ORDER BY glh.Priority ASC";

        var throatGuidelines = await dbConnection.QueryAsync<Throat> (query);
        return throatGuidelines;
        //ADD IN i.Image after Heading Text - left out because byte array is too large.
    }
```

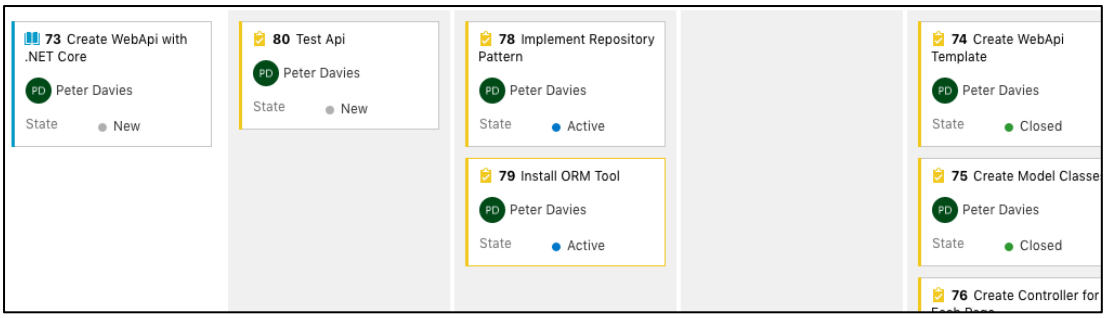
7. Push Repository to Azure DevOps and Publish on Azure Portal

An added feature to this timebox is the Azure DevOps repository services and automatic build deployments to the Azure Portal web server. A repository was created on Azure DevOps at the beginning of this project, to allow code to be pushed directly via the GitKraken software.

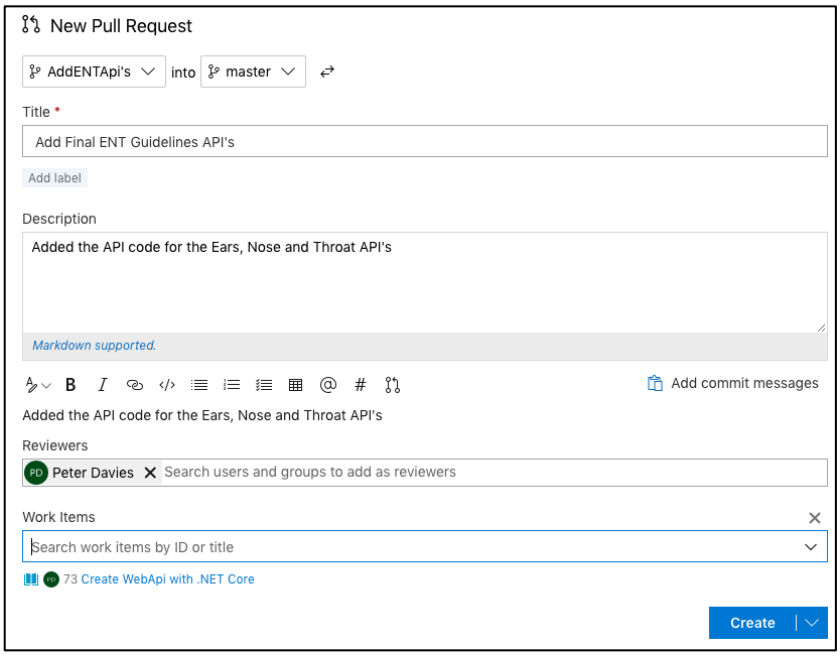
Each time a new feature is successfully developed and tested, it is pushed to the repository and a pull request is created allowing for review of code. In a real-world scenario, this code would be checked by another team member for quality.



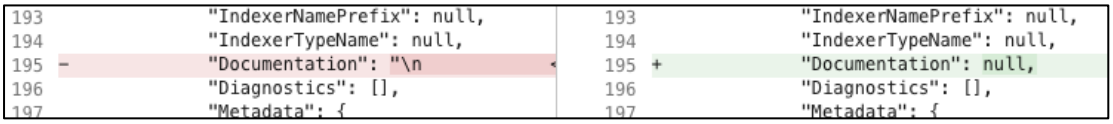
In addition to the repository, the DevOps Agile organisation framework was also utilised to keep track on the projects sprint/timeboxes' using the product backlog, user-story and Kanban board features.



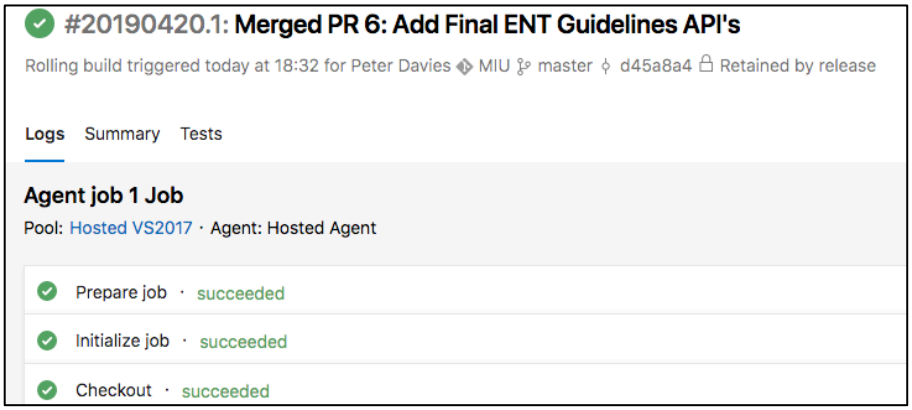
Each of these features can be linked to a pull-request, although, the PR shown below relates to the whole user-story created as the implementation is now complete.

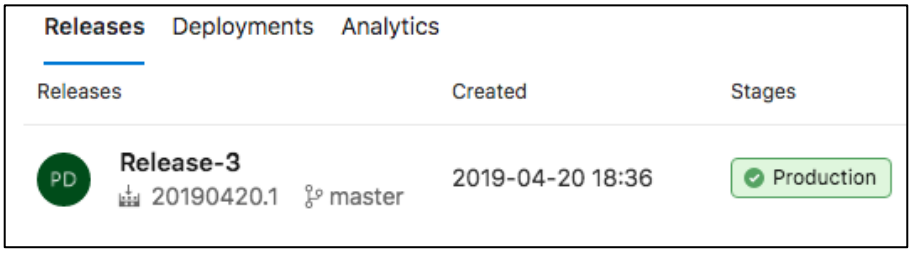


Once created, the code is reviewed using DevOps where any changes are highlighted in green and red and any whitespace removal shown.



Once the code is reviewed and approved the PR is merged to the master GIT branch and the whole web application repository is built and tested on DevOps before being published directly to the Azure Portal web servers.





The API is now live on the web and can be viewed by specifying the endpoints in the browser. For example, to view the Throat guidelines API response:

https://miu-gl.azurewebsites.net/api/throat

iv. ***Software Testing***

Before the code can be pushed to the repo and deployed, localhost testing has been conducted on the working API endpoints. The scope of the test:

1. Displaying Throat guidelines API

2. Displaying Nose guidelines API

3. Displaying Ear guidelines API

The Tests:

1.	1. Visit throat guideline API endpoint 2. Visit throat guideline API endpoint with ID 3 3. Visit nose guideline API endpoint 4. Visit nose guideline API endpoint with ID 5 5. Visit ear guideline API endpoint 6. Visit ear guideline API endpoint with ID 6

The Results:

1.	1. JSON response for all throat guidelines appears. 2. JSON response for throat guideline 3 appears. 3. JSON response for all nose guidelines appears. 3. JSON response for throat guideline 5 appears. 5. JSON response for all ear guidelines appears. 6. JSON response for throat guideline 6 appears.	1. PASS 2. PASS 3. PASS 4. PASS 5. PASS 6. PASS

Sample of JSON Results for Test 1

URI: https://localhost:5001/api/throat/3


```
"throat":[ ⊖
   { ⊖
      "glhID":1,
      "headingText":"<h2 id=\"anatomy\">Anatomy<h2>",
      "image":null,
      "imgDesc":"Anatomy of the throat, side view.",
      "guidelineText":"<ul><li>
>The pritority is to asses ABC - If the airway is not clear or
/li></ul>",
      "priority":1
   },
   { ⊕ },
   { ⊖
      "glhID":2,
      "headingText":"<h2 id=\"history\">History<h2>",
      "image":null,
      "imgDesc":null,
      "guidelineText":"<ul><li>Breathing difficulties</li>",
      "priority":2
```


Sample of JSON Results for Test 2

URI: https://localhost:5001/api/throat/3


```
   "throat":[ ⊖
      { ⊖
         "glhID":3,
         "headingText":"<h2 id=\"examination\">Examination<h2>",
         "image":null,
         "imgDesc":"Tympanic membrane",
         "guidelineText":"<ul><li>
<b>Ensure when looking down troat that good light source and ton
</b></li><br>",
         "priority":3
      }
   ]
```


The full acceptance test sheet can be found in appendix D5.

Conclusion

The API produced currently only displays the guidelines for each ENT section of the document and specific guidelines in each document by the ID. The capabilities to create, update and delete are yet to be implemented due to limited time. These features will be documented in the future recommendations section.

For complete testing of the API, each test can be conducted using the following API endpoints:

1. http://miu-gl.azurewebsites.net/api/page
2. https://miu-gl.azurewebsites.net/api/throat
3. https://miu-gl.azurewebsites.net/api/throat/3
4. https://miu-gl.azurewebsites.net/api/nose
5. https://miu-gl.azurewebsites.net/api/nose/36
6. https://miu-gl.azurewebsites.net/api/ear
7. https://miu-gl.azurewebsites.net/api/ear/17

Should localhost testing be required, the application can be started by using the CLR command:

```
MacBook:MIU Pet$ dotnet run
```

The URI for testing will then be https://localhost:5001/api/{guideline}/{id}

The Azure portal has firewall rules in place on the database. Access from certain IP addresses is prohibited, UWTSD and Swansea University's IP has been logged, but others may not work. An attempt has been made at disabling the firewall with limited success, therefore, should yours be blocked, please email me at:

pdavies.079868@student.uwtsd.ac.uk

v. ***Usability Testing***

There is no usability testing required for the MIU API.

vi. ***Requirements Met (Section 5.2.1)***

- The system should have a RESTful service layer.
- The system must operate across all operating systems & browsers.

5.4.5.4 Implementation - Timebox Four

Date	*Duration*	*Completion Date*
16/04/19	*7 Days*	23/04/19

i. ***Timebox Feature Sets***

The feature list [section 5.4.2] specified timebox four would implement search features into the application, however, with the solution delivery deadline looming the project supervisors advised the aim of the project has been delivered, albeit in three separate entities which need combining: an SQL data service, an application following the MVC pattern using a RESTful web service and a usable front-end interface, therefore, timebox four will focus on bug fixes and making the final recommended improvements to the UI discovered in timebox two. The updated feature list is shown below:

Feature Set	*Feature*
<action> <-ing> a(n) <object>	*<action> the <result> <by|for|of|to> <a(n)> <object>*
4. Update the MIU User Interface	Investigate and fix the fixed footer. Reorganise alphabetical ordering in the main menu. Create container for main body text. Underline & Increase padding on in-text links. Make menu link containers clickable links. Alphabetically order right-hand menu. Insert line breaks in-between each page section. Increase padding size on links to increase highlighting. Guideline body text should be larger. Add new guidelines to system to increase testing difficulty.

ii. ***Feature Design***

No documentation on the design of these features as many are amendments to what has already been discussed or bug fixes.

iii. ***Feature Implementation***

1. *Investigate and fix the fixed footer covering content.*

The footer had the following style conditions implemented to keep it at the bottom of the page:

```
footer.idx-log-footer {
    background-color: #005EB8;
    height: 60px;
    position: fixed;
    bottom: 0;
    width: 100%;
```

However, the main body content had no margin-bottom set, therefore, the content was disappearing underneath the fixed footer. To fix this bug, a margin-bottom of 50px was set.

```
main {
  background: #fff;
  margin-bottom: 50px;
}
```

2. *Reorganise alphabetical ordering in the main menu.*

Re-organisation was simply done by moving the order of the guideline title HTML div containers in each row on the home page.

```
<div class="row">
    <div class="col-md-4">
      <h3><a href="#1">Ear Conditions/Injuries</a></h3>
      <p>Anatomy, history, examination, foreigAddn bodies, perforations, etc.</p>
    </div>
```

3. *Create media-query container for body on larger screens.*

To address this issue a CSS media screen query was used to adjust the margins on the container and other elements on the page to draw content back into the focus of the user allowing them to view the main body content without moving their head, this also supports Tidwell's theories on the use of the two-panel selector to reduce cognitive load and eye strain

[230]. The styles added are applied when the screen is >= 1366px and >= 1600px for very large monitors.

```
@media screen and (min-width: 1336px) {
  .content-container {
    margin: 0 100px 0 100px;
  }
```

```
@media screen and (min-width: 1600px) {
  .content-container {
    margin: 0 200px 0 200px;
  }
```

4. *Underline & Increase padding on in-text links.*

Adding the underline on the in-text links required specific targeting of the <a> tags in the main section container, otherwise all the <a> tags throughout the page would be underlined, something not required for the right-hand menu. This was achieved by adding the following CSS to target the <a> tags specifically in the section and content containers.

```
section.content a {
  text-decoration: underline;
}
```

To increase the highlighting on hover, increased padding was considered, however, when tested the increase meant the text was spaced out to far either side of the link, to overcome this, the CSS property box-shadow was used instead to add a shadow of the same colour around the <a> tag of 4px.

```
section.content a:hover {
  box-shadow: 0 0 0 4px #ffcd60;
}
```

5. *Links in both menus should allow for whole link container to be clickable.*

To increase the clickable area in the right-hand menu the CSS property *display:block;* was set on the anchor tag inside the list-item tags which results in the <a> tag filling the area of its parent <li> tag and the whole area becoming the link.

In addition to this minor change, to further increase feedback to the user about their location in the document, the highlight colour and underline text-decoration was added to class which is applied by the jQuery script discussed in timebox two. This results in the selected location in the document being highlighted with the blue left border and a yellow highlight. Additionally, this highlight style was added to the left-hand menu. Now when a menu is selected, it stays highlighted, giving increased feedback to the user.

6. *Minor Chest Injuries is not in order.*

   This has been rectified whilst addressing issue 2.

7. *Right-hand menu should be in alphabetical order.*

   The right-hand menu has been organised alphabetically and the corresponding anchor ID's arranged accordingly to ensure the automatic scroll to each heading works correctly. Although directly asked for by users during testing, it is still considered that this menu is better organised by following the documents structure, therefore, this will be scrutinised in the final round of user testing.

```
<li class="sb-active"><a href="#one">Anatomy</a></li>
<li><a href="#nine">Bacterial Tonsillitis</a></li>
<li><a href="#three">Examination</a></li>
<li><a href="#six">Epiglottis</a></li>
<li><a href="#twelve">Foreign Body in Throat</a></li>
```

8. *Content should have clearer breaks in-between each section.*

   This was achieved by adding line breaks at the end of each section using the <hr> tag which adds thematic break in the HTML. The colour of the line break was set to hex *#aeb7bd* as per NHS digital's UX guidelines.

9. *Highlight on link hover should be bigger.*

   This issue was addressed along with issue 4 as the box-shadow style will apply to all body <a> tags.

10. *Guideline body text size should be increased.*

    Following guidelines from NHS digital the main body text size was set to 16px with a line height 1.5 times the size of the text. This has resulted in text becoming clearer to read.

```
section.content li {
  font-size: 16px;
  line-height: 1.5;
}
```

    Additionally, NHS digital state that for larger screens, the font size should increase to 19px, therefore, using the same media query used in task three this was set.

11. *Add more guidelines to the system to increase testing difficulty.*

The current tests on the UI have been conducted using only one selectable guideline in the left-hand menu, therefore, to thoroughly test the systems navigation the Ear and Nose guidelines will be added to increase complexity of tasks carried out in the following section.

iv. ***Software Testing***

With the improvements implemented, the navigation of the application was tested, however, following advice from timebox two, the system was tested on Apple's Safari browser along with Chrome. The test scope:

1. Visit nose guideline page using home page links
2. Navigate to every section of the nose guidelines using accordion menu
3. Navigate to every section of the nose guidelines using right-hand menu
4. Navigate back to home page using NHS logo
5. Visit ear guideline page using home page links
6. Navigate to every section of the ear guidelines using accordion menu
7. Navigate to every section of the ear guidelines using right-hand menu
8. Navigate back to home page using breadcrumb link
9. Logout of the system

The Tests:

1.	1. Visit nose guideline page using home page links 2. Navigate to every section of the nose guidelines using accordion menu 3. Navigate to every section of the nose guidelines using right-hand menu 4. Navigate back to home page using NHS logo 5. Visit ear guideline page using home page links 6. Navigate to every section of the ear guidelines using accordion menu 7. Navigate to every section of the ear guidelines using right-hand menu 8. Navigate back to home page using breadcrumb link 9. Logout of the system

The Results:

Test	*Expected Result*	*Pass/Fail*	
		Chrome	*Safari*
1.	1. Nose guideline page appears. 2. Each section comes into focus at top of page. 3. Each section comes into focus at top of page. 3. Home page appears. 5. Ear guidelines page appears. 6. Each section comes into focus at top of page. 7. Each section comes into focus at top of page. 8. Home page appears 9. Log-in screen appears	1. PASS 2. PASS 3. PASS 4. PASS 5. PASS 6. FAIL 7. FAIL 8. PASS 9. PASS	1. PASS 2. PASS 3. PASS 4. PASS 5. PASS 6. FAIL 7. FAIL 8. PASS 9. PASS

Comments:

Test	*Comments*
1.	6. Screen does not scroll into view using Red Flags & Pitfalls link in accordion. 7. There is no Red Flags & Pitfalls Link in the right-hand menu.

Actions Taken

The Red Flags & Pitfalls link was added to the right-hand menu HTML with the correct anchor tags to enable the auto-scroll feature. This was re-tested and now works on both browsers.

Comments

Although all the features worked on both browsers, on Safari, the typography did not look correct and the links in the accordion menu were squashed. It appears that Safari is using the fall-back font set in the font-family used: Arial, resulting in a larger body text. This issue has been acknowledged and will be addressed in future iterations. The full test sheet is found in appendix D7.

v. Usability Testing

Timebox two stated that alterations made to the system in timebox four would be both tested by means of a cognitive walkthrough and user testing. However, time constraints limited testing to a cognitive walkthrough conducted by the developer. Given that the system has scored very highly on the previous user tests, with no major issues being discovered, the final cognitive walkthrough should be sufficient to test all the improvements made in timebox four and provide additional evidence proving that the system has met the project's aim.

Cognitive Walkthrough

The cognitive walkthrough will be constructed using similar tasks to those used for user testing as these tasks were designed to match the user's goals discovered from the literature review and user personas created in section 5.3.3. Each task is broken down into sub-tasks which will be required fulfil the user's goals.

Task One

- *Find the guidelines for a patient presenting with a foreign body in their throat.*

a. Enter username and password. (Any)

b. Click log-in button.

c. Click on 'Throat Conditions'

d. Click on 'Foreign Body in Throat'

Task One Conclusion

Task one was repeated for each test section added to the system (ENT) and found no problems. The results of the cognitive walkthrough reside in appendix D8.1.

Task Two

- *From the Throat Guidelines page find guidelines for Epistaxis in the Nose*

a. Click on Nose Guidelines section in main menu.

b. Scroll through menu.

c. Click on 'Epistaxis'.

Task 2c.

Click on Epistaxis	*Success?*	*Comments*
Does the user know what they want to do?	*Yes*	Yes, they want to click the Epistaxis link.
Can they see a control that will do the job?	*Yes*	Yes, links to each section follow web conventions.
Is it clear how to operate the control?	*Yes*	Yes, links are underlined, blue in colour and highlighted on hover.
Is the immediate feedback understandable?	*No*	No, link for Epistaxis scrolls to 'Sore Throat' on current Throat Guidelines page.

Task Two Conclusion

Task two was also repeated for each of the test sections added and discovered that the links in the accordion menu under each guideline section were broken and only scroll to guidelines on that current page rather than delivering the expected behaviour of loading the desired page directly to the specified section in the page. For example, the Epistaxis link should open the Nose Guidelines page and scroll directly to the Epistaxis section.

On investigation, this problem was due to the current anchor system which uses ID's on the anchor tags to reference sections in the document, implemented in timebox one. This will be investigated further, remedied and tested in timebox five.

As tasks A and B presented no problems their results are found in appendix D8.2.

vi. ***Requirements Met (Section 5.2.1)***

As timebox four implements bug fixes and improvements, no more requirements have been met.

5.4.5.5 Implementation - Timebox Five

Date	*Duration*	*Completion Date*
24/04/19	*1 Day*	24/04/19

Timebox Feature Sets

No feature sets for timebox five, timebox will implement the correct link/anchor system.

vii. ***Feature Design***

Bug fix – no documentation.

viii. ***Feature Implementation***

1. Investigate and fix the link/anchoring system on ENT pages.

Upon investigation, the problem was the anchor links between each page. A simple fix which involved adding the URL to the correct page pages with the anchor tag added.

```
<li><a href="nose.html#one">Anatomy</a></li>
<li><a href="nose.html#two">History</a></li>
<li><a href="nose.html#three">Examination</a></li>
<li><a href="nose.html#four">Epistaxis</a></li>
```

ix. ***Software Testing***

Testing showed that the links now navigate to the correct section of each page, however, the offset added by the jQuery to scroll each heading into view is no longer working on the linked pages meaning headings are hidden behind the header. With no time left for development, this will need to be added to the product backlog for further investigation.

x. ***Usability Testing***

Bug fix – no usability testing.

xi. ***Requirements Met (Section 5.2.1)***

Big fix – no requirements met.

Conclusion

The HTML pages have now been pushed to the Azure DevOps repository and deployed to the Azure portal following the same procedure found in timebox three (feature 7). It is accessible at the following URL:

https://miu-ent.azurewebsites.net/

5.5 Repositories

Each component developed (SQL, API and HTML) has a git repository on Azure DevOps for future developers to continue this work. Should access be required to these repositories please email me at:

pdavies.079868@student.uwtsd.ac.uk

5.6 Conclusion

Section five documented the design, development and implementation of the MIU system by first breaking down the problem to be solved through discovering the system's requirements, organised using the MoSCow methodology. The updated aim and objectives [section 1] followed.

The design stage followed, investigating the database design by using the MIU guideline documentation to develop a relational table prototype, testing then commenced in MS excel and the database subsequently improved and re-tested. The auditing table has then been briefly discussed and a data governance policy produced in line with current GDPR laws (appendix C3).

The final design stage developed prototype interfaces through user personas created from the literature review research to discover the user's goals and needs. These were then translated into paper-based mock-ups following known design patterns which were evaluated, firstly using Tidwell's behavioural pattern theories and secondly by user tests. Unfortunately, a cognitive walkthrough was omitted due to an oversight: this would have added further insight for analysis. However, the data gathered from user testing was analysed and recommendations made.

Implementation followed FDD practices, iterating through 5 timeboxes, documenting the creation of the database tables and data entry, the front-end design using static HTML and jQuery and creation of an API using the MVC architectural pattern (minus the views). Each timebox was subjected to either software tests, usability tests or both. Timeboxes 3 and 5 document improvements made to the system as a result.

Unfortunately, time limitations meant no client-side frame work was used to amalgamate the three components built: adding the 'V' in the MVC by consuming the API and displaying data from the database. Code repetition would have also been avoided using server-side template engines like Razor or client-side JavaScript functionality. Additionally, the overall model produced [section 5.4.1] does not reflect this, an updated model has been omitted due to time constraints.

Furthermore, the brief states that guidelines should be accessible through a mobile device, something which is echoed by the need for integration into clinicians' workflow [section 2.4.4] and NHS digital stating that most visitors to their applications visit from a mobile device [299]. Disappointingly, the development did not take the recommended approach by Wroblewsk [306], to develop for mobile first, meaning that there was no time to add CSS media queries to remedy this.

6. EVALUATION

The project's goal was always to deliver the aim, originally stated in the project proposal, however, further research into the subject area resulted in the aim changing slightly. The updated aim from section 5.2.3 is:

> *"To develop and deliver a user-centred Computerised Clinical Practice Guideline system, as a web app, using an MVC framework with a RESTful web service layer and an SQL data service with a usable, intuitive interface".*

It is concluded the project has delivered this aim, albeit in three separate entities which need to be amalgamated to deliver a viable product for use in the NHS. Therefore, the three separate components will be evaluated individually.

6.1 SQL Data Service

The database design was influenced through evidence in section 1, that stated medical datasets reach obsolescence quickly, this notion was supported by section 2.4.4 which found that clinical data needed to be adapted easily and regularly for CDSS to be successful. Therefore, the data store was designed with the mindset that it would be queried regularly, meaning referential integrity and adherence to normalisation standards were paramount, as was ensuring the data structure resembled a real-world document where possible.

Extensive testing of the database designs through excel [section 5.3.1] and live testing [section 4.4.5.1] concluded the design would form the foundations of a good CDSS data service, meeting the standards required by practitioners discovered [section 2.4.4]. Furthermore, the use of cutting-edge Azure data store cloud technologies has delivered on objective three which states that the latest technologies should be used, ensuring future proofing of the system.

However, database testing did produce interesting questions regarding its design which are answered in appendix D1. These answers suggest there would be better solutions to database design to avoid the use of complex front-end framework which could result in an unintuitive UI for users, when performing CRUD operations. Currently, the query to retrieve guidelines and headings for a specific page uses a complex SQL join query, meaning that, for users to insert data, a set of pre-defined queries would need to be implemented as stored procedures for use in a client-side front-end framework which communicated with the SQL datastore to insert user-entered data in the right order without users being bogged down with the database logic.

If repeated, a more extensive research process into front-end frameworks which can communicate effectively and intuitively with a data store would be performed, ensuring the simplest, cheapest, most maintainable and extendable solution possible for use in a real-world NHS environment.

6.2 RESTful Web Service

Health organisations like the NHS need to display their data on several different devices as practitioners cannot work effectively through a desktop computer alone. Shiffman provided evidence in section 2.4.4 of the need to develop the data source as an API allowing the guideline data to be consumed by many different interfaces and devices, such as mobile devices for practitioner accessibility, even allowing for a different UI design depending on NHS trust, as a RESTful web service is MVC without the view [307].

The use of REST technology has also realised objective two, as well as part of the aim, however, the aim also states the application should be MVC, although at present the system is *'MC'* as no views have been created to consume the API.

In conclusion, an API would be used again, however, more time would be spent developing and testing it, as at present only data can only be read from the data store. Capabilities to create, update and delete should be implemented but time constraints and poor time management in reference to the development and methodology section hampered the development stages. Furthermore, this affected the front-end integration with the web service, if repeated a cutting-edge front-end technology like Microsoft's Blazor or a JS framework would be implemented to consume the API and present it in a view developed in-line with this project's user interface research.

6.3 Usable & Intuitive Interface

Evidence in section 2.4.4 showed that that CDSS were not used due to poor usability as they were being technology driven rather than user-driven, therefore, the design and implementation was conducted using a user-centred approach.

Meaning the literature review focused on researching user-centred design regarding CDSS as well investigating the integration of existing UX practices and existing solutions to IA, such as SNOMED which utilises a hierarchical ontology [section 2.3.2.5].

This led to use of user personas and involvement of the user from as early as possible, evident through the testing of paper interface designs. These tests gathered data on the proposed designs, specifically testing the navigation, IA and features discovered to be crucial to CDSS success through the user-personas. User comments were reviewed, and subsequent changes made as a result.

Testing conducted on the interfaces produced good feedback from the users and produced very high usability scores: an expected outcome, as this was a direct result from research into UX practices and user involvement from stage one, as well as known interface design patterns.

When comparing the final interface testing data to the literature review findings on usability it can be concluded that, overall, the interface met Nielsen's 5 quality components in section 2.5.2 and has delivered a CDSS interface that follows the proposed UX honeycomb framework meeting the 4 most important recognised segments in section 2.5.3 which state a CDSS should be useful, usable, findable and desirable.

Given the opportunity to design an interface for the NHS, or any health organisation again the research and testing would be carried out specifically using trained medical staff who would use the system, to further improve adoption rates.

Section 4.5.3.4 states the user testing was conducted using the best available resources: first-aid trained participants, which did, as Krug suggested, highlight many usability problems, however, it could be argued this is not a true reflection of the systems usability or user experience, as many of the participants were highly computer literate, were not testing the system under real-world, time pressured conditions and participants only had a limited number of guidelines to choose from in the system.

Therefore, to gauge the usability and user experience of this CDSS the system should put to test again within its *actual* environment by its *actual* users, with addition of more difficult tasks such as adding/updating/deleting guidelines or searching for data 3 or 4 levels down in the ontology. Only then could the data be analysed, and a conclusion drawn on whether this interface is suited to the high-pressure MIU environment.

6.4 Conclusion

Although results from testing may have provided a skewed view on what is *actually* usable in the real world through testing with unsuitable users, the project has delivered the aim as best it could, accounting for the circumstances and limitations of time and resources.

To deliver this aim, objective one is met through research into current CDSS technologies and existing UX and usability practices with the addition of introducing experimental UX frameworks which could aid future CDSS design. Secondly, an agile FDD approach using the latest technologies has been used and documented to address objective two. Objective three has been met through basic acceptance tests of the software and extensive usability testing with objective four being met through the evaluation and conclusion of this report.

7. CONCLUSION & RECOMMENDATIONS

7.1 Conclusion

This project is a real-world problem which NHS Wales is facing, the introduction stated this is the reason the MIU approached the university: for help in solving the current usability and adherence issues with their systems, the aim of this project. This problem is already recognised by NHS England, who, in 2013, identified a need for common user interfaces to improve usability and UX whilst reducing the likelihood of clinical errors through misinterpretation across their digital systems, to do this, the NHS digital team was formed [308].

This team was formed as tackling issues of this magnitude require a highly experienced and dedicated team: it is for this reason this project has been extremely challenging to conduct by one person. However, best efforts were made by firstly conducting research into DSS and CDSS in section 2.2 and 2.3, discovering the best type of system needed to meet the aim. These sections concluded that the IRS required would be a data-driven, rule and knowledge-based, passive, computerised clinical guideline system.

Section 2.4, built on these discoveries, exploring the underlying algorithms in CDSS and the challenges previous researchers encountered when attempting to computerise guidelines in standardised format, and, more importantly, the challenges faced when implementing these systems into clinical settings and ensuring clinicians' adoption. The evidence as to why became clear: current CDSS are simply not used because they are ineffectual in clinical environments due to a non-user centred approach to design, something which NHS England have started to address.

This discovery focused research onto current usability and UX practices, identifying Morville's honeycomb as the perfect framework to aid development of a user-centred CDSS, furthermore, this section found a conceivable link between Osheroff's CDS five rights statement [section 2.3.4] and Morville's honeycomb and has suggested further research to aid future developers and hopefully, save lives.

Section three, looked in-depth at research and development methodologies needed to meet the objectives: discovering this project will cover both objectivist and subjectivist methodologies through positivist and phenomenological research approaches by means of a literature review, a case study and the development of software.

Section four stated the *how* by outlining the methodologies used to develop a system to meet the aim: adhering to findings from the literature review, user stories, personas, and known interface design

patterns were discussed, and paper prototyping introduced to involve the user from stage one. Agile FDD development was also discussed as it supports single member team development through incremental timeboxes which split up features into manageable chunks. Finally, testing methodologies were stated providing the measurables needed to compare this project to research to discover that it has met its aim.

With the methodologies stated, section five documented the development, starting with database design and testing to provide a foundation. Continuing the design, detailed wireframes were developed, adhering to the personas created which were subjected to user tests with the results documented and carried forward into the next stage of development, in doing so, the user was involved before any code had been written, something had been lacking in CDSS to date [section 2.5].

Finally, the development commenced, beginning with implementing the database into a distributed cloud-based server for increased accessibility and expansion through reliable Microsoft servers with no down-time. A front-end interface was developed following the user-certified mock-ups with user's recommendations [section 5.3.3.5] considered. Finally, a web API provides endpoints to MIU data, which an array of devices can consume, even AI systems with no interface, something found to be important when considering clinicians' workflow integration [section 2.4.4].

All development was conducted using Azure Git repositories allowing for continuation of research and development. Each timebox was subjected to software and usability tests, where applicable, with problems addressed accordingly, again, involving the user throughout development.

When comparing the components developed to the project aim, it has been delivered, however, it is evident these components need to be improved, combined and further tested to conclusively confirm if this solution would stand up to the rigours of a clinical environment. As paragraph two of this conclusion stated, the challenge of producing a deliverable CDSS by one person is an impossible task, therefore, looking forward, this project is considered a starting block for future students to build on for their final year projects, or PhD doctorates.

7.2 Recommendations

This project, as many before it, has left loose ends which hopefully will be picked up and concluded by anyone who continues this groundwork. These are the recommended areas for future research to ensure success of CDSS of this nature:

- Further research into mapping the CDS five-rights framework to the UX honeycomb framework.
- More features discovered from the user personas should be implemented.
- More *must have* and *should have* requirements should be met.
- Further research into implementation into AI and voice-controlled navigation.
- The integration of BLE Bluetooth beacons.
- Further research into a front-end framework to consume the API for a data-driven system.
- Add complete CRUD capabilities to the API.
- Add all the MIU data and user test in a clinical, time pressured environment.
- Research the possibility of using SNOMED vocabulary for increased terminology standardisation.
- Add a database audit table from the plans stated in section 5.3.2
- Research into a CMS as another solution to the MIU problem.
- Integrate the current NHS security protocols for log-ins.
- Test software produced thoroughly using unit tests.
- Utilise the existing NHS Digitals front-end design repository.
- Ensure front-end is completely responsive in design.

8. REFLECTION

In October 2017, students were given the major project titles. The project that instantly drew my attention was the Web-based A&E guidelines for MIU, supervised by Dr Nik Whitehead. Reason being, firstly the NHS holds significant value to me personally: having overcome serious personal illnesses in the past, solely because of this great institution and its wonderful staff, I felt it would be my opportunity to repay them in some way. Secondly, and more selfishly, when reading the project brief which stated:

> *"Local Minor Injuries Units include, within their documentation for staff, a comprehensive list of other things to check for when patients attend the MIU with particular symptoms. This aids the staff in making sure that potentially dangerous complications are not missed. A need has arisen for a computerised version of these documents, organised as a website that can be accessed easily through a mobile device. Usability, information architecture and security are of prime importance for this website"*

I considered this project to be simple to implement for a web student who had so far been academically successful. Furthermore, it would call on my two favourite areas: front-end web development and UX. Fast-forward to October 2018 and reality hits: this project was far bigger and more complex than envisaged.

This complexity was initially discovered through the literature review, which was completed by Christmas 2018, far longer than planned. However, I felt that to build a CDSS, a deep understanding was required, therefore my research started from the very origins of DSS and worked its way through the DSS and CDSS timeline, helping me understand that poorly designed clinical IT systems were not something just the NHS was suffering from, but a problem every clinical institution worldwide shared, with CDSS still not widely adopted or used today.

Research also led me into interesting ethical issues facing the NHS today with the advent of AI technology, such as Babylon Health's GP at hand service, which has the potential to revolutionise services delivered by the NHS whilst saving millions, however, Babylon Health is a private company, and I personally consider this to be another step towards a privatised NHS where profits become before patient care. I hope that this technology can come into public ownership to protect the NHS.

My work also uncovered a possible mapping between the CDS five rights framework to Morville's UX honeycomb, which I hope could provide a framework for future CDSS developments to follow, addressing the major pitfall in current systems: poor usability and user experience. The value of such a framework is shared with Dr Whitehead who has suggested collaboration in writing a paper to

document these ideas. Given the impact that Morville's honeycomb has had on the UX world, and to work with a UX expert like Dr Whitehead to produce something that could have a similar impact is an extremely exciting prospect.

Reflecting on the subsequent research and development methodology sections, it is evident that their aim was misunderstood. I invested too much time in researching and documenting the processes I would use in my implementation section (appendices B & C), and although I gained invaluable knowledge, it left me with little time to develop the system to the standard I would have liked.

Lost time and underestimation of how long development would take shows in the system submitted, for example, Microsoft's experimental framework Blazor was investigated for use, to pull all the components developed together (DB, API & front-end). Despite initial systems being developed using this technology, and the deadline looming it was abandoned to focus developing the components separately, however, having learnt about this technology, I will be using it for future projects.

The UI could also have benefited from using the existing open-source, NHS digital repositories: saving the time spent modifying the template I used, as I was constantly fighting conflicting CSS styles and JavaScript to adhere to the NHS digital's design patterns. Unfortunately, this repository was only discovered late April, meaning my opportunity was missed, however, I can now recommend this repo for future NHS projects.

The literature research pointed to a major problem with CDSS: integration workflow, and I had planned to address this through means of voice navigation. Research into basic voice control showed that implementation was not difficult, furthermore, the project brief stated that security was of prime importance and Microsoft logins were considered to allow users access using their existing NHS outlook accounts, something which would have saved NHS staff stress. Again, time constraints forced abandonment.

Documentation wise, I feel my UML diagrams and descriptions are poor and I had no time to produce relevant use case diagrams and software user stories as FDD requires. Furthermore, there was no time to conduct unit tests and I felt my acceptance testing was poor due to the system's simplicity. The usability testing also suffered as I forgot to conduct cognitive walkthroughs before user tests, meaning time was wasted during user testing finding bugs in the system which should have been discovered earlier, without wasting my participants time.

When looking back to my project proposal risk analysis [18], underestimating the development time was already recognised:

R1. Underestimating the time required to build the web application.

LOW	MODERATE	SIGNIFICANT	HIGH

and although the omission of the aforementioned features suggests this warning was ignored, development started early March with database design. The database was considered the foundation for the whole system, therefore, the upmost care was taken in its development and testing meaning more time was spent than planned, furthermore, as the database attempts to follow a document structure, the design was somewhat new and needed extensive research.

Another significant risk identified was the data entry into the system. To overcome this, the ENT guidelines were selected for the development stage as they best demonstrate the clinical algorithms implemented as links between related guidelines, without spending too much time on data entry. Insertion of all the data could take weeks.

R6. Input of data from MIU guidelines will be time costly.

LOW	MODERATE	SIGNIFICANT	HIGH

8.1 Conclusion

As stated, the real-world problem faced was one of gargantuan scale and despite my best efforts, I have only delivered a fraction of what I would have liked to and what would be required to see this system implemented into a MIU department. However, I feel that I have provided a good amount of background research ready for myself, or other academics to continue researching this important and complex issue NHS Wales faces.

The gargantuan scale has led to this report exceeding the word count by some margin, something I am disappointed with and will need to learn from for my professional career, however, in the real-world, this report would be even larger if it were to cover all the techniques of research, development and testing to the standard required by the NHS.

Another important risk identified was the balance of this project with other modules of study required this year.

R2. Incorrect balance of project aim and objectives with other modules of study throughout the final year of the B.Sc. course.

LOW	MODERATE	SIGNIFICANT	HIGH

Admittedly, this is something that I struggled with. Assignment deadlines meant weeks were spent away from this project, ultimately interrupting my flow and having a detrimental effect on its outcome, however, this is considered a valuable life lesson as with any project there will always be interruptions, therefore it is important to plan for them accordingly.

This project has, almost certainly, changed my future as a developer, before it began, I was working part-time as a handyman for Swansea University's student's union, but during the project I applied for and became an intern analyst programmer with Swansea University's ISS department and post project I am due to start a full-time role.

I firmly believe that the skills I have learnt and the confidence I have gained from conducting a professional research project has contributed to my recent appointments through the use of desirable cutting-edge technologies such as Azure DevOps and Azure cloud hosting services as well as honing my skills with desirable technologies such as C#, SQL and Git version control. I also endeavour to transfer my UX experience to Swansea University to hopefully improve their dreadful university intranet and website!

Overall, this project has been one of the most emotionally, physically and mentally challenging, but ultimately rewarding experiences I have undertaken, teaching me valued lessons to learn from to develop professionally. I hope that upon graduation I can look back and be proud of what I have achieved.

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“Seven Steps to Effective Data Governance.”

11. APPENDIX

A. Abbreviations

Abbreviation	*Definition*
A&E	Accident and Emergency
AI	Artificial Intelligence
DB	Database
DBMS	Database Management System(s)
CDS	Clinical Decision Support
CDSS	Clinical Decision Support System(s)
CPG	Clinical Practice Guideline(s)
CCPG	Computerised Clinical Practice Guideline(s)
CPG	Clinical Practice Guideline(s)
CPOE	Computerised Physician Order Entry
DSS	Decision Support System
EHR	Electronic Health Record(s)
ECG	Electrocardiogram
ES	Expert System(s)
FDD	Feature Driven Development
GUI	Graphical User Interface
HCI	Human Computer Interaction
IRS	Information Retrieval Systems
IA	Information Architecture
IxD	Interaction Design
KBS	Knowledge-Based System(s)
MIU	Minor Injury Unit
NKBS	Non-Knowledge Based System(s)
UX	User Experience

B. Development Methodology

B1. User Persona Examples

The following tables provide a brief example of what personas should look like.

Persona	*Profile*
Persona A	Persona A is an experienced MIU ward nurse, interested in a wide range of injuries and illnesses. They use the system often but are extremely time limited so focus on finding information as quickly as possible through tablets and a desktop pc. As they are experienced, they see themselves as a leader on the ward.

Table 14 - Basic Example User Persona

This basic persona gives a glimpse at what the target user's pains and goals are, their roles and responsibilities, what tasks they need to carry out and on which devices as shown in table 5.

User's	*Details*
Name	Persona A
Demographic	Unknown
Description	Persona A is sister in the MIU at Royal Gwent Hospital
Goals	Finding information as quickly as possible
Pain	Frustrations arising from not finding what they want in their limited time.
Device Preference	Desktop PC and mobile tablet.
Responsibilities	Sister of MIU. Cares for 1000's of patients a month.
Tasks	Finding important information relating to medical problems faced.

Table 15 - Basic Needs for Example Persona

Using this data, the designer can now ensure the system focuses on fast information retrieval, where the information is of a professional standard and can be found and displayed equally as quick and legible on both a desktop pc and tablet.

Typically, a user persona will contain more detail than the example shown. More detailed personas for a range of users following this methodology can be found in section 5.2.

B2. Design Patterns

Behavioural Pattern	*Brief Explanation / Example*
Safe Exploration	- Feeling free to press buttons and click links leads users to explore a piece of software. - Actions can be easily undone.
Instant Gratification	- Users want results instantly. - The first page should allow users to create something.
Satisficing	- Users don't want to think. - Users don't want a manual, labels should be short & obvious. - Users develop habits.
Changes in Midstream	- Users goals change.
Deferred Choices	- Do not make users register to use an application or website.
Incremental Construction	- Good, rapid feedback induces a state of flow.
Habituation	- Regular actions become habitual. - If actions differ from existing applications/websites they cause problems. - Consistency is important.
Microbreaks	- Pages must have short load times
Spatial Memory	- Users remember where things are, not what they are called. - Similar functionality in similar places.
Prospective Memory	- Users think ahead and provide reminders for things. - Don't close a window or start a screensaver because the system has been idle for a while. - Remind users where they left of, or where they were recently.
Streamlined Repetition	- Repeated actions should have shortcuts.
Keyboard Only	- Data entry is fastest with a keyboard. - Some users struggle with a mouse or trackpad.
Other People's Advice	- Users are influenced by what others think.
Personal Recommendations	- Things need to be sharable in some way.

Table 16 – Tidwell's Related Interface Behavioural Patterns

B3. Feature Driven Development Processes

Coad *et al.* [240] state that FDD is based on a well-known system life-cycle pattern, ETVX and comprises of five sequential processes with every phase having different tasks (fig. 15). Chowdhury and Huda [245] add that these five tasks can be further divided into two main stages. The first discovers the features to be implemented which are required by the customer, who, in stage one, should be present fulltime. Stage two involves development of discovered features in short iterations, usually 1-3 weeks long. Each iteration has a *'work package'* comprising of a group of features small enough to be completed in one iteration (aka timebox/sprint). Upon completion of a work package, *something* is delivered to the customer for review, testing and feedback, as per agile methodology [309].

B3.1 FDD Stage One

i. Develop Overall Model

The first process involves an intense, collaborative and highly iterative high-level walkthrough of the proposed system and its context performed by domain experts. A high-level model is then created then further divided into smaller domain areas with more detailed walkthroughs being held. A development team is then formed who compose models in support of each walkthrough, the models are then presented to other teams for discussion and review, an overall model is then formed through consensus of the teams which becomes the model for that domain area. The process repeats until an overall model shape is contracted for the system [239][310].

The models are typically built using Coad's [240] colour modelling technique with the aim being for developers and domain members to fully understand the problem. The models developed in this stage are wide, focusing on breadth rather than depth, the latter being added iteratively throughout the project, meaning that the model is a *'living artefact'* which the team uses for discussion, clarification and challenge, subsequently changing the model as the project evolves [241].

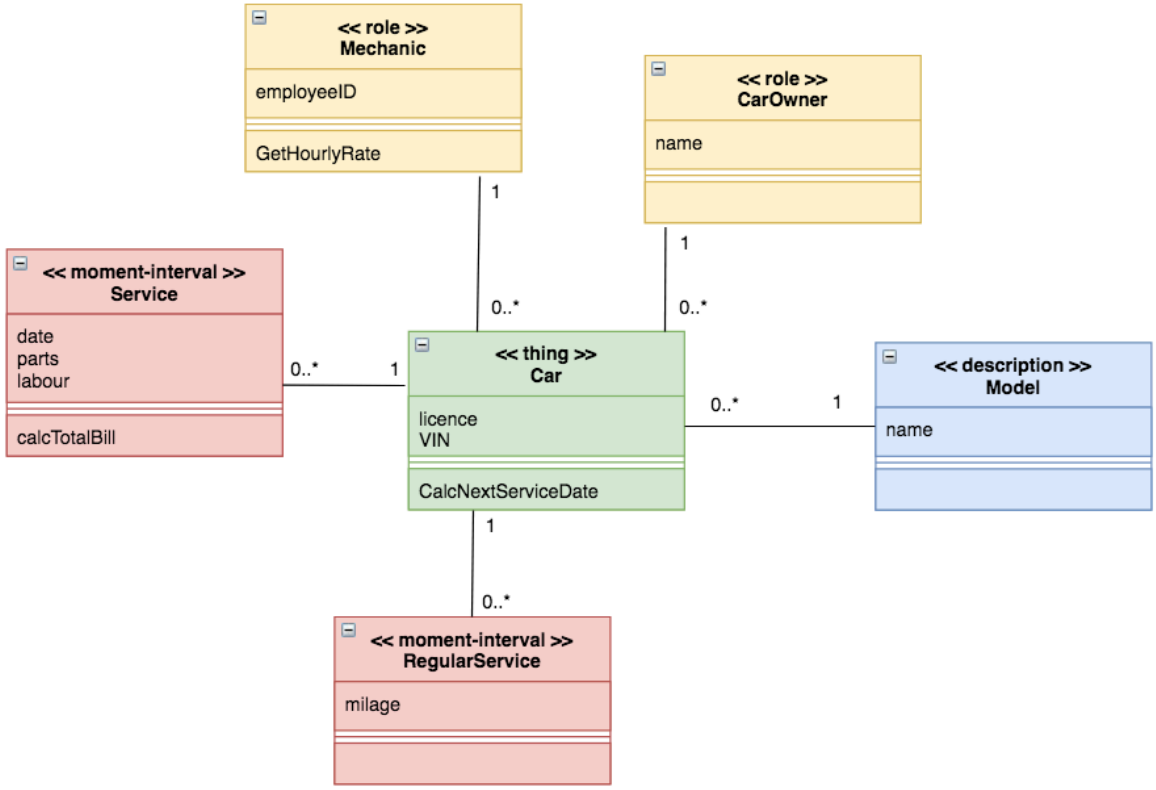


Figure 31 - Overall Model Example using Colour UML [237]

Figure 16 shows a basic overall model for a vehicle garage application which keeps track of service intervals for vehicles using Coad's colour UML diagrams which allow for easy differentiation between roles (yellow), place or thing (green), descriptions (blue) and moment intervals (pink).

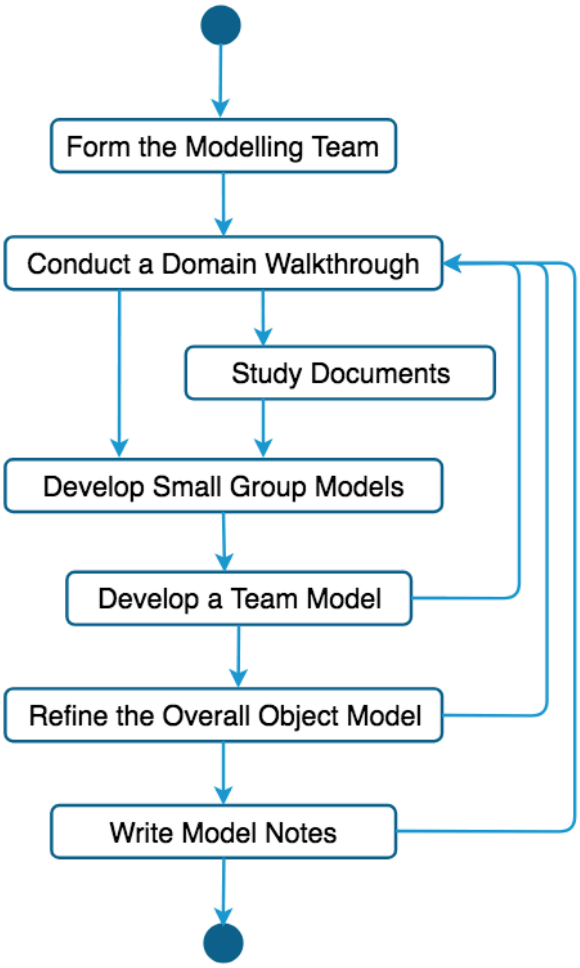


Figure 32 - Develop Overall Model Process Flowchart

ii. ***Build Feature List***

The second process is to use the overall model to guide the development of a features list. Features are defined in FDD as small, client valued functions, typically implemented in 1-3 days but no more than 10 [241], which are expressed in the following form:

<action> the <result> <by|for|of|to> <a(n)> <object>

Using the overall model in figure 16, feature examples would be:

calculate <action> the next service date <result> of a car <object>
Asses <action> the time spent <result> servicing a car <object>
Calculate <action> the total parts and labour cost <result> of a service <object>

These features can then be grouped into a *'feature-set'* which is a group of business-related features which is named using the following form:

<action> <-ing> a(n) <object>

Which would translate into:

Performing <action><-ing> a vehicle service on a car <object>

These feature sets can then be further classified into major feature sets using the form:

<object> management

Which translates into:

Car-servicing <object> management

The process of developing the feature list begins whilst developing the overall model, features are recorded as domain members discuss their models and ideas. A detailed feature list is then developed once the overall model is completed with most features coming from the overall model's pink, moment-interval (business area) [240].

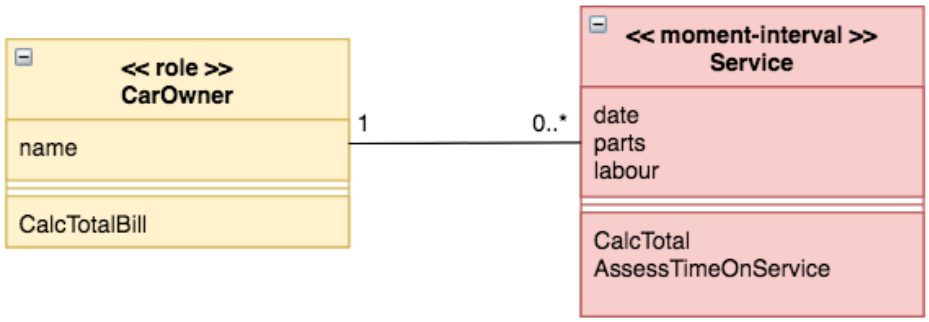


Figure 33 - Snippet of Business Area from Overall Model

Figure 17 depicts an example from the vehicle garage model which can be used to transform the methods found in each class into the major feature set, the feature set and the features which have been shown in the above examples. Additional features can then be added to the model diagram to as the project develops to satisfy the client's needs.

For example, the client may wish to add a feature which calculates the total tax of parts for each service or the total tax on each customer invoice. They also may wish to add a feature which assesses a clients

preferred mechanic, or parts price point level. These features will be added to the model during the FDD iterations.

By developing a feature list in this manner, domain members communicate better, in turn increasing a developer's understanding of the problems in the domain and how things interrelate. Additionally, it reduces frustration caused by different domain experts using different naming conventions for the same things as there is a ubiquitous language used in the overall model everyone is interacting with. New feature sets which bring significant business advantage are also more easily discovered through collaborative exploration of what could be done, what might be done and what can make a real difference [240], [241].

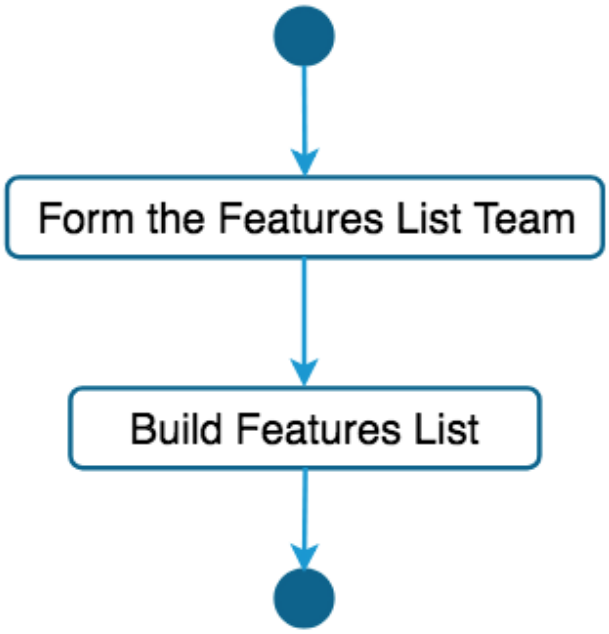


Figure 34 - Build Feature List Process Flowchart

iii. ***Plan by Feature***

The third process in first stage of FDD involves the construction of a development plan stating the schedule and assignment of tasks ordered by their priorities and dependencies [239]. Typically, feature sets are assigned to chief developers who then consider which classes to assign to their developers [310], however, unlike traditional agile methods which choose not to assign collective code ownership, FDD assigns responsibility of classes to particular developers. Palmer [241] states this has the following advantages:

- The conceptual integrity of a class is the sole responsibility of one developer ensuring that when enhancements are made, the purpose and design of their class is not compromised.

- Each classes developer is an 'expert' on that class meaning explanation of classes is simplified.
- Changes made to a class by the class owner will be implemented quicker through their familiarity with that class.
- Class owners can take personal pride in a class which they wrote well.

Despite the benefits of class ownership, there are disadvantages. For example, a feature could be held up as one developer is waiting for a code completion by another, however, owned classes are not mutually exclusive to their owners, other developers can make changes to a class, but they will need the owner to be aware of changes made and get their approval.

The development plan is considered a high-level view of the project where clients and developers can see the estimated release dates for the features derived in process two for testing [237], [241]. Once this process is complete, construction of the software can begin.

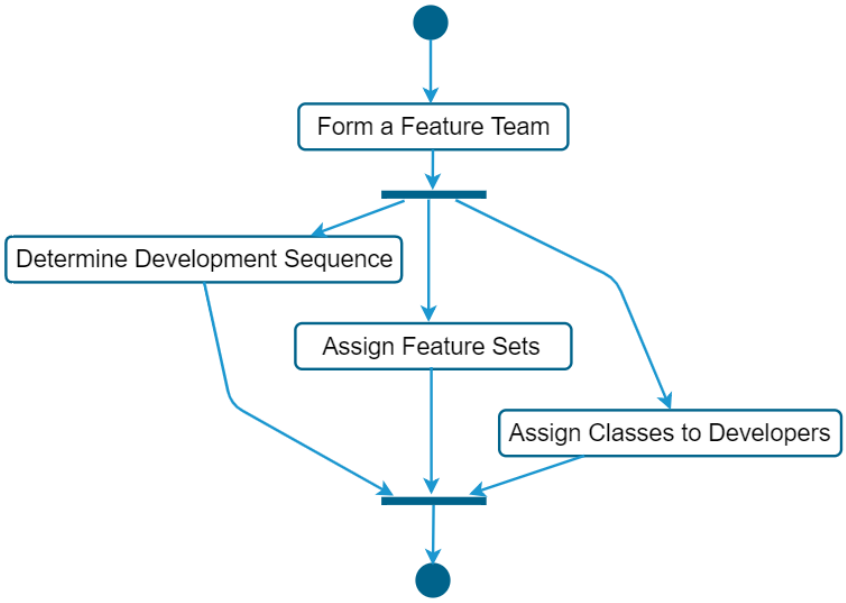


Figure 35 - Plan by Feature Process Flowchart

B3.2 FDD Stage Two

iv. Design by Feature

The first process in stage two is development-designing by feature. Chief programmers start iterations of this process, followed by process five (build by feature). To begin this process, chief developers select

features from the feature sets assigned to them, typically choosing the feature sets which can be completed in a few days and which need to be developed first [237].

Chief programmers can choose multiple features if they implement the same classes, these are known as *'Chief Programmer Work Packages'.* Feature teams are then formed by identifying the best developers to assign ownership of the classes to. These teams then produce sequence diagrams and begin writing the classes and methods. After each iteration, the chief programmer updates and refines the overall object model [310].

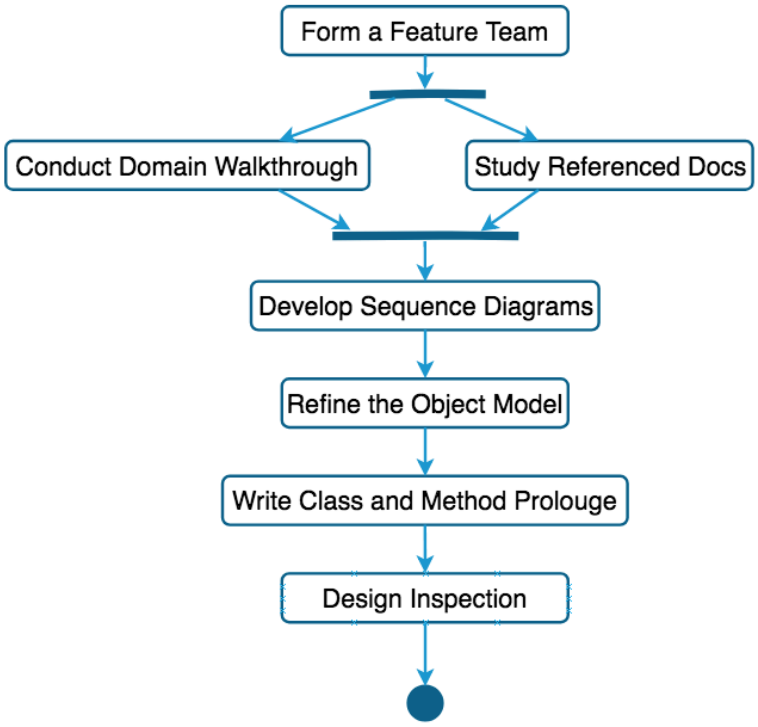
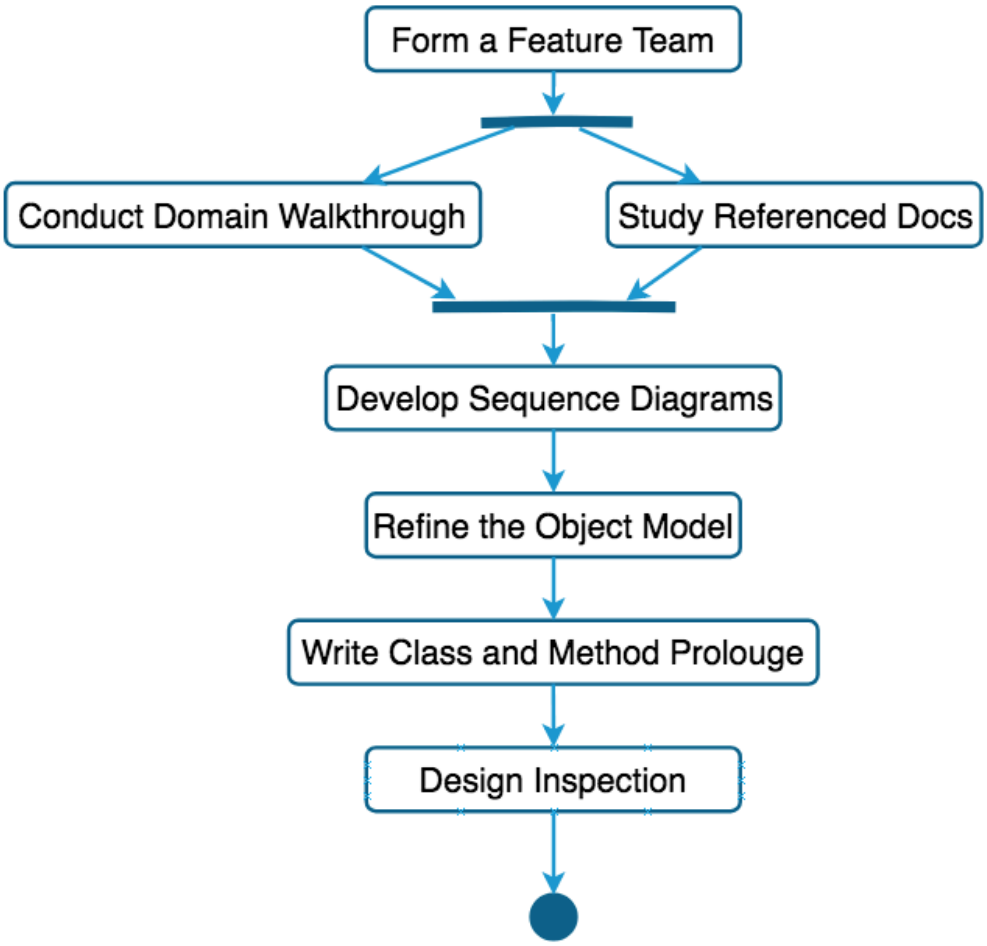


Figure 36 - Design by Development Process Flowchart

v. ***Build by Feature***

The final process is to build each feature. Palmer [237] states that FDD processes four and five could have been amalgamated as five always follows four, however, he argues that the split is merely for phycological reasons; separating design from implementation.

Each developer now codes their classes, unit tests them and submits the code for inspection to the chief programmer, upon success, the code is permitted to build [310].


Form a Feature Team
Conduct Domain Walkthrough
Study Referenced Docs
Develop Sequence Diagrams
Refine the Object Model
Write Class and Method Prologue
Design Inspection

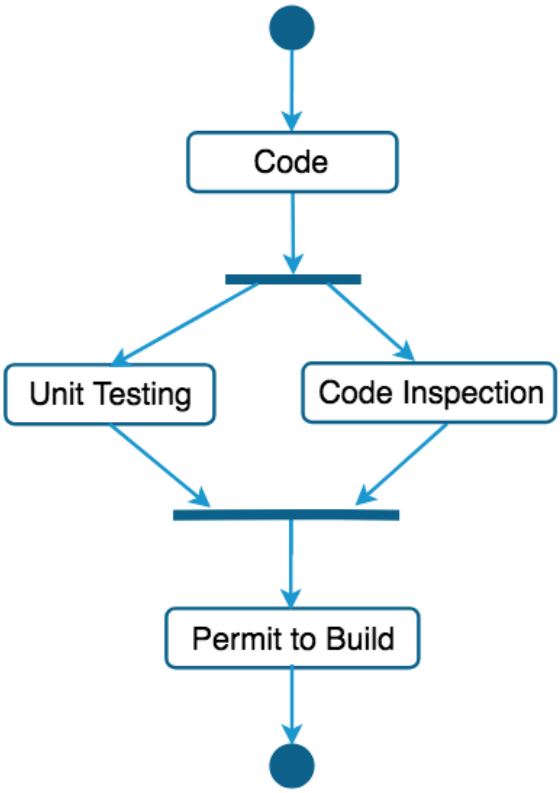


Figure 37 - Build by Feature Process Flow Chart

B4 Software Testing

B4.1 Introduction

Fournier [311] states that to achieve this goal the software tester should have knowledge of the basics, or '*testing essentials',* which include knowledge of:

- Black Box Testing
- White Box Testing
- Unit Testing
- The Functional Requirements
- The Non-Functional Requirements
- The Stakeholders Needs
- The Feature List

Amman and Offutt [312] confirm that software tests, for a wide range of applications, can be designed through knowledge of a few basic software testing concepts. They add that tests can be derived from the design artefacts, the source code or the requirements and specification analysis with each test being matched to a software development activity or process, providing the information for each test. These processes are:

- ***Acceptance Testing*** – assess software in respect to requirements.
- ***System Testing*** – assess software with respect to architectural design.
- ***Integration Testing*** – assess software with respect to subsystem design.
- ***Module Testing*** – assess software with respect to detailed design.
- ***Unit Testing*** – assess software with respect to implementation

B4.2 V-Model Software Testing

Software tests can only be performed after implementation, meaning that as the development process iterates, software tests will be designed at each stage ready for testing upon implementation. By designing tests throughout the development process, defects in design decisions can be uncovered which in hindsight may have appeared reasonable. Identifying problems early allows for reduced stress, time spent fixing bugs and decreases in costs.

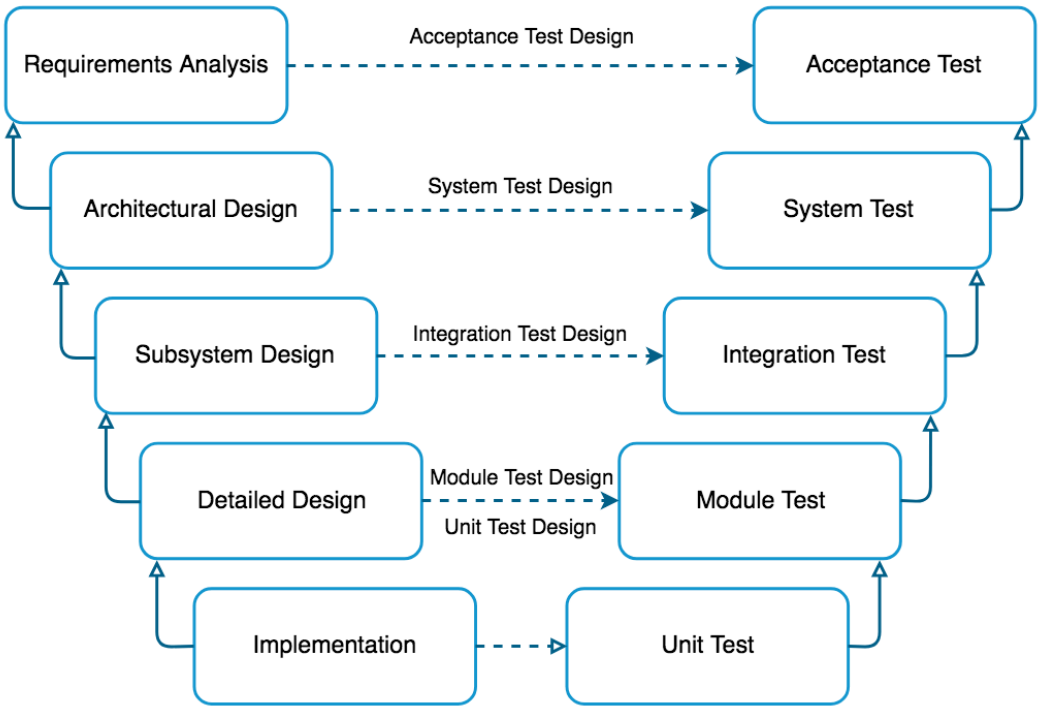


Figure 38 - Software Development Life Cycle V-Model

This form of design and implementation of software tests is known as the development lifecycle V-model (fig. 20), first introduced by Rook [313] in 1986, it is an adaptation of the waterfall model [314]. This model improves efficiency and effectiveness of software development by mapping the relationship between test and development events [315] where [312]:

i. ***Requirements Analysis & Acceptance Tests***

A requirements analysis is to discover the customer needs and wants from the software, from this, acceptance tests can be designed. Acceptance testing is a form of black box testing, which is

usually conducted by users/customer [316]. It determines if the finished software has met the customer's requirements by means on binary testing (pass or fail) each feature [317]. An example of an acceptance test for the MIU system would be searching for certain keywords and measuring the result against the expected result.

ii. ***Architectural Design & System Tests***

This design phase picks components and connectors that when together make up a system of which the specification is intended to meet the requirements identified in stage (i). The system tests are designed to discover if the assembled system meets the original specification, assuming that the individual components work individually and as a whole. System testing aims to discover design and specification problems; however, lower-level faults are very expensive to find. System testing is usually done by specific testing teams.

iii. ***Subsystem Design & Integration Tests***

Specifying the structure and behaviour, the subsystem design phase aims to satisfy functions in the overall architecture. Assuming that modules work correctly, integration tests are designed to assess whether the interfaces between the modules are consistent and communicate correctly. Integration tests uncover inconsistencies between components, even if those individual components were proved satisfactory through component tests [247].

iv. ***Detailed Design & Module Tests***

Module testing is concerned with discovering the structure and behaviour of individual modules. Here, methods or procedures in a class, file or package are defined as modules and their associated data structures are tested for interaction between one another by isolating them. Each module receives an input and the output is then verified against the expected output.

v. ***Implementation & Unit Tests***

This stage produces the code which can be iteratively tested back up the V-model using the tests designed. At this stage, unit tests are performed on individual modules of code to assess the that all paths though a test object are executed and the component build executes [311]. Units are the smallest, testable piece of software which can be compiled, assembled, linked, loaded and controlled by a test harness. Unit testing shows if a unit meets the functional specification and if its implemented structure matches that of intended design structure [247].

As the MIU system will be published on Microsoft's Azure portal, unit testing will be carried out automatically though the Azure DevOps Pipeline system which automatically publishes the application upon success and documents the test results which can be viewed in the build summary [318].

B5. Usability Testing Methodology

B5.1 Test Task List

Krug [254] states the task list is a two-step process, first, the tasks are chosen, then the tasks are translated into scenarios with details of context for use in the user script [section 4.2.3.2]. An example for the MIU system would be:

Task	*Scenario*
1. Ask user to find the hand injuries page in the system.	1. You need to login to the system using the login name 'staff' and password 'password' and please could you navigate to the hand injuries page, without using the search function. Once you have found it, could you tell me what you think of the page, how easy it was to get there and anything you liked/disliked?

Table 17 - Example Task & Scenario

The example above shows how context has been added to the task to allow the user to correctly perform it. This will be used in the user script to guide the user through completion.

The task list may be large, however, the testing time with participants may be limited, therefore, no more than ten short tasks or one large one should be conducted. The tasks chosen should firstly be the most

critical tasks which the user of your system must be able to do. Secondly, things the developer feels may be difficult to do should be tested and finally tasks derived from user research of what might be difficult. Testing from these three points of view should flag up most usability problems.

B5.2 Testing Script Description

To remain consistent throughout the testing process the moderator conducting the user test typically uses an unbiased script when interacting with each participant [251]. The script is used to allow the moderator to:

1. Welcome the user and explain the purpose of the test, what equipment is being used and how it will work.
2. Inform the user the session is being recorded for analysis of the results and ask them for consent.
3. Inform the user that it is the product or system which is being tested, not them. To be as candid as possible, to think out loud throughout the test and to ask any questions at any time.
4. Conduct a pre-test interview to find out how much they use the internet or systems/products of this type and to help relax them.
5. Lead the participant through the pre-planned test tasks [section 4.5.3.2].
6. Ask conclusion questions about the user's overall experience or anything they liked or disliked about the process.
7. Ask the participant to carry out a post-test Likert questionnaire.

The testing script used is shown below. This structure is modified from Krug's [254] sample test scripts. He reminds facilitators of their responsibilities throughout the testing process, highlighting the importance of the ethical issues (data governance section 5.3.2.1) and getting them to externalise their thoughts (think out loud) without influencing them.

B5.3 User Testing Script

Paper Prototyping User Test

1. User Test Preamble

This section serves as an aide memoir to the team running tests and is essentially a checklist for the conduct of each test

TEST iPAD and DESKTOP WITH DIFFERENT USERS / CIRCLE ONE

iPAD / DESKTOP

Welcome

- Thanks for helping me out today.
- I have scheduled this session to run approximately 60 minutes.
- Before I start, I'll explain the setup and explain how the session works.

What we're doing today:

- I'm conducting some user research for my final year, web dev project.
- I'm trying to identify issues that could be fixed to make the eventual system/website easier to use starting with testing on paper prototypes.
- And to do that I'm talking to people like you and based on your feedback I'm hoping to pinpoint areas for improvement.

Room setup

Let me explain the setup:

- I'll be asking you questions and talking you through the tests.
- I will be observing and taking notes.
- I have a camera and a microphone to record what you do and say as you are using the application. (May have to use headphones)
- I will record the session for notetaking purposes and the footage will only be seen by myself and possibly my lecturer's and the examiners of the project (if they are interested, which I'm sure they won't be).
- The session is divided into three parts: an informal interview, some user tests on the paper prototypes and a very short questionnaire at the end.

Paper Prototyping User Test

There are a few things to keep in mind that will help the tests run smoother...

- First, this session is called a usability test. But it's important to know that I am not testing you I am testing the paper prototype of the application. There are no right or wrong answers, there are no trick questions, and I'm not trying to catch you out in any way. If you do come across problems, please understand that it's not your fault, it's the software's fault. And in fact, the more problems you find, the better I can fix them.

- Second, please be as candid as possible. If you don't like something, or think it's just plain silly, please say so. You won't hurt my feelings - I am here to improve this system so be as honest as possible!

- Thirdly, as you navigate around the paper prototype of the application, whatever is going through your head, please verbalise it. So, for example, if you're about to pretend click on a button, say "I'm going to click here because I think it's going to take me to the next page". Or "I'm looking around the pretend screen for the X". Basically, I want you to think out oud as it helps me write better notes. Also, if you could approach things slightly slower than you normally would, that would be helpful. If you work your way around the site too fast, I might not be able to take notes quick enough. I'll remind you to think out loud and to slow down throughout the session if needed.

- Finally, please feel free to ask any questions you like. It's a great way for me to understand your thoughts. But in order to keep the test as realistic as possible, I may not always answer your questions. Thanks for understanding. Do you have any questions now before we begin?

2. Pre-test Interview

Before we start using the paper prototype of the application/website, I'd just like to ask you some simple background questions, if that's okay?

Personal questions

Name:

Age: 19 – 25 / 26 – 35 / 36 – 45 / 46 – 55 / 56 – 65 / 66 – 75 / 75+

Occupation:

Where do you live?

How do you access the internet? Home? Work? Phone?

Do you own a laptop or desktop or tablet?

Do you consider yourself a heavy computer user?

Do you use applications on your laptop/pc or tablet?

What sort of applications do you use?

Paper Prototyping User Test

System Usage

Please tell me about any websites you have used when looking for a medical diagnosis?

What are the main websites you used to find medical information?

Is there a site you prefer? Why?

What was most important when you searched for a diagnosis?

e.g. Speed of finding information, trustworthiness?

3. User Testing Session

- **Web browser (paper prototype) should be open to home page of the system.**

IMPORTANT INFORMATION

If you would, I'm going to ask you to sign a simple permission form for me. It just says that I have your permission to record you, and that the recording will only be seen by myself and maybe the lecturer's and examiners marking the project.

- **Give them a recording permission form and a pen.**
- **While they sign it, START the SCREEN RECORDER**

Do you have any questions so far?

- **START Silverback 3.**
- **Read each task aloud to participant**
- **Allow the user to proceed until you don't feel like it's producing any value, or the user becomes very frustrated.**
- **Repeat for each task or until time runs out.**

RESEARCH OBJECTIVES

- Observe how user go through the full search/locating process.
- Can user navigate the menus correctly?
- Does the user like the design?
- Is the layout clear?
- Is the design familiar at all?

THE TASKS

For the purposes of the test, we'll assume the following:

You are a health professional trying to locate specific medical information in this paper prototype. First, you will need pretend to login using the login screen and navigate your way to a page I will specify in a moment. Do you understand?

1. *Could you please tell me how you would log in to this system?*

   What do you think of the login screen?

   SHOW HOME PAGE 1

2. *Look around this page for a few minutes. How do you feel about it?*

   SHOW HOME PAGE 2

3. *Look around this page for a few minutes. How do you feel about it?*

4. *From the home page, could you navigate to the Hand Injuries section?*

SHOW BLANK PAGE WITH MENU.

5. *From this page, could you again navigate to the Hand Injuries section?*

6. *How easy is the text on this page to read?*

SHOW HAND INJURY PAGE

7. *From this Hand Injury Page, could you navigate to the stress testing section? (Note which menu they used Left or Right or Top menu if iPad)*

SHOW STRESS TESTING PAGE

8. *Could you now locate the Median Nerve – Motor Function section?*

SHOW MEDIAN NERVE SCREEN

9. *On this Median Nerve page, is it clear which sections of this document are currently being displayed to you? As in, do you know where you are in the system?*
   (See if they pick up on the highlights on the menus and the breadcrumbs)

10. *Can you see anyway you could change the screen colours to a darker setting? (See if they can find the dark mode).*

11. *Could you now navigate back to the homepage please? (See if they click the NHS logo or the breadcrumbs)*

Thank you for completing those tests, could I now ask you to complete a quick questionnaire which won't take you longer than a few minutes.

GIVE SUS QUESTIONNAIRE

Facilitator Helper Questions

General

- What do you see on this page?
- What will you do next?
- Are you drawn to anything?
- Is this what you were expecting?

Conclusion Questions

- Overall, what did you think of that experience?
- Was there anything you particularly liked or disliked about that process?
- Was there anything you expected to see but did not?
- Was there anything you were surprised to see?

WRAPPING UP

Do you have any questions for me, now that we're done?

B5.4 User Test Script Explained

i. *User Test Preamble*

The test introduction welcomes the participant, explains the test, the setup, thanks them for their help and a few things to help the test run smoothly. This section is solely designed to relax the participant and ensure they understand the test.

ii. *Pre-Test Interview*

This section of the test is to gain a better understanding of the participant and their usage of computers/internet. It helps relax the participant and shows engagement from the facilitator. The section on system usage allows for gauging of their computer literacy, as this system will be used by health professionals, not computer professionals, this section is important to understand if the tests are being conducted with the right user in mind, relating to the user personas. It also gathers information on current medical information retrieval sites used which will allow for investigation into what users currently like and want from health information applications.

iii. *The Test Tasks*

Firstly, this section seeds the user into the persona role of a health professional whose aim it is to find medical information in the application. The participant is then set a series of tasks to complete and notes are taken from the observations. The questions:

1. ***Could you please tell me how you would log in to this system?***

   This question is to discover the ease of use of the log-in interface. As the design has followed known design patterns, it is expected that no users will find any difficulties.

   What do you think of the login screen?

   Asking users what their thoughts are about the look and feel of the page will help discover if they like it, or if they recognise it and most importantly if they recognise what it is and the purpose of it.

2. ***Look around this page for a few minutes. How do you feel about it?***

   Now on the home page, the user is asked again for their thoughts. Here the purpose is to find out the purpose of it, the subject matter and if they recognise the organisation behind it.

3. ***Look around this page for a few minutes. How do you feel about it?***

   The user is then shown the 2nd version of the home page (appendix C4). The purpose is the same as above, however, here the purpose is also to discover which interface users prefer, and why.

4. ***From the home page, could you navigate to the Hand Injuries section?***

   Here the purpose is to test the organisation of the links to guidelines on the home page. The aim is to discover if users can find what they want quickly and if the text/links are clear and convey known affordances.

5. ***From this page, could you again navigate to the Hand Injuries section?***

   Now on the blank menu screen, the purpose is to test the accordion menu structure and the hierarchical ontology used. Again, the test focuses on organisation and speed to locating the correct guidelines.

6. ***How easy is the text on this page to read?***

   Now showing displaying the hand injury guidelines, the body text size is scrutinised for size and clarity.

7. ***From this Hand Injury Page, could you navigate to the stress testing section? (Note which menu they used Left or Right or Top menu if iPad)***

   Here the focus is on navigation to sub-level menu items, to discover if they are easily found, and which menu users will choose to use.

8. ***Could you now locate the Median Nerve – Motor Function section?***

   Again, focus is on sub-level menu items and if 3rd level items are easily found, and which menu users will use first and why.

9. ***On this Median Nerve page, is it clear which sections of this document are currently being displayed to you? As in, do you know where you are in the system?***
   (See if they pick up on the highlights on the menus and the breadcrumbs)

   Here the focus is on whether the application is communicating enough information to the user about their whereabouts in the system. With information possibly buried deep in the IA it is important users know exactly where they are and how they can get back to where they came from.

10. ***Can you see any way you could change the screen colours to a darker setting? (See if they can find the dark mode).***

    A simple test to see if the button is labelled properly and is easily found.

11. ***Could you now navigate back to the homepage please? (See if they click the NHS logo or the breadcrumbs)***

    Another simple test to discover users' preferences for returning home using known web navigation conventions. Does the user see the logo as their route home, or do they even notice the breadcrumb trail?

B5.5 System Usability Scale Questionnaire

Participant Name: _____ Date: ___/___/___

System Usability Scale

Instructions: For each of the following statements, mark one box that best describes your reactions to the paper prototype application *today*.

		Strongly Disagree				Strongly Agree
1.	I think that I would like to use this application frequently.	☐	☐	☐	☐	☐
2.	I found this application unnecessarily complex.	☐	☐	☐	☐	☐
3.	I thought this application was easy to use.	☐	☐	☐	☐	☐
4.	I think that I would need assistance to be able to use this application.	☐	☐	☐	☐	☐
5.	I found the various functions in this application were well integrated.	☐	☐	☐	☐	☐
6.	I thought there was too much inconsistency in this application.	☐	☐	☐	☐	☐
7.	I would imagine that most people would learn to use this application very quickly.	☐	☐	☐	☐	☐
8.	I found this application very cumbersome/awkward to use.	☐	☐	☐	☐	☐
9.	I felt very confident using this application.	☐	☐	☐	☐	☐
10.	I needed to learn a lot of things before I could get going with this application.	☐	☐	☐	☐	☐

Please provide any comments about this website:

B5.6 Students Union Correspondence

Peter Davies 13 February 2019 at 23:04

Usability Testing

To: yoursu@uwtsd.ac.uk

To whom it may concern;

I am a third year student studying BSc Web Development in SA1, currently carrying out my third year project in developing a clinical decision support system for Newport Gwent's Minor Injury Unit.

I am currently looking for students to participate in usability tests to gather results on the user experience and usability of my system. As this system is being designed for users in the medical profession it would be beneficial to my study that my test subjects have a certain degree of medical training. I understand that our university does not offer medical courses, however, any students with medical training will be ideal for my user tests (first aid etc.).

Would it be possible to put out an email to Swansea students asking for help with this? I am willing to offer freebies (chocolate, alcohol etc.) upon completion of user tests which will take no longer than an hour.

If there are any issues with doing this I can refer you to my supervisor, Dr Nicola Whitehead who suggested I email you to ask for help.

I understand you may require more information so please do not hesitate to ask. If this is possible, could guide me on the best and appropriate way to recruit test participants that would be great. I also understand that there may be nothing you can do to help me with this but I would appreciate your help!

Thank you for your time,

I look forward to hearing from you,

Kind regards,

Peter Davies

Your SU 14 February 2019 at 09:36 YS

RE: Usability Testing

To: Peter Davies

Hi Peter,

Yes it wouldn't be an issue to put a message out - although we use the University e-mail system and our e-mails get approved by the Uni so they may not allow us to send an all-student e-mail on this topic.

We'd be happy to post on social media though etc, just send us the message that you'd like published

Your SU

Peter Davies 1 March 2019 at 13:08

Re: Usability Testing

To: Your SU

Hi Your SU (Do you have a name?),

Sorry for my late reply, it has been a bit manic! Are you still ok to put out a message on social media for me? If so could you please post (or something similar if you think a better way to write it) -

A 3rd year Web Development student is looking for FIRST AID trained or trainee/professional MEDICAL staff for user testing a medical web application for his final year project!

Can you help?

The tests on the web application will take place on any of the Swansea campuses, which ever suits you best. They will take no longer than 30 minutes and there will be free incentives for participating!

If you can help out, please contact Peter by email: pdavies.079868@student.uwtsd.ac.uk

I think that should cover it? Do I need to mention anything else?

If you could sent me a link to the post(s) so I can share & retweet etc, that would be great!

Thank you for helping me out,

Peter

B5.7 Usability Test Consent Form

Consent & Recording Release Form

Thank you for participating in our usability test.

I will be recording your session to allow Peter Davies of UWTSD to thoroughly analyse this session after it has been completed. Additionally, for marking purposes, lecturer's Dr Nicola Whitehead and Dr Kemi Ademoye may also view/listen to the recording as well as any external examiners marking this project/

Please read the statement below and sign where indicated.

I understand that my usability test session will be recorded. I grant the students/lecturers/examiners permission to use this recording, for the purpose of improving the application design.

I understand that participation in this usability study is voluntary and I agree to immediately raise any concerns or areas of discomfort during the session with the study administrator.

I understand that I am being asked to take part in this study because I have the required first aid or higher level of medical training.

Please sign below to indicate that you have read, and you understand the information on this form and that any questions you might have about the session have been answered.

Date: _____

Please print your name: _____

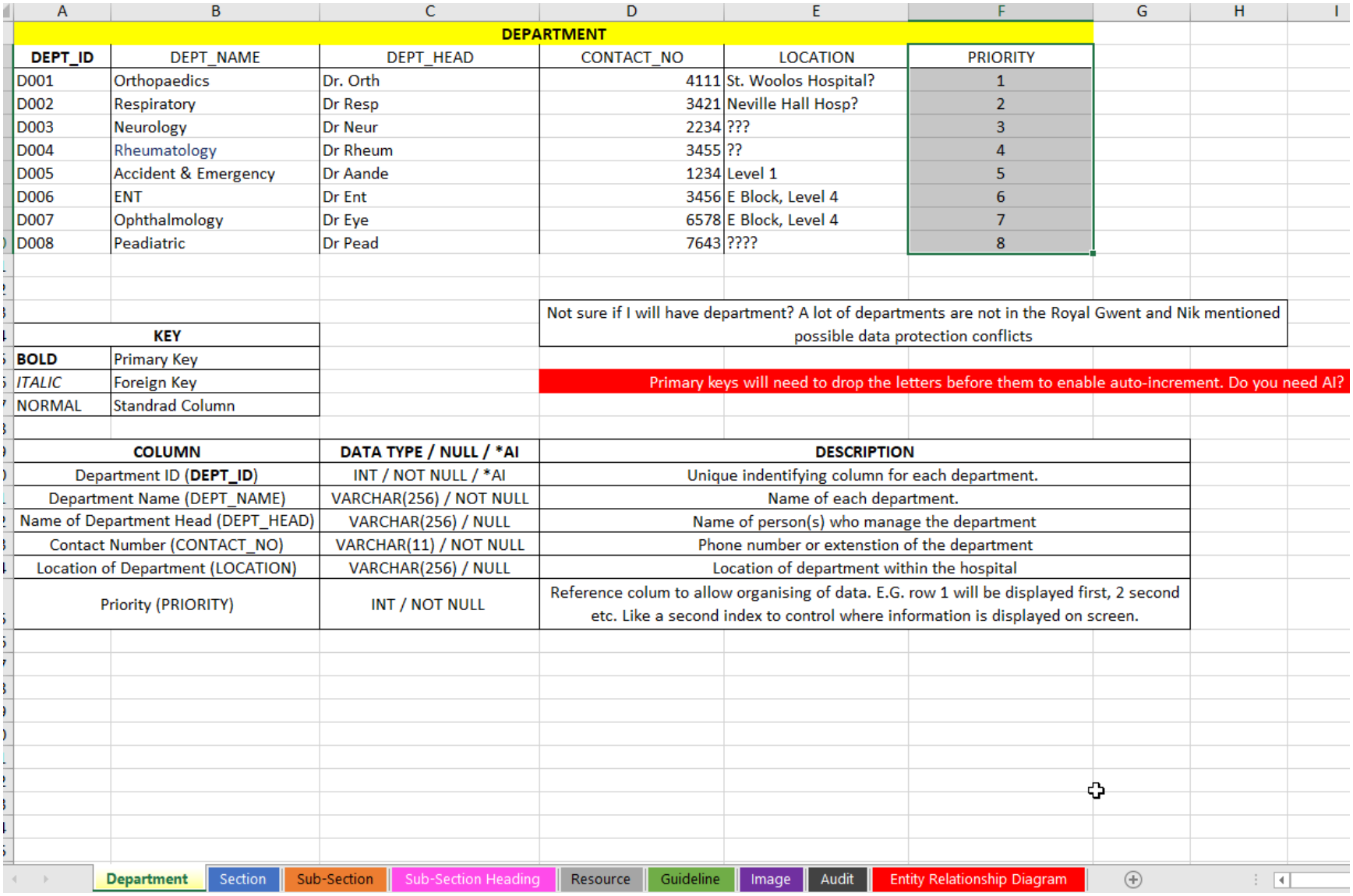
Please sign your name: _____

Thank you, I appreciate your participation.

C. Design

C1. Excel Testing of Database Design One

The excel spreadsheet for testing of database version one is found on the following landscape view page.



DEPARTMENT

DEPT_ID	DEPT_NAME	DEPT_HEAD	CONTACT_NO	LOCATION	PRIORITY
D001	Orthopaedics	Dr. Orth	4111	St. Woolos Hospital?	1
D002	Respiratory	Dr Resp	3421	Neville Hall Hosp?	2
D003	Neurology	Dr Neur	2234	???	3
D004	Rheumatology	Dr Rheum	3455	??	4
D005	Accident & Emergency	Dr Aande	1234	Level 1	5
D006	ENT	Dr Ent	3456	E Block, Level 4	6
D007	Ophthalmology	Dr Eye	6578	E Block, Level 4	7
D008	Peadiatric	Dr Pead	7643	????	8

Not sure if I will have department? A lot of departments are not in the Royal Gwent and Nik mentioned possible data protection conflicts

Primary keys will need to drop the letters before them to enable auto-increment. Do you need AI?

KEY	
BOLD	Primary Key
ITALIC	Foreign Key
NORMAL	Standrad Column

COLUMN	DATA TYPE / NULL / *AI	DESCRIPTION
Department ID (**DEPT_ID**)	INT / NOT NULL / *AI	Unique indentifying column for each department.
Department Name (DEPT_NAME)	VARCHAR(256) / NOT NULL	Name of each department.
Name of Department Head (DEPT_HEAD)	VARCHAR(256) / NULL	Name of person(s) who manage the department
Contact Number (CONTACT_NO)	VARCHAR(11) / NOT NULL	Phone number or extenstion of the department
Location of Department (LOCATION)	VARCHAR(256) / NULL	Location of department within the hospital
Priority (PRIORITY)	INT / NOT NULL	Reference colum to allow organising of data. E.G. row 1 will be displayed first, 2 second etc. Like a second index to control where information is displayed on screen.

Department | Section | Sub-Section | Sub-Section Heading | Resource | Guideline | Image | Audit | Entity Relationship Diagram

SECTION			
S001	Clinical Assessment	D005	1
S002	Hand Injuries	D001	2
S003	Wrist Injuries	D001	3
S005	Elbow Injuries	D001	4
S006	Shoulder injuries	D001	5
S007	Foot Injuries	D001	6
S008	Ankle & Lower Leg	D001	7
S009	Knee injuries	D001	8
S010	Hips	D001	9
S011	Chest	D002	10
S012	Minor Head Injury	D001	11
S013	Neck Injury	D004	12
S014	Back Pain & Injury	D004	13
S015	Wound Management	D005	14
S016	Throat	D006	15
S017	Ear	D006	16
S018	Nose	D006	17
S019	Facial Injury	D001	18
S020	Eye Injury	D007	19
S021	Childrens Injuries	D008	20

KEY	
BOLD	Primary Key
ITALIC	Foreign Key
NORMAL	Standrad Column

Example for Hand Injuies

Primary keys will need to drop the letters before them to enable a

COLUMN	DATA TYPE / NULL / AI	DESCRIPTION
Section ID (**SEC_ID**)	INT / NOT NULL / *AI	Unique indentifying column for each section.
Section Name (SEC_NAME)	VARCHAR(256) / NOT NULL	Name of each section in the document.
Section Department (*SEC_DEPT*)	INT	ID referenccing DEPARTMENT table which holds information on each department that each section belongs to. EG. Ears, Nose and Throat are part of the ENT department.
Priority (PRIORITY)	INT / NOT NULL	Reference colum to allow organising of data. E.G. row 1 will be displayed first, 2 second etc. Like a second index to control where information is displayed on screen.

Department | Section | Sub-Section | Sub-Section Heading | Resource | Guideline | Image | Audit | Entity Relationship Diagram

SUBSECTION

SUBSEC_ID	SUBSEC_NAME	*SEC_ID*	PRIORITY
SS001	Anatomy	S002	1
SS002	History	S002	2
SS003	Examination	S002	3
SS004	Thumb Movements	S002	4
SS005	Stress Testing	S002	5
SS006	Neurovascular	S002	6
SS007	Fractured Neck of Fifth Metacarpal	S002	7
SS008	Fractured Metacarpal Shaft	S002	8
SS009	Metacarpal Base Fractures	S002	9
SS010	Phalangeal Fractures	S002	10
SS011	Bennett's Fracture	S002	11
SS012	Volar Plate Injury	S002	12
SS013	Interphalangeal Joint Dislocation	S002	13
SS014	Epiphyseal Injuries in Children	S002	14
SS015	Nail Bed Injuries	S002	15
SS016	Subungual Haematoma	S002	16
SS017	Finger Tip Injury	S002	17
SS018	Burns	S002	18
SS019	Flexor Tendon Injury	S002	19
SS020	Extensor Tendon Injury	S002	20
SS021	Swan Neck Deformity	S002	21
SS022	Glass Injuries	S002	22
SS023	High Pressure Injection Injury	S002	23
SS024	Ulnar Collatral Ligament	S002	24
SS025	Digital Nerve Injury	S002	25
SS026	Trigger Thumb/Finger	S002	26
SS027	Cellulitus	S002	27
SS028	Paronychia	S002	28
SS029	Herpatic Whitlow	S002	29
SS030	Pulp Space Infection	S002	30
SS031	ORF	S002	31
SS032	Purulent Flexor Tenosynovitis	S002	32
SS033	Palmar Space Infection	S002	33
SS034	Septic Arthritis/Osteomyelitis	S002	34

KEY	
BOLD	Primary Key
ITALIC	Foreign Key

Fields are repeated in all sections

Example for Hand Injuies

Primary keys will need to drop the letters before them to enable auto-increment. Do you need AI?

COLUMN	DATA TYPE / NULL / AI	DESCRIPTION
Sub-Section ID (**SUBSEC_ID**)	INT/ NOT NULL / *AI	Unique indentifying column for each sub-section.
Sub-Section Name (SUBSEC_NAME)	VARCHAR(250) / NOT NULL	Name of each sub-section in the document.
Section ID (*SEC_ID*)	INT(10)	ID referenccing SECTION table which holds information on each section that each subsection belongs to. EG. Nail bed injuries belong to hand
Priority (PRIORITY)	INT / NOT NULL	Reference colum to allow organising of data. E.G. row 1 will be displayed first, 2 second etc. Like a second index to control where information is displayed on screen.

SUBSECTION HEADING			
SSH_ID	SS_HEADING	*SUBSEC_ID*	PRIORITY
SH001	Look	SS003	1
SH002	Feel	SS003	2
SH003	Move	SS003	3
SH004	Ulnar Collateral Ligament	SS005	4
SH005	Collateral Ligaments of Fingers	SS005	5
SH006	Median Nerves - Motor Function	SS005	6
SH007	Ulna Nerve - Motor Function	SS005	7
SH008	Radial Nerve	SS005	8
SH009	Treatment	SS007	9
SH010	Treatment	SS008	10
SH011	Treatment	SS009	11
SH012	Treatment	SS010	12
SH013	Treatment	SS011	13
SH014	Treatment	SS012	14
SH015	Treatment	SS013	15
SH016	Treatment	SS014	16
SH017	Treatment	SS015	17
SH018	Treatment	SS016	18
SH019	Treatment	SS017	19
SH020	Treatment	SS018	20
SH021	Treatment	SS019	21
SH022	Treatment	SS020	22
SH023	Treatment	SS021	23
SH024	Treatment	SS022	24
SH025	Treatment	SS023	25
SH026	Treatment	SS024	26
SH027	Secondry to Open Wound	SS020	27
SH028	Mallet Deformity	SS020	28
SH029	Boutonniere Deformity	SS020	29
SH030	Treatment	SS025	30
SH031	Treatment	SS026	31
SH032	Treatment	SS027	32
SH033	Treatment	SS028	33
SH034	Treatment	SS029	34

KEY	
BOLD	Primary Key
ITALIC	Foreign Key
NORMAL	Standrad Column

Example for Hand Injuies

Repeated in every section

Treatment is repeated a lot!! How else to avoid this when you need to perform CRUD on inparticular treatment heading in different sections?

Primary keys will need to drop the letters before them to enable auto-increment. Do you need AI?

COLUMN	DATA TYPE / NULL / AI	DESCRIPTION
Sub-Section Heading ID (**SSHEAD_ID**)	INT / NOT NULL / *AI	Unique indentifying column for each sub-section heading.
Sub-Section Heading (SS_HEADING)	VARCHAR(256) / NOT NULL	Name of sub section heading.
Sub-Section ID (SUB*SEC_ID*)	INT	ID referenccing SUBSECTION table which holds information on each subsection that each sub section heading belongs to. EG. Sub-Section Heading 'Flexor Tendons' belongs to sub-section 'move' (SS006).
Priority (PRIORITY)	INT / NOT NULL	Reference colum to allow organising of data. E.G. row 1 will be displayed first, 2 second etc. Like a second index to control where information is displayed on screen.

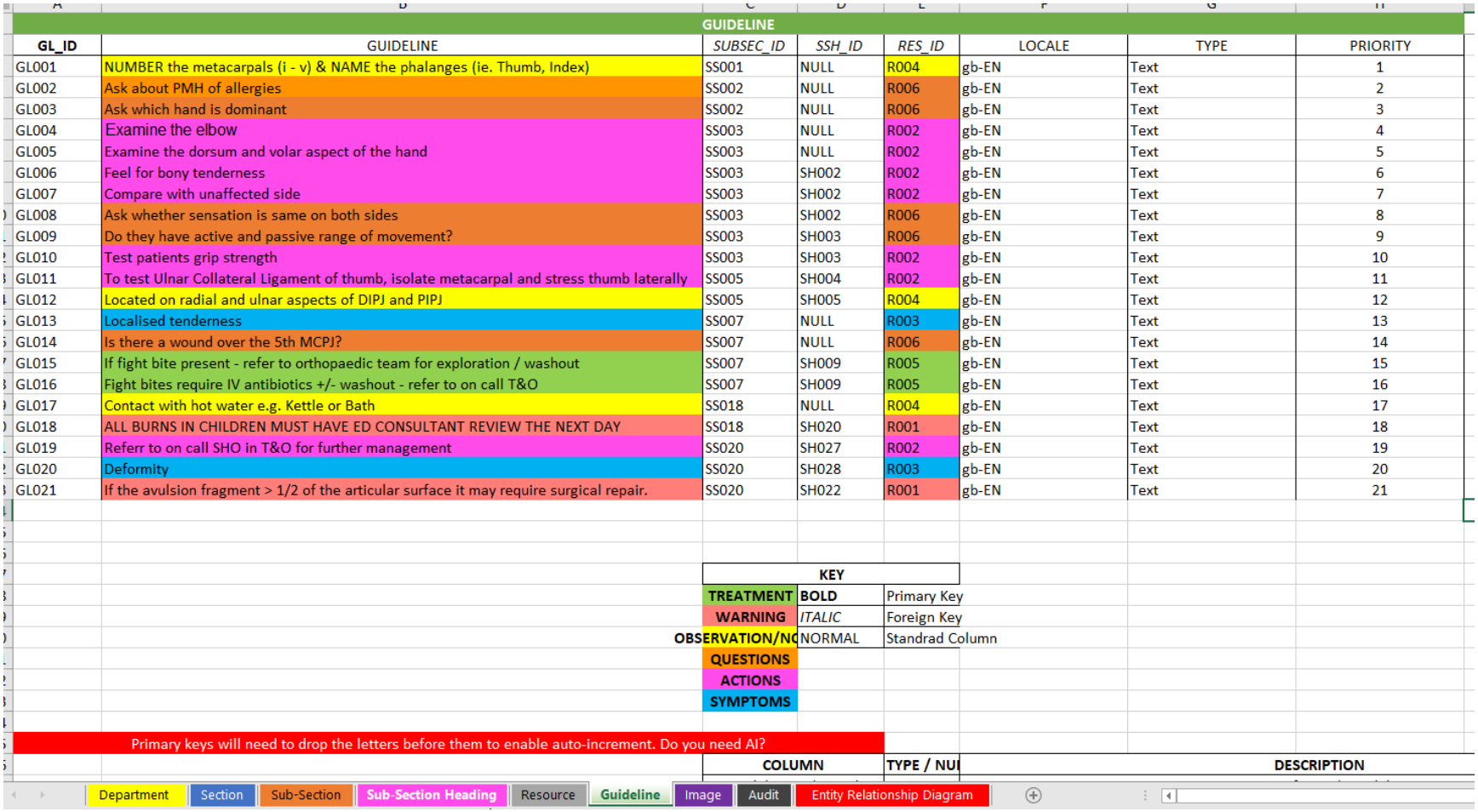
RES_ID	RES_GROUP		NORMAL	Standrad Column	OBSERVATION/NOTES	Example for Hand Injuies
R004	Observationes/Notes					
R005	Treatment				QUESTIONS	
R006	Question				ACTIONS	
					SYMPTOMS	

COLUMN	DATA TYPE / NULL / AI	DESCRIPTION
Resource ID (**RES_ID**)	INT / NOT NULL / *AI	Unique ID for each resource.
Resource Name (SEC_NAME)	VARCHAR(256)	Name of each resource group which each guideline will be catorgorised in to.

Each guideline, as in text string which guides the clinician has been broken down into 6 different sections to allow identification and classification.

Primary keys will need to drop the letters before them to enable auto-increment. Do you need AI?

WILL YOU ALLOW USERS TO ADD RESOURCES? PROBABLY NOT - THEY SHOULD BE ABLE TO CATORGORISE EVERY THING UNDER THESE HEADINGS



GUIDELINE

GL_ID	GUIDELINE	*SUBSEC_ID*	*SSH_ID*	*RES_ID*	LOCALE	TYPE	PRIORITY
GL001	NUMBER the metacarpals (i - v) & NAME the phalanges (ie. Thumb, Index)	SS001	NULL	R004	gb-EN	Text	1
GL002	Ask about PMH of allergies	SS002	NULL	R006	gb-EN	Text	2
GL003	Ask which hand is dominant	SS002	NULL	R006	gb-EN	Text	3
GL004	Examine the elbow	SS003	NULL	R002	gb-EN	Text	4
GL005	Examine the dorsum and volar aspect of the hand	SS003	NULL	R002	gb-EN	Text	5
GL006	Feel for bony tenderness	SS003	SH002	R002	gb-EN	Text	6
GL007	Compare with unaffected side	SS003	SH002	R002	gb-EN	Text	7
GL008	Ask whether sensation is same on both sides	SS003	SH002	R006	gb-EN	Text	8
GL009	Do they have active and passive range of movement?	SS003	SH003	R006	gb-EN	Text	9
GL010	Test patients grip strength	SS003	SH003	R002	gb-EN	Text	10
GL011	To test Ulnar Collateral Ligament of thumb, isolate metacarpal and stress thumb laterally	SS005	SH004	R002	gb-EN	Text	11
GL012	Located on radial and ulnar aspects of DIPJ and PIPJ	SS005	SH005	R004	gb-EN	Text	12
GL013	Localised tenderness	SS007	NULL	R003	gb-EN	Text	13
GL014	Is there a wound over the 5th MCPJ?	SS007	NULL	R006	gb-EN	Text	14
GL015	If fight bite present - refer to orthopaedic team for exploration / washout	SS007	SH009	R005	gb-EN	Text	15
GL016	Fight bites require IV antibiotics +/- washout - refer to on call T&O	SS007	SH009	R005	gb-EN	Text	16
GL017	Contact with hot water e.g. Kettle or Bath	SS018	NULL	R004	gb-EN	Text	17
GL018	ALL BURNS IN CHILDREN MUST HAVE ED CONSULTANT REVIEW THE NEXT DAY	SS018	SH020	R001	gb-EN	Text	18
GL019	Referr to on call SHO in T&O for further management	SS020	SH027	R002	gb-EN	Text	19
GL020	Deformity	SS020	SH028	R003	gb-EN	Text	20
GL021	If the avulsion fragment > 1/2 of the articular surface it may require surgical repair.	SS020	SH022	R001	gb-EN	Text	21

KEY		
TREATMENT	**BOLD**	Primary Key
WARNING	*ITALIC*	Foreign Key
OBSERVATION/NO	NORMAL	Standrad Column
QUESTIONS		
ACTIONS		
SYMPTOMS		

Primary keys will need to drop the letters before them to enable auto-increment. Do you need AI?

COLUMN	TYPE / NUI	DESCRIPTION

Department | Section | Sub-Section | Sub-Section Heading | Resource | Guideline | Image | Audit | Entity Relationship Diagram

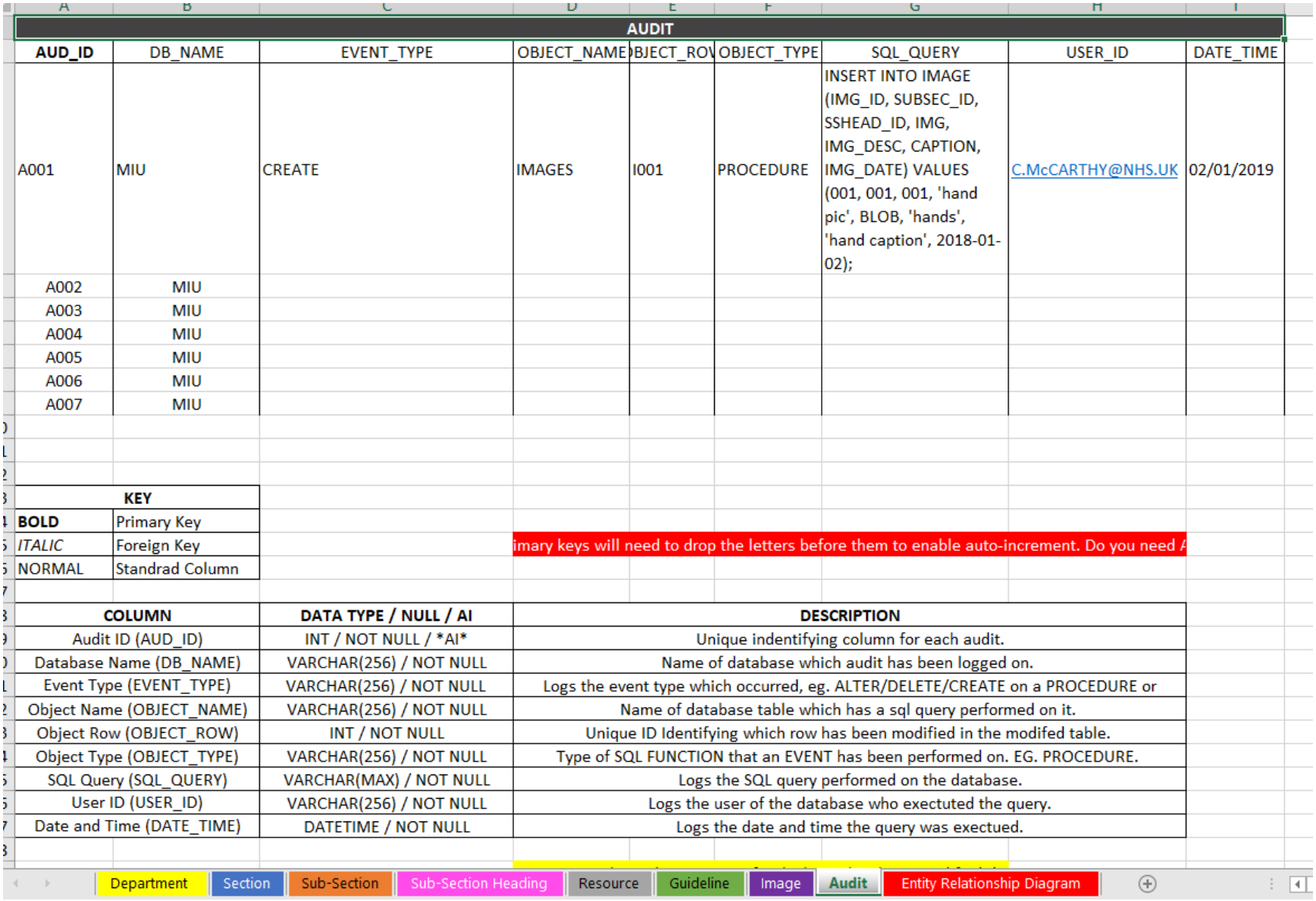
IMAGE							
IMG_ID	IMAGE	IMG_DESC	CAPTION	IMG_DATE	*SUBSEC_ID*	*SSHEAD_ID*	PRIORITY
I001	Hand_Anatomy	Annotated skeleton of hand	NULL	01/02/2010	SS001	NULL	1
I002	Boutonniere_Deformity	Side view of boutonnaire deformity	Boutonniere Deformity	01/02/2019	SS003	NULL	2
I003	Nerves	Nerve locations	Nerve Locations in Hand	01/02/2019	SS003	SH002	3
I004	Flexon_Tendon	Testing of flexon tendon	Flexon Tendons	01/02/2019	SS003	SH003	4
I005	Extensor_Tendon	Extensor tendon tests	Extensor Tendons	01/02/2019	SS003	SH003	5
I006	Collatoral_Ligaments	Stress tests of collateral ligaments	NULL	01/02/2019	SS005	SH005	6
I007	Finger_Tip	Cross-sectional anatomy of finger tip	NULL	01/02/2019	SS017	SH019	7

KEY	
BOLD	Primary Key
ITALIC	Foreign Key
NORMAL	Standrad Column

CRET

COLUMN	DATA TYPE / NULL / AI	DESCRIPTION
Image ID (IMG_ID)	INT / NOT NULL / *AI*	Unique indentifying column for each image
Image (IMAGE)	BLOB / NOT NULL	Image stored as a binary large object in the database.
Image Description (IMG_DESC)	VARCHAR(256) / NULL	Description of the image which is to be stored in the database.
Caption (CAPTION)	VARCHAR(256) / NULL	Caption which will be displayed above of below image.
Image Date (IMG_DATE)	DATETIME / NOTNULL	of creation/insertion of image into the DB to ensure they know they
Sub-Section ID (*SUBSEC_ID*)	INT / NOT NULL	sub-section table to identify which sub-section the image will be di
Sub-Section Heading ID (SSH_ID)	INT / NULL	FK referencing subsection heading table to idenify which sebsection heading the image will reside under (if any).
Priority (PRIORITY)	INT / NOT NULL	Reference colum to allow organising of data. E.G. row 1 will be displayed first, 2 second etc. Like a second index to control where information is displayed on screen.

Department | Section | Sub-Section | Sub-Section Heading | Resource | Guideline | Image | Audit | Entity Relationship Diagram



AUDIT								
AUD_ID	DB_NAME	EVENT_TYPE	OBJECT_NAME	BJECT_ROV	OBJECT_TYPE	SQL_QUERY	USER_ID	DATE_TIME
A001	MIU	CREATE	IMAGES	I001	PROCEDURE	INSERT INTO IMAGE (IMG_ID, SUBSEC_ID, SSHEAD_ID, IMG, IMG_DESC, CAPTION, IMG_DATE) VALUES (001, 001, 001, 'hand pic', BLOB, 'hands', 'hand caption', 2018-01-02);	C.McCARTHY@NHS.UK	02/01/2019
A002	MIU							
A003	MIU							
A004	MIU							
A005	MIU							
A006	MIU							
A007	MIU							

KEY	
BOLD	Primary Key
ITALIC	Foreign Key
NORMAL	Standrad Column

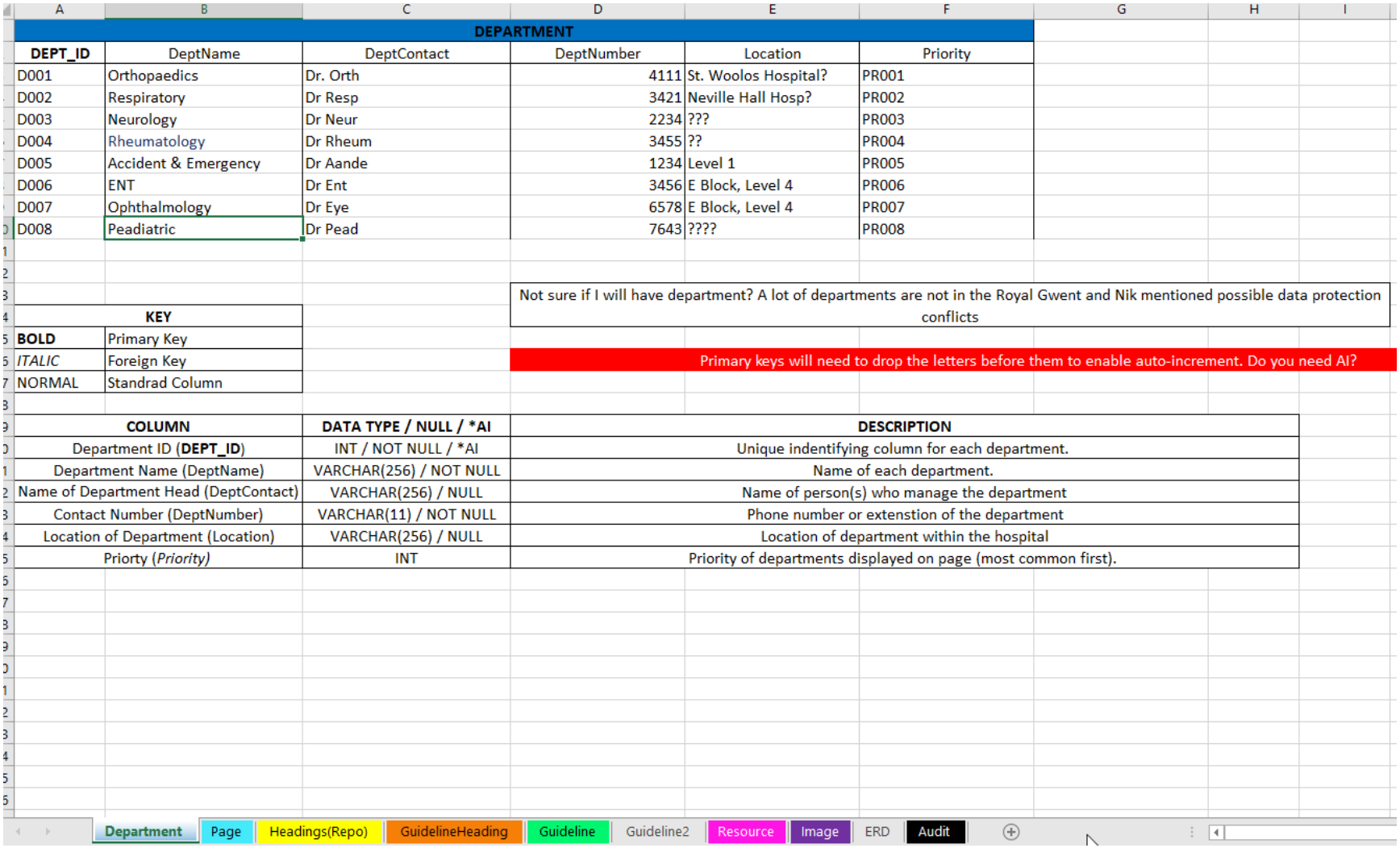
imary keys will need to drop the letters before them to enable auto-increment. Do you need A

COLUMN	DATA TYPE / NULL / AI	DESCRIPTION
Audit ID (AUD_ID)	INT / NOT NULL / *AI*	Unique indentifying column for each audit.
Database Name (DB_NAME)	VARCHAR(256) / NOT NULL	Name of database which audit has been logged on.
Event Type (EVENT_TYPE)	VARCHAR(256) / NOT NULL	Logs the event type which occurred, eg. ALTER/DELETE/CREATE on a PROCEDURE or
Object Name (OBJECT_NAME)	VARCHAR(256) / NOT NULL	Name of database table which has a sql query performed on it.
Object Row (OBJECT_ROW)	INT / NOT NULL	Unique ID Identifying which row has been modified in the modifed table.
Object Type (OBJECT_TYPE)	VARCHAR(256) / NOT NULL	Type of SQL FUNCTION that an EVENT has been performed on. EG. PROCEDURE.
SQL Query (SQL_QUERY)	VARCHAR(MAX) / NOT NULL	Logs the SQL query performed on the database.
User ID (USER_ID)	VARCHAR(256) / NOT NULL	Logs the user of the database who exectuted the query.
Date and Time (DATE_TIME)	DATETIME / NOT NULL	Logs the date and time the query was exectued.

Department | Section | Sub-Section | Sub-Section Heading | Resource | Guideline | Image | Audit | Entity Relationship Diagram

C2. Excel Testing of Database Design Two

The excel spreadsheet for testing of database version two is found on the following landscape view page



DEPARTMENT					
DEPT_ID	DeptName	DeptContact	DeptNumber	Location	Priority
D001	Orthopaedics	Dr. Orth	4111	St. Woolos Hospital?	PR001
D002	Respiratory	Dr Resp	3421	Neville Hall Hosp?	PR002
D003	Neurology	Dr Neur	2234	???	PR003
D004	Rheumatology	Dr Rheum	3455	??	PR004
D005	Accident & Emergency	Dr Aande	1234	Level 1	PR005
D006	ENT	Dr Ent	3456	E Block, Level 4	PR006
D007	Ophthalmology	Dr Eye	6578	E Block, Level 4	PR007
D008	Peadiatric	Dr Pead	7643	????	PR008

Not sure if I will have department? A lot of departments are not in the Royal Gwent and Nik mentioned possible data protection conflicts

Primary keys will need to drop the letters before them to enable auto-increment. Do you need AI?

KEY	
BOLD	Primary Key
ITALIC	Foreign Key
NORMAL	Standrad Column

COLUMN	DATA TYPE / NULL / *AI	DESCRIPTION
Department ID (**DEPT_ID**)	INT / NOT NULL / *AI	Unique indentifying column for each department.
Department Name (DeptName)	VARCHAR(256) / NOT NULL	Name of each department.
Name of Department Head (DeptContact)	VARCHAR(256) / NULL	Name of person(s) who manage the department
Contact Number (DeptNumber)	VARCHAR(11) / NOT NULL	Phone number or extenstion of the department
Location of Department (Location)	VARCHAR(256) / NULL	Location of department within the hospital
Priorty (*Priority*)	INT	Priority of departments displayed on page (most common first).

Department | Page | Headings(Repo) | GuidelineHeading | Guideline | Guideline2 | Resource | Image | ERD | Audit

PAGE

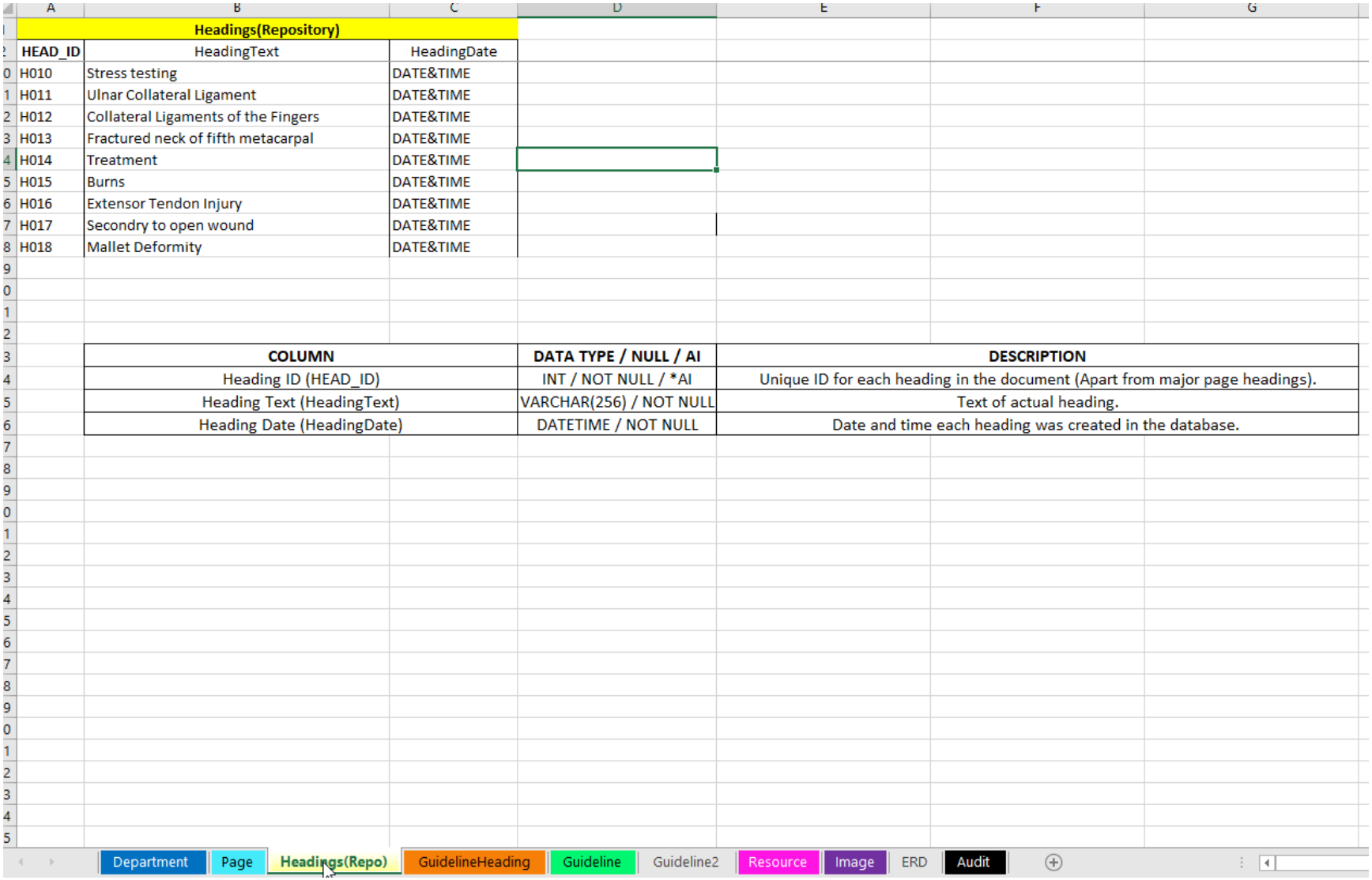
PAGE_ID	PageName	PageDescription	PageDate	*DEPT_ID*	Priority
H000	Review Clinic	General clinic overview	02/01/2019	D005	PR000
P001	Clinical Assessment	General Clinical Asses	02/01/2019 15:00	D005	PR001
P002	Hand Injuries	Page for breakages, etc.	02/01/2019 15:00	D001	PR002
P003	Wrist Injuries	Desc.	03/01/2019 15:00	D001	PR003
P004	Elbow Injuries	Desc.	04/01/2019 15:00	D001	PR004
P005	Shoulder injuries	Desc.	05/01/2019 15:00	D001	PR005
P006	Foot Injuries	Desc.	06/01/2019 15:00	D001	PR006
P007	Ankle & Lower Leg	Desc.	07/01/2019 15:00	D001	PR007
P008	Knee injuries	Desc.	08/01/2019 15:00	D001	PR008
P009	Hips	Desc.	09/01/2019 15:00	D001	PR009
P010	Chest	Desc.	10/01/2019 15:00	D002	PR010
P011	Minor Head Injury	Desc.	11/01/2019 15:00	D001	PR011
P012	Neck Injury	Desc.	12/01/2019 15:00	D004	PR012
P013	Back Pain & Injury	Desc.	13/01/2019 15:00	D004	PR013
P014	Wound Management	Desc.	14/01/2019 15:00	D005	PR014
P015	Throat	Desc.	15/01/2019 15:00	D006	PR015
P016	Ear	Desc.	16/01/2019 15:00	D006	PR016
P017	Nose	Desc.	17/01/2019 15:00	D006	PR017
P018	Facial Injury	Desc.	18/01/2019 15:00	D001	PR018
P019	Eye Injury	Desc.	19/01/2019 15:00	D007	PR019
P020	Childrens Injuries	Desc.	20/01/2019 15:00	D008	PR020

KEY	
BOLD	Primary Key
ITALIC	Foreign Key
NORMAL	Standrad Column

Example for Hand Injuies

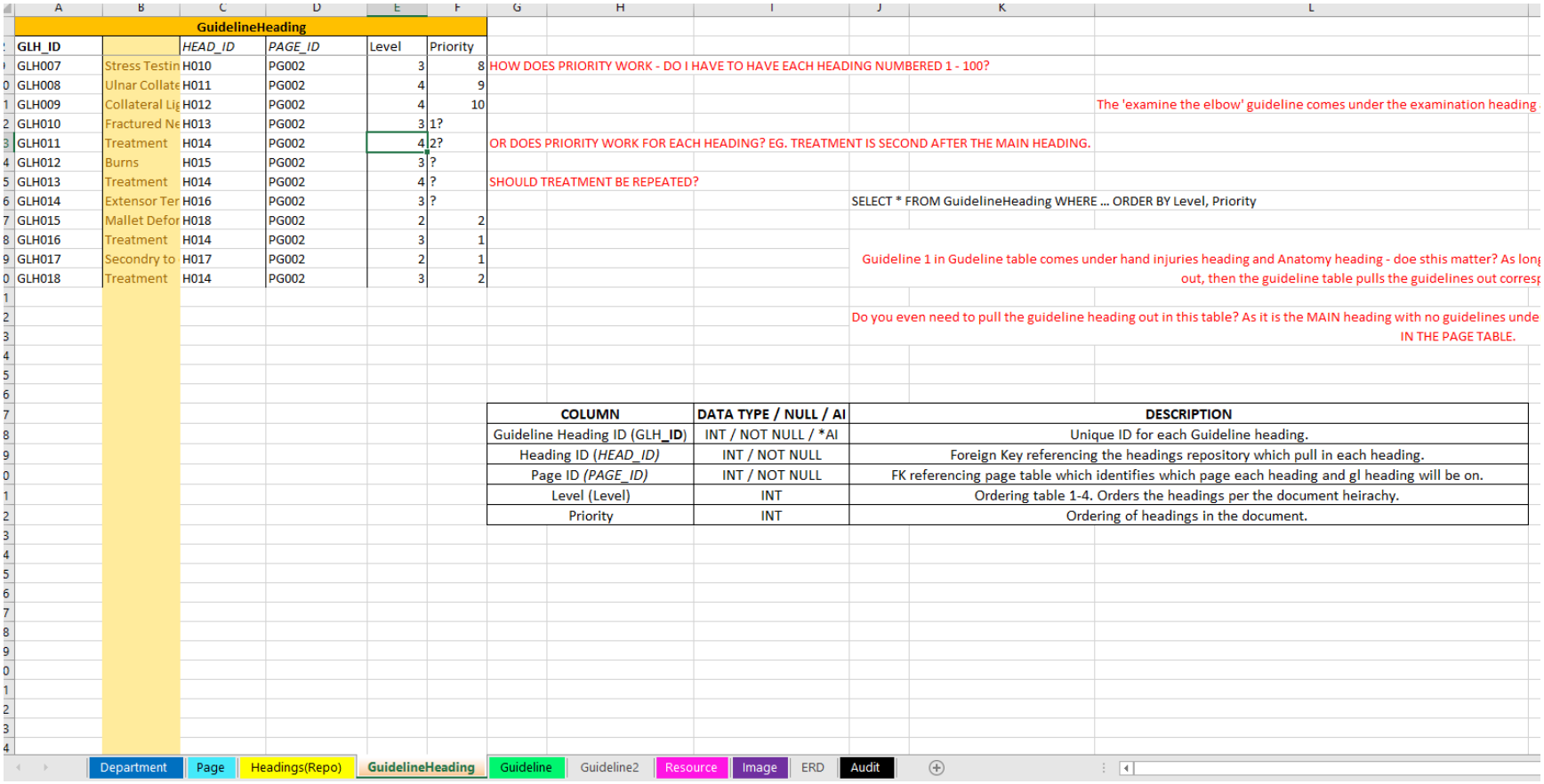
Primary keys will need to drop the letters before them to enab

COLUMN	DATA TYPE / NULL / AI	DESCRIPTION
Page ID (**PAGE_ID**)	INT / NOT NULL / *AI	Unique indentifying column for each spage.
Name of Page (Guideline book section) (PageName)	VARCHAR(256) / NOT NULL	Name of each page in the document.
Page Descirption (PageDescription)	VARCHAR(MAX) / NULL	Description of each page - what is on it what it is for etc.
Page Creation Date (PageDate)	DATETIME / NOT NULL	Date and time page was created.
Section Department (DEPT_ID)	INT / NOT NULL	ID referenccing DEPARTMENT table which holds information on each department that each section belongs to. EG. Ears, Nose and Throat are part of the ENT department.
Priority *(Priority)*	INT / NOT NULL	Colum for piority allowing organising of data. E.G. row 1 will be displayed first, 2 second etc. Like a second index to control where information is displayed on screen.



Headings(Repository)		
HEAD_ID	HeadingText	HeadingDate
H010	Stress testing	DATE&TIME
H011	Ulnar Collateral Ligament	DATE&TIME
H012	Collateral Ligaments of the Fingers	DATE&TIME
H013	Fractured neck of fifth metacarpal	DATE&TIME
H014	Treatment	DATE&TIME
H015	Burns	DATE&TIME
H016	Extensor Tendon Injury	DATE&TIME
H017	Secondry to open wound	DATE&TIME
H018	Mallet Deformity	DATE&TIME

COLUMN	DATA TYPE / NULL / AI	DESCRIPTION
Heading ID (HEAD_ID)	INT / NOT NULL / *AI	Unique ID for each heading in the document (Apart from major page headings).
Heading Text (HeadingText)	VARCHAR(256) / NOT NULL	Text of actual heading.
Heading Date (HeadingDate)	DATETIME / NOT NULL	Date and time each heading was created in the database.



GuidelineHeading					
GLH_ID		*HEAD_ID*	*PAGE_ID*	Level	Priority
GLH007	Stress Testin	H010	PG002	3	8
GLH008	Ulnar Collate	H011	PG002	4	9
GLH009	Collateral Lig	H012	PG002	4	10
GLH010	Fractured Ne	H013	PG002	3	1?
GLH011	Treatment	H014	PG002	4	2?
GLH012	Burns	H015	PG002	3	?
GLH013	Treatment	H014	PG002	4	?
GLH014	Extensor Ter	H016	PG002	3	?
GLH015	Mallet Defor	H018	PG002	2	2
GLH016	Treatment	H014	PG002	3	1
GLH017	Secondry to	H017	PG002	2	1
GLH018	Treatment	H014	PG002	3	2

HOW DOES PRIORITY WORK - DO I HAVE TO HAVE EACH HEADING NUMBERED 1 - 100?

OR DOES PRIORITY WORK FOR EACH HEADING? EG. TREATMENT IS SECOND AFTER THE MAIN HEADING.

SHOULD TREATMENT BE REPEATED?

The 'examine the elbow' guideline comes under the examination heading

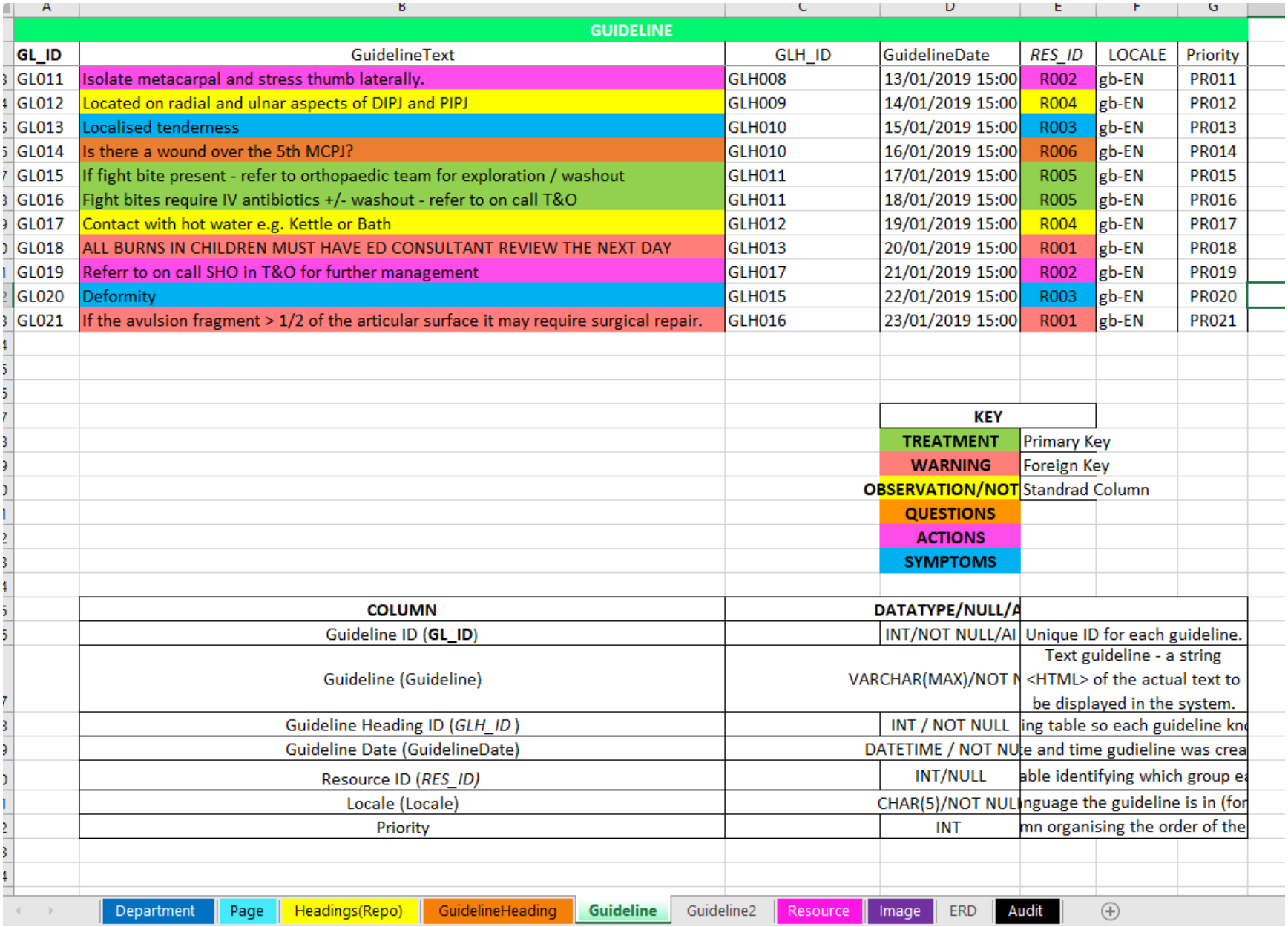
SELECT * FROM GuidelineHeading WHERE ... ORDER BY Level, Priority

Guideline 1 in Gudeline table comes under hand injuries heading and Anatomy heading - doe sthis matter? As long
out, then the guideline table pulls the guidelines out corresp

Do you even need to pull the guideline heading out in this table? As it is the MAIN heading with no guidelines unde
IN THE PAGE TABLE.

COLUMN	DATA TYPE / NULL / AI	DESCRIPTION
Guideline Heading ID (GLH_**ID**)	INT / NOT NULL / *AI	Unique ID for each Guideline heading.
Heading ID (*HEAD_ID*)	INT / NOT NULL	Foreign Key referencing the headings repository which pull in each heading.
Page ID (*PAGE_ID*)	INT / NOT NULL	FK referencing page table which identifies which page each heading and gl heading will be on.
Level (Level)	INT	Ordering table 1-4. Orders the headings per the document heirachy.
Priority	INT	Ordering of headings in the document.

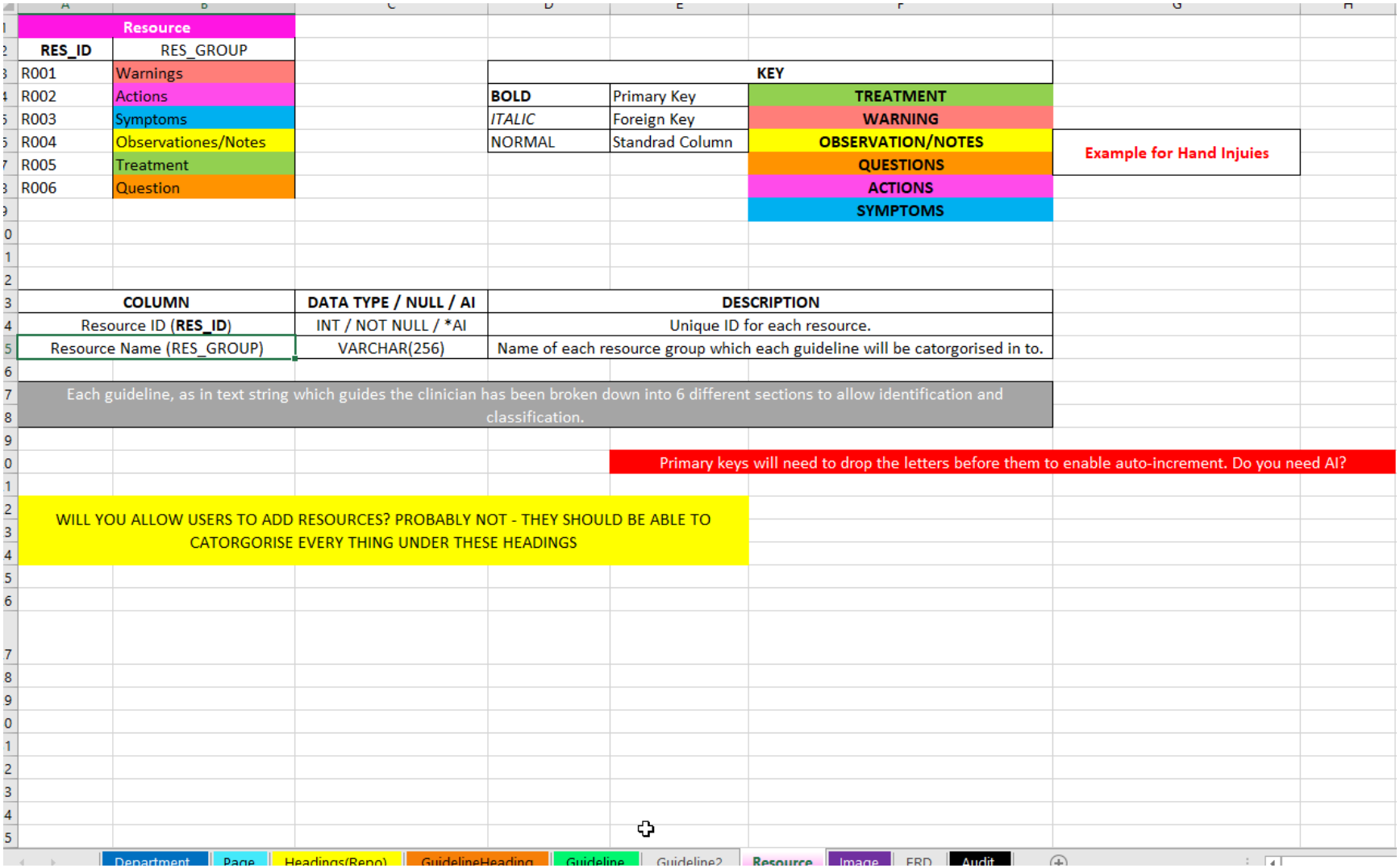
Department | Page | Headings(Repo) | GuidelineHeading | Guideline | Guideline2 | Resource | Image | ERD | Audit



GUIDELINE						
GL_ID	GuidelineText	GLH_ID	GuidelineDate	*RES_ID*	LOCALE	Priority
GL011	Isolate metacarpal and stress thumb laterally.	GLH008	13/01/2019 15:00	R002	gb-EN	PR011
GL012	Located on radial and ulnar aspects of DIPJ and PIPJ	GLH009	14/01/2019 15:00	R004	gb-EN	PR012
GL013	Localised tenderness	GLH010	15/01/2019 15:00	R003	gb-EN	PR013
GL014	Is there a wound over the 5th MCPJ?	GLH010	16/01/2019 15:00	R006	gb-EN	PR014
GL015	If fight bite present - refer to orthopaedic team for exploration / washout	GLH011	17/01/2019 15:00	R005	gb-EN	PR015
GL016	Fight bites require IV antibiotics +/- washout - refer to on call T&O	GLH011	18/01/2019 15:00	R005	gb-EN	PR016
GL017	Contact with hot water e.g. Kettle or Bath	GLH012	19/01/2019 15:00	R004	gb-EN	PR017
GL018	ALL BURNS IN CHILDREN MUST HAVE ED CONSULTANT REVIEW THE NEXT DAY	GLH013	20/01/2019 15:00	R001	gb-EN	PR018
GL019	Referr to on call SHO in T&O for further management	GLH017	21/01/2019 15:00	R002	gb-EN	PR019
GL020	Deformity	GLH015	22/01/2019 15:00	R003	gb-EN	PR020
GL021	If the avulsion fragment > 1/2 of the articular surface it may require surgical repair.	GLH016	23/01/2019 15:00	R001	gb-EN	PR021

KEY	
TREATMENT	Primary Key
WARNING	Foreign Key
OBSERVATION/NOT	Standrad Column
QUESTIONS	
ACTIONS	
SYMPTOMS	

COLUMN	**DATATYPE/NULL/A**	
Guideline ID (**GL_ID**)	INT/NOT NULL/AI	Unique ID for each guideline.
Guideline (Guideline)	VARCHAR(MAX)/NOT N	Text guideline - a string <HTML> of the actual text to be displayed in the system.
Guideline Heading ID (*GLH_ID*)	INT / NOT NULL	ing table so each guideline kn
Guideline Date (GuidelineDate)	DATETIME / NOT NU	e and time gudieline was crea
Resource ID (*RES_ID*)	INT/NULL	able identifying which group e
Locale (Locale)	CHAR(5)/NOT NUL	nguage the guideline is in (for
Priority	INT	mn organising the order of the



Resource	
RES_ID	RES_GROUP
R001	Warnings
R002	Actions
R003	Symptoms
R004	Observationes/Notes
R005	Treatment
R006	Question

KEY		
BOLD	Primary Key	**TREATMENT**
ITALIC	Foreign Key	**WARNING**
NORMAL	Standrad Column	**OBSERVATION/NOTES**
		QUESTIONS
		ACTIONS
		SYMPTOMS

Example for Hand Injuies

COLUMN	DATA TYPE / NULL / AI	DESCRIPTION
Resource ID (**RES_ID**)	INT / NOT NULL / *AI	Unique ID for each resource.
Resource Name (RES_GROUP)	VARCHAR(256)	Name of each resource group which each guideline will be catorgorised in to.

Each guideline, as in text string which guides the clinician has been broken down into 6 different sections to allow identification and classification.

Primary keys will need to drop the letters before them to enable auto-increment. Do you need AI?

WILL YOU ALLOW USERS TO ADD RESOURCES? PROBABLY NOT - THEY SHOULD BE ABLE TO CATORGORISE EVERY THING UNDER THESE HEADINGS

Department | Page | Headings(Repo) | GuidelineHeading | Guideline | Guideline2 | Resource | Image | ERD | Audit

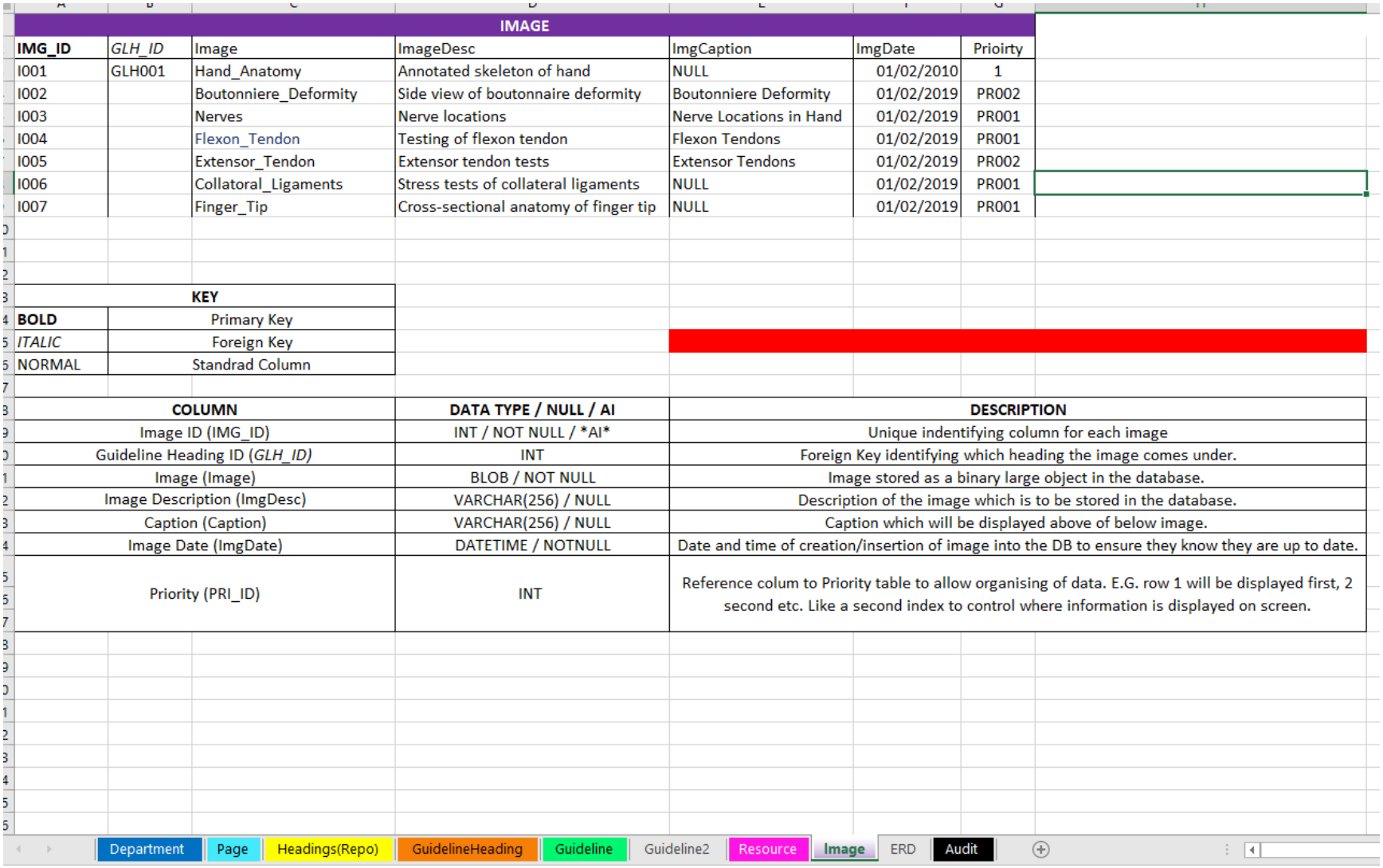
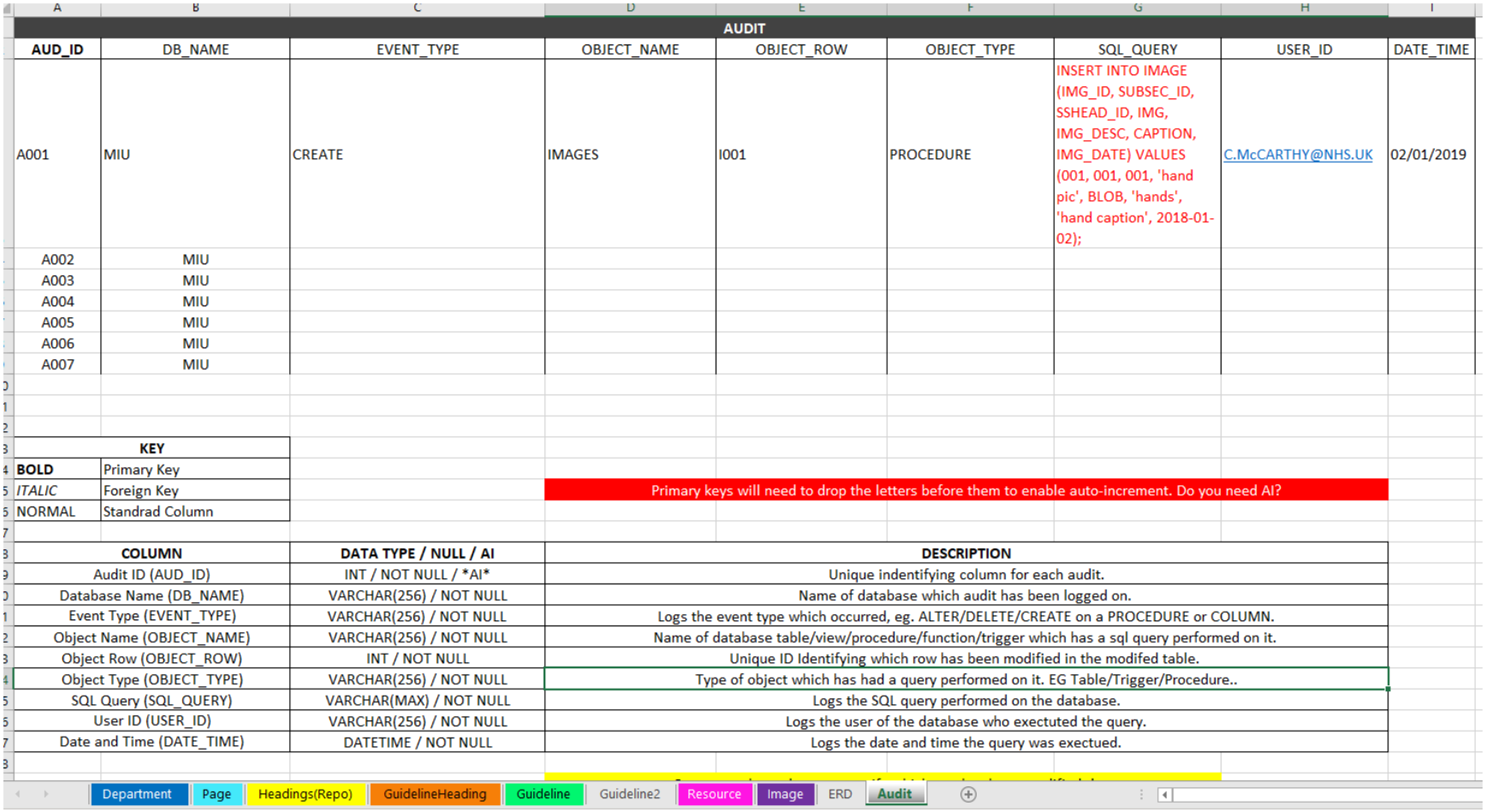


IMAGE						
IMG_ID	*GLH_ID*	Image	ImageDesc	ImgCaption	ImgDate	Prioirty
I001	GLH001	Hand_Anatomy	Annotated skeleton of hand	NULL	01/02/2010	1
I002		Boutonniere_Deformity	Side view of boutonnaire deformity	Boutonniere Deformity	01/02/2019	PR002
I003		Nerves	Nerve locations	Nerve Locations in Hand	01/02/2019	PR001
I004		Flexon_Tendon	Testing of flexon tendon	Flexon Tendons	01/02/2019	PR001
I005		Extensor_Tendon	Extensor tendon tests	Extensor Tendons	01/02/2019	PR002
I006		Collatoral_Ligaments	Stress tests of collateral ligaments	NULL	01/02/2019	PR001
I007		Finger_Tip	Cross-sectional anatomy of finger tip	NULL	01/02/2019	PR001

KEY	
BOLD	Primary Key
ITALIC	Foreign Key
NORMAL	Standrad Column

COLUMN	DATA TYPE / NULL / AI	DESCRIPTION
Image ID (IMG_ID)	INT / NOT NULL / *AI*	Unique indentifying column for each image
Guideline Heading ID (*GLH_ID*)	INT	Foreign Key identifying which heading the image comes under.
Image (Image)	BLOB / NOT NULL	Image stored as a binary large object in the database.
Image Description (ImgDesc)	VARCHAR(256) / NULL	Description of the image which is to be stored in the database.
Caption (Caption)	VARCHAR(256) / NULL	Caption which will be displayed above of below image.
Image Date (ImgDate)	DATETIME / NOTNULL	Date and time of creation/insertion of image into the DB to ensure they know they are up to date.
Priority (PRI_ID)	INT	Reference colum to Priority table to allow organising of data. E.G. row 1 will be displayed first, 2 second etc. Like a second index to control where information is displayed on screen.



AUDIT								
AUD_ID	DB_NAME	EVENT_TYPE	OBJECT_NAME	OBJECT_ROW	OBJECT_TYPE	SQL_QUERY	USER_ID	DATE_TIME
A001	MIU	CREATE	IMAGES	I001	PROCEDURE	INSERT INTO IMAGE (IMG_ID, SUBSEC_ID, SSHEAD_ID, IMG, IMG_DESC, CAPTION, IMG_DATE) VALUES (001, 001, 001, 'hand pic', BLOB, 'hands', 'hand caption', 2018-01-02);	C.McCARTHY@NHS.UK	02/01/2019
A002	MIU							
A003	MIU							
A004	MIU							
A005	MIU							
A006	MIU							
A007	MIU							

KEY	
BOLD	Primary Key
ITALIC	Foreign Key
NORMAL	Standrad Column

Primary keys will need to drop the letters before them to enable auto-increment. Do you need AI?

COLUMN	DATA TYPE / NULL / AI	DESCRIPTION
Audit ID (AUD_ID)	INT / NOT NULL / *AI*	Unique indentifying column for each audit.
Database Name (DB_NAME)	VARCHAR(256) / NOT NULL	Name of database which audit has been logged on.
Event Type (EVENT_TYPE)	VARCHAR(256) / NOT NULL	Logs the event type which occurred, eg. ALTER/DELETE/CREATE on a PROCEDURE or COLUMN.
Object Name (OBJECT_NAME)	VARCHAR(256) / NOT NULL	Name of database table/view/procedure/function/trigger which has a sql query performed on it.
Object Row (OBJECT_ROW)	INT / NOT NULL	Unique ID Identifying which row has been modified in the modifed table.
Object Type (OBJECT_TYPE)	VARCHAR(256) / NOT NULL	Type of object which has had a query performed on it. EG Table/Trigger/Procedure..
SQL Query (SQL_QUERY)	VARCHAR(MAX) / NOT NULL	Logs the SQL query performed on the database.
User ID (USER_ID)	VARCHAR(256) / NOT NULL	Logs the user of the database who exectuted the query.
Date and Time (DATE_TIME)	DATETIME / NOT NULL	Logs the date and time the query was exectued.

Department | Page | Headings(Repo) | GuidelineHeading | Guideline | Guideline2 | Resource | Image | ERD | Audit

C3 Data Governance Policy

Date	***Policy Name***
12/03/2019	NHS Wales / MIU / UWTSD Data Governance Policy
Version No.	***Created By***
1.0	Peter Davies (Project Manager)
i. Background	
Data held on the staff and users of the MIU system is of high value to the project; without it, a sub-standard system will ensue. Therefore, the appropriate governance for the management and use of this data is critical to the systems success. Lack of governance could expose NHS Wales, the MIU, UWTSD and the project stakeholders & manger to unwanted risks.	
ii. Policy Purpose	
The purpose of this policy is to provide all involved with this university project with a framework to ensure all personal data is acquired, stored, processed and transferred in accordance with the law and associated standards, including: The Data Protection Act, GDPR, Caldicot Principles, the ICO and the Department of Health.	
iii. Policy Scope	
This policy applies to everyone involved with the project including stakeholders, the project manager, NHS Wales, the UWTSD, user test participants, volunteers, or any other persons undertaking duties on behalf of the project manager, NHS Wales and the UWTSD. For the purpose of this policy NHS Wales includes all health boards and trusts and UWTSD includes all campuses and colleges.	
v. Policy Rules	
Data Access	The persons stated in the policy scope are in some circumstances required by law to disclose information under the Freedom of Information Act, the Environmental Information Act, and/or requests for personal data. Where information is requested, advice should be sought from the data steward stated in the roles/responsibilities.
Data Usage	Data protection legislation stipulates that personal data, including special category data must be processed (collected, used, disclosed, shared, retained, or disposed of) fairly and lawfully. The processing must be carried out openly and with transparency.
Data Location	The data will only be stored at two physical locations, the project managers laptop and desktop pc for development. Upon deployment of the application, the data will reside in Microsoft's Azure cloud storage databases. Data stored is subject to this policy as well as Microsoft's own data governance policy, found in the resources section of this policy.
Data Integrity	Persons mentioned in the policy scope will uphold the appropriate confidentiality, integrity and availability of the information held and the

	services which hold it. The risks will be managed from internal and external threats.

v. Roles / Responsibilities

Role	*Responsibility*
Data Custodian(s)	As owners of the project, the UWTSD and NHS Wales are the custodians of the data and any metadata.
Data Owner(s)	Dr Nicola Whitehead is the data owner, guiding appropriate use of the MIU data assets whilst ensuring local university policies are in place. Access to MIU data has been granted by Dr Whitehead and delegated to the data steward.
Data Steward	Peter Davies, the project manager is responsible for the data's integrity, quality, implementation and enforcement of this policies rules to persons in the polices scope. The data steward classifies and approves all access to data under guidance from the data custodian/owner.
Data Creators	The data creators are MIU staff, University stakeholders and the project manager who has created data for use in this project through research.
Data Specialists	The data specialists are Dr Nicola Whitehead and Sue Maw of UWTSD. They are business and technical subject matter experts in data and information asset management. They can/will be providing ongoing support to the project's data related matters.

vi. Review Process

This policy should be reviewed for every project undertaken by the project manager where any persons in the policy scope are involved or where there are changes in legislation, changes in technology/system, development practices or methodologies. Any suggestions for change can be forwarded to the data steward.

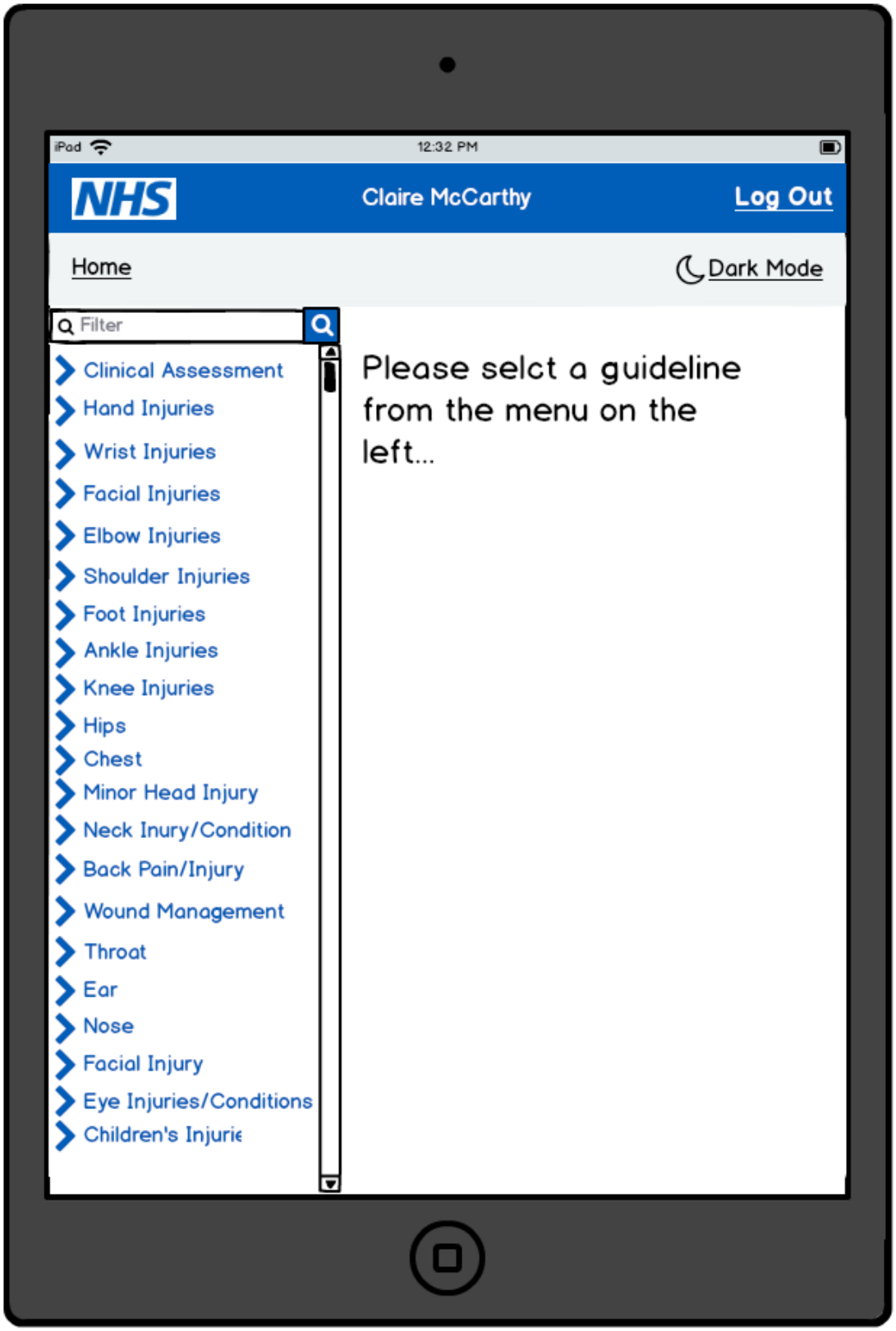
vii. Resources

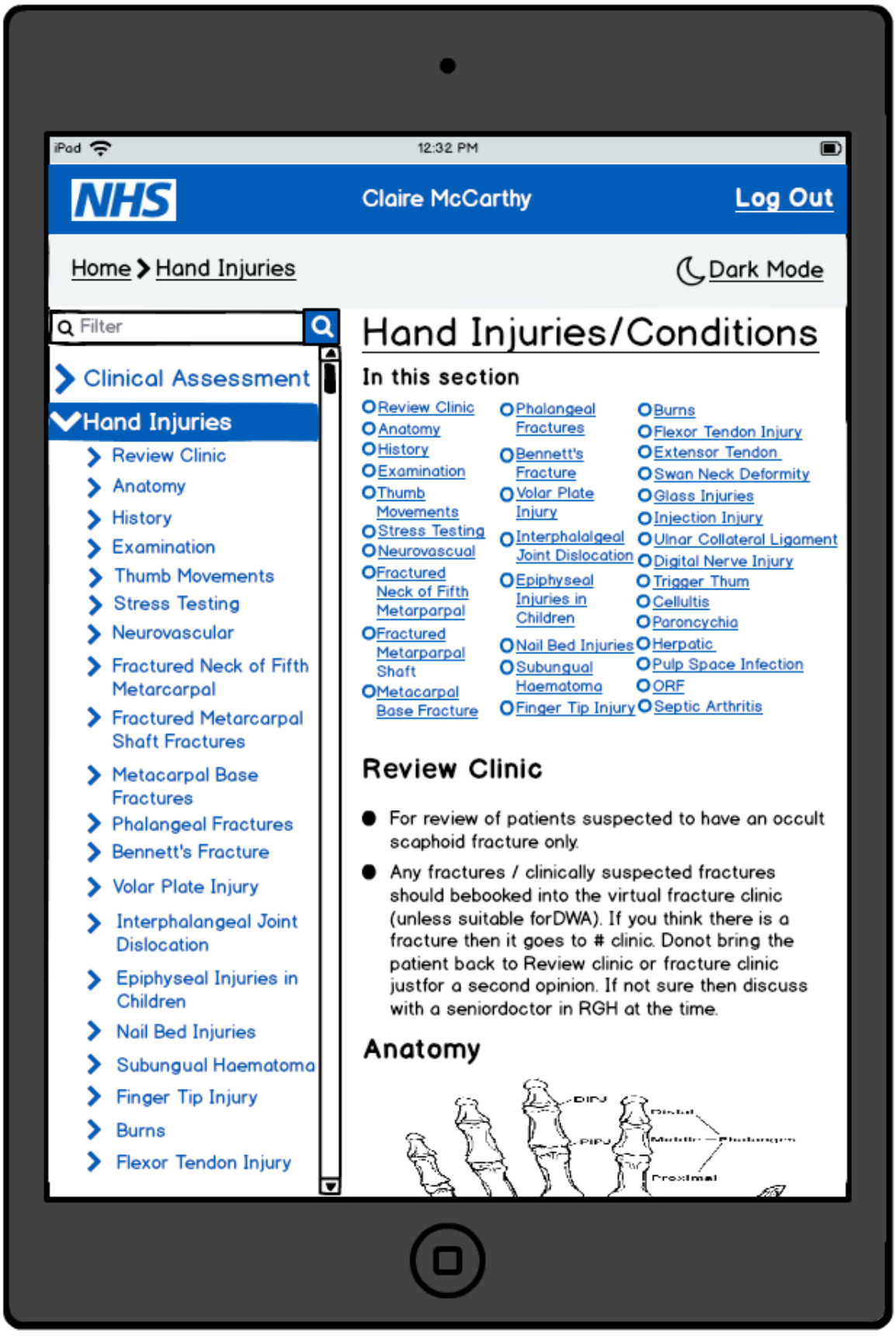
Material Type	*Name*	*Location/Link*
PDF Document	MIU Guidelines Document	MIU Guidelines 2017
Excel Spreadsheet	Database Metadata	Database Structure/MetaData
PDF Document	Microsoft DG Policy	Microsoft GDPR Compliance

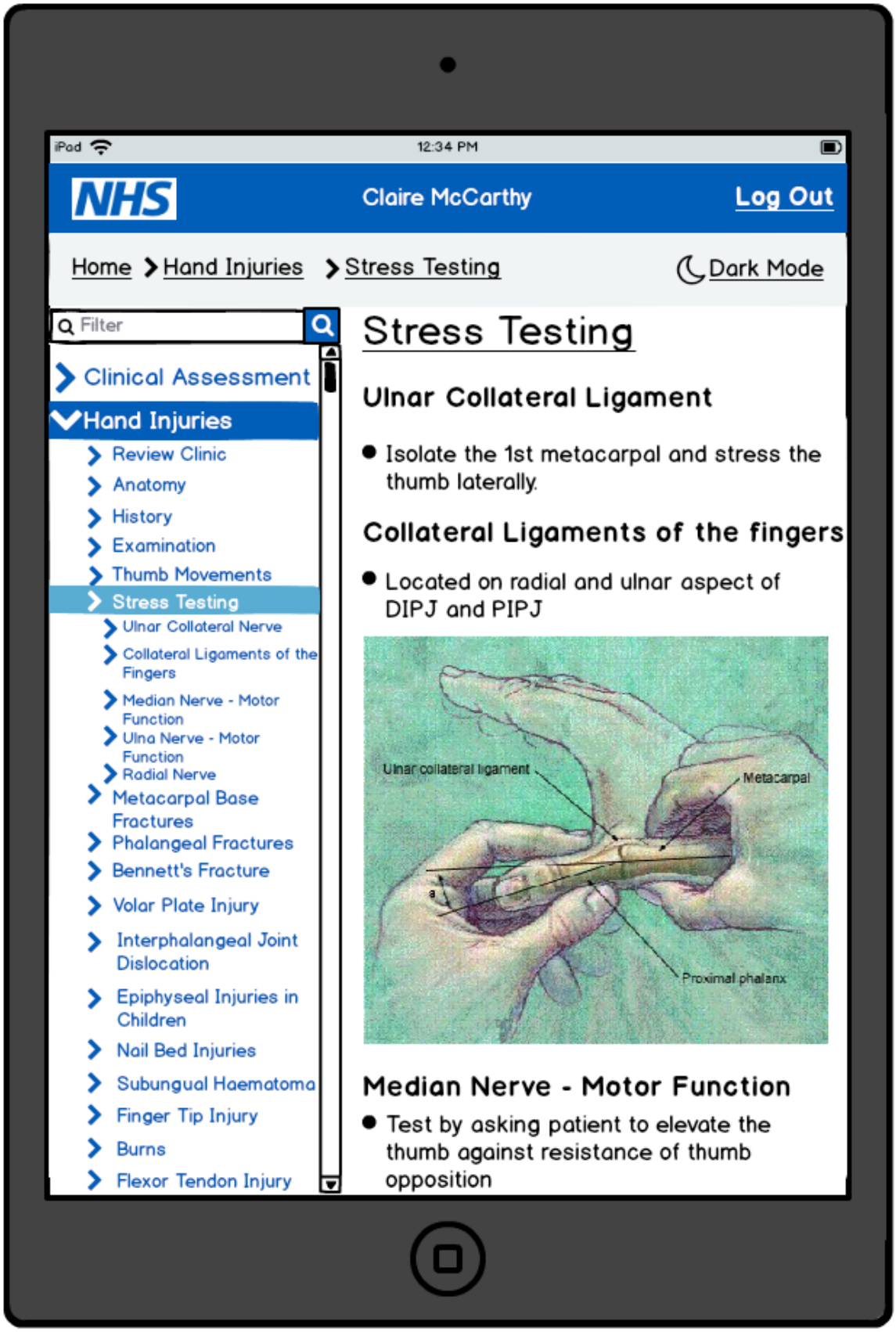
viii. Contacts

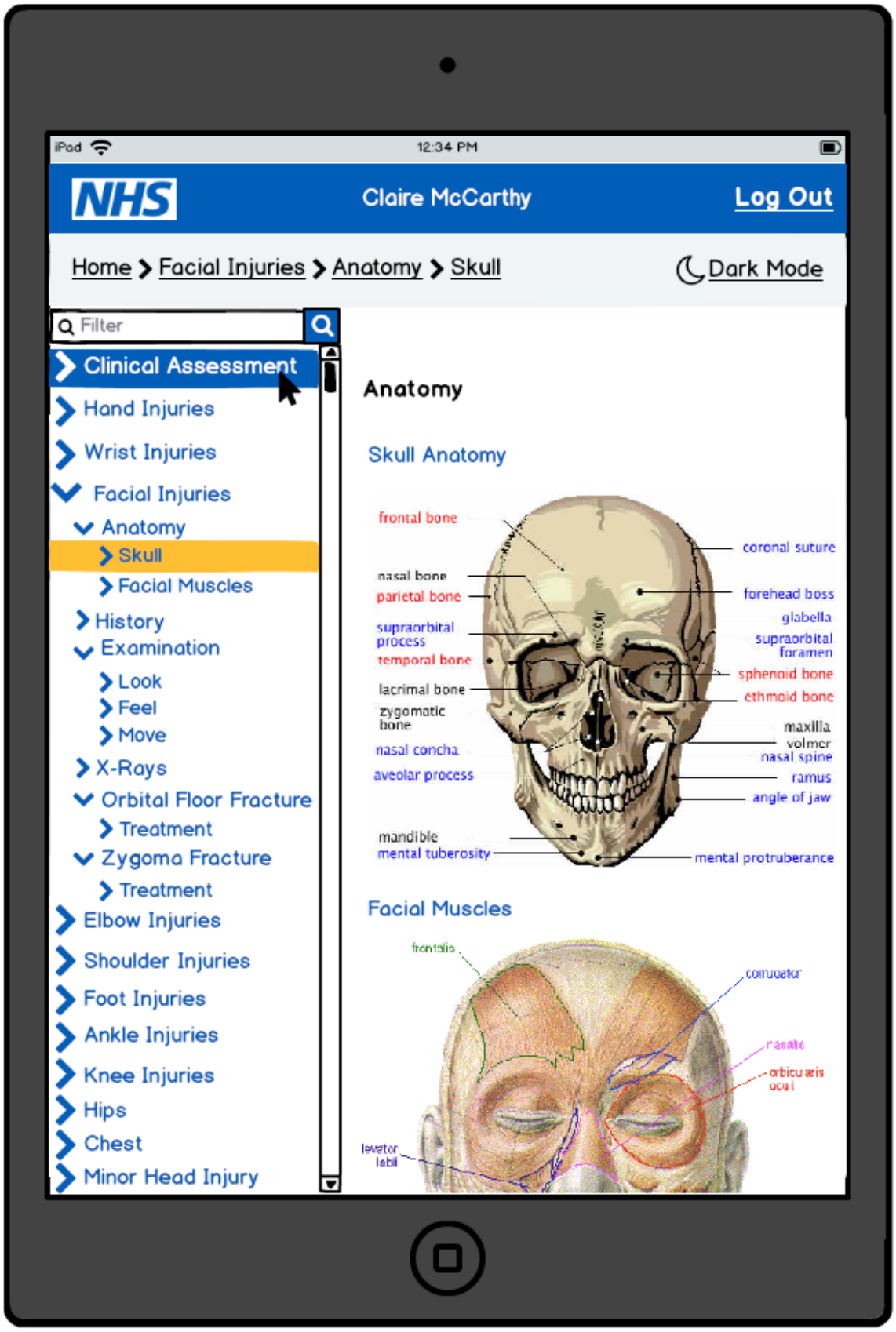
Name	*Email*
Peter Davies	pdavies.079868@student.uwtsd.ac.uk
Dr Nicola Whitehead	nik.whithead@uwtsd.ac.uk
Dr Kemi Ademoye	kemi.ademoye@uwtsd.ac.uk
Sue Maw	Sue.maw@uwtsd.ac.uk

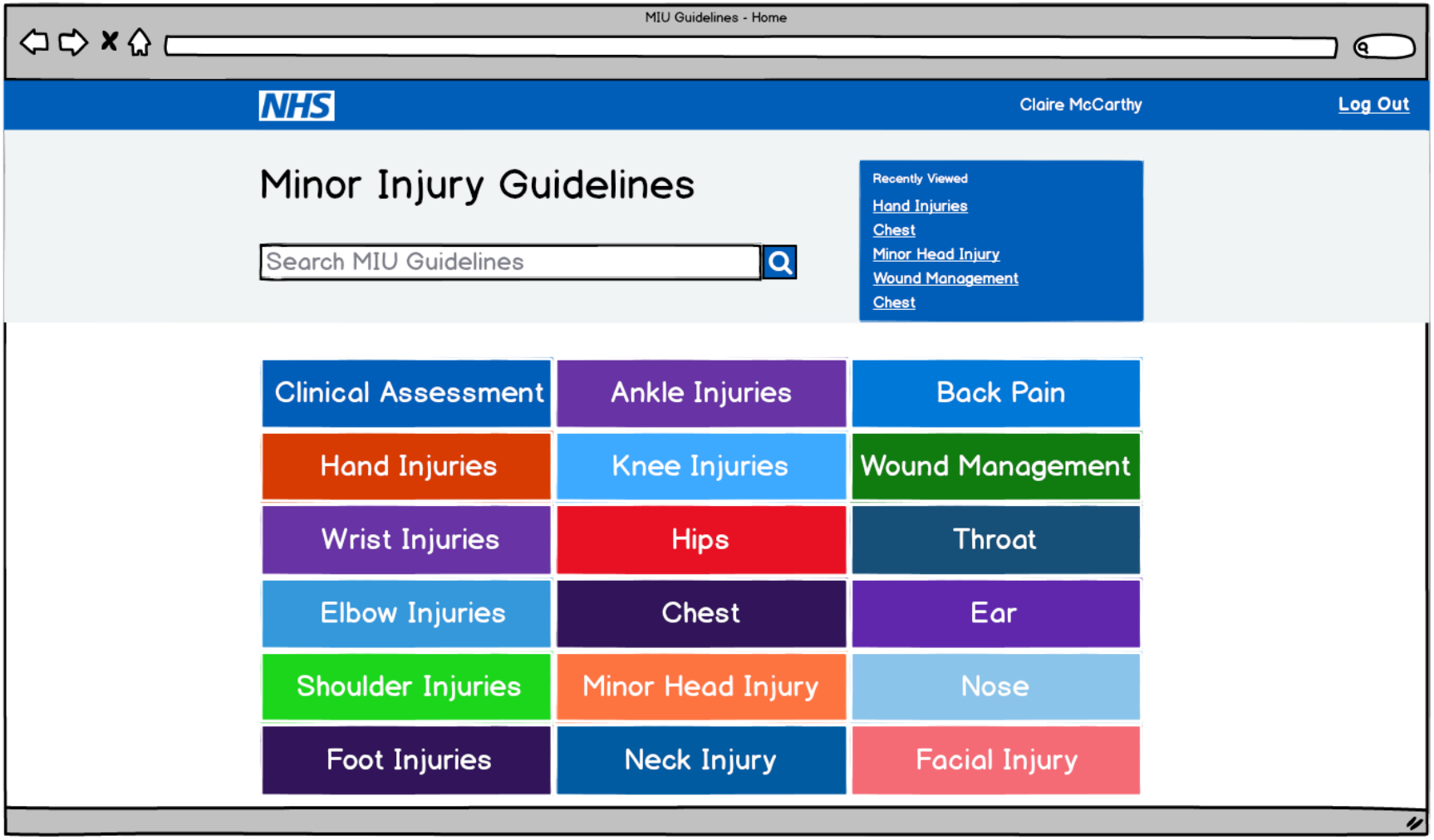
C4. Remaining Paper Prototype Designs

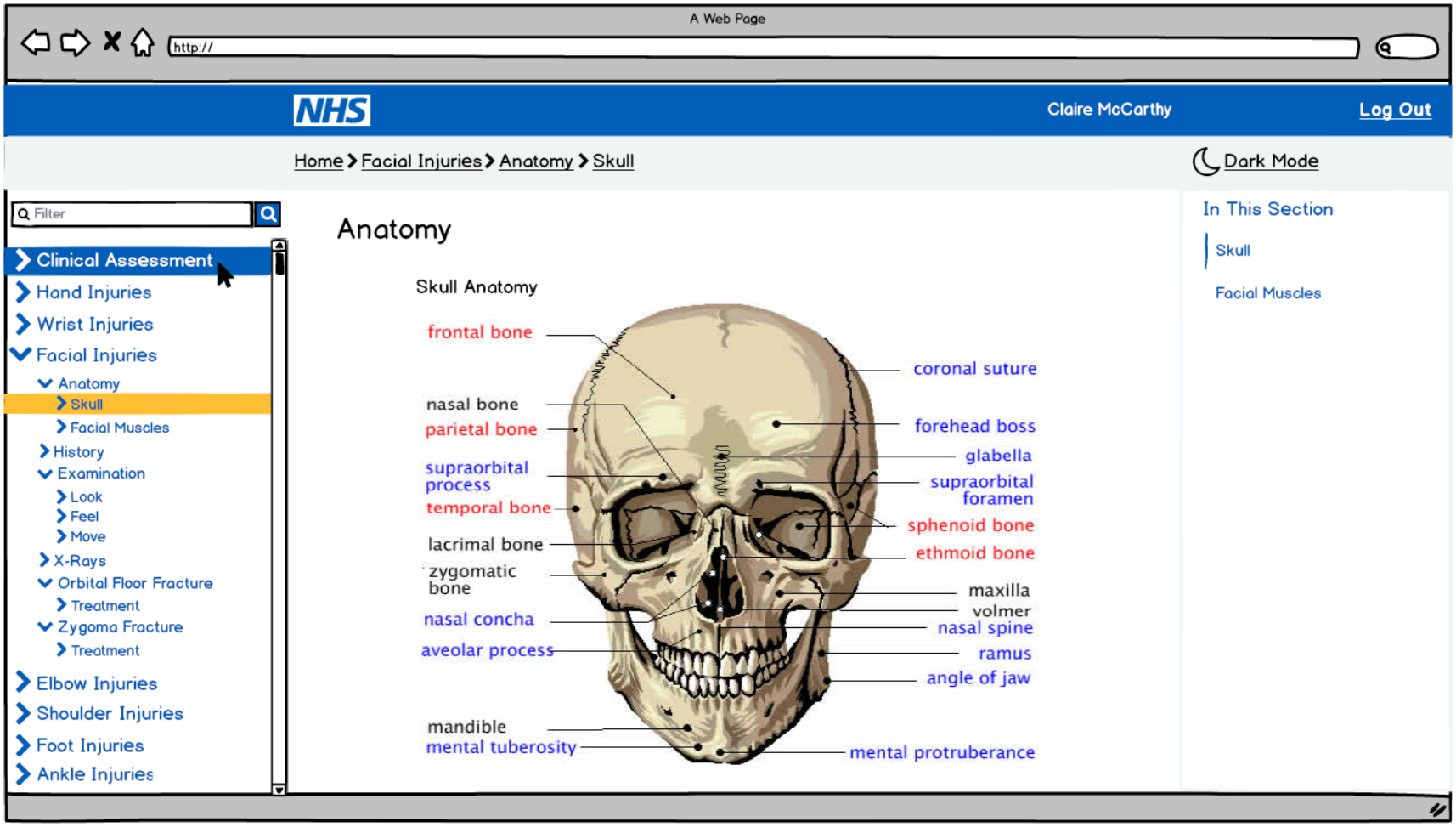


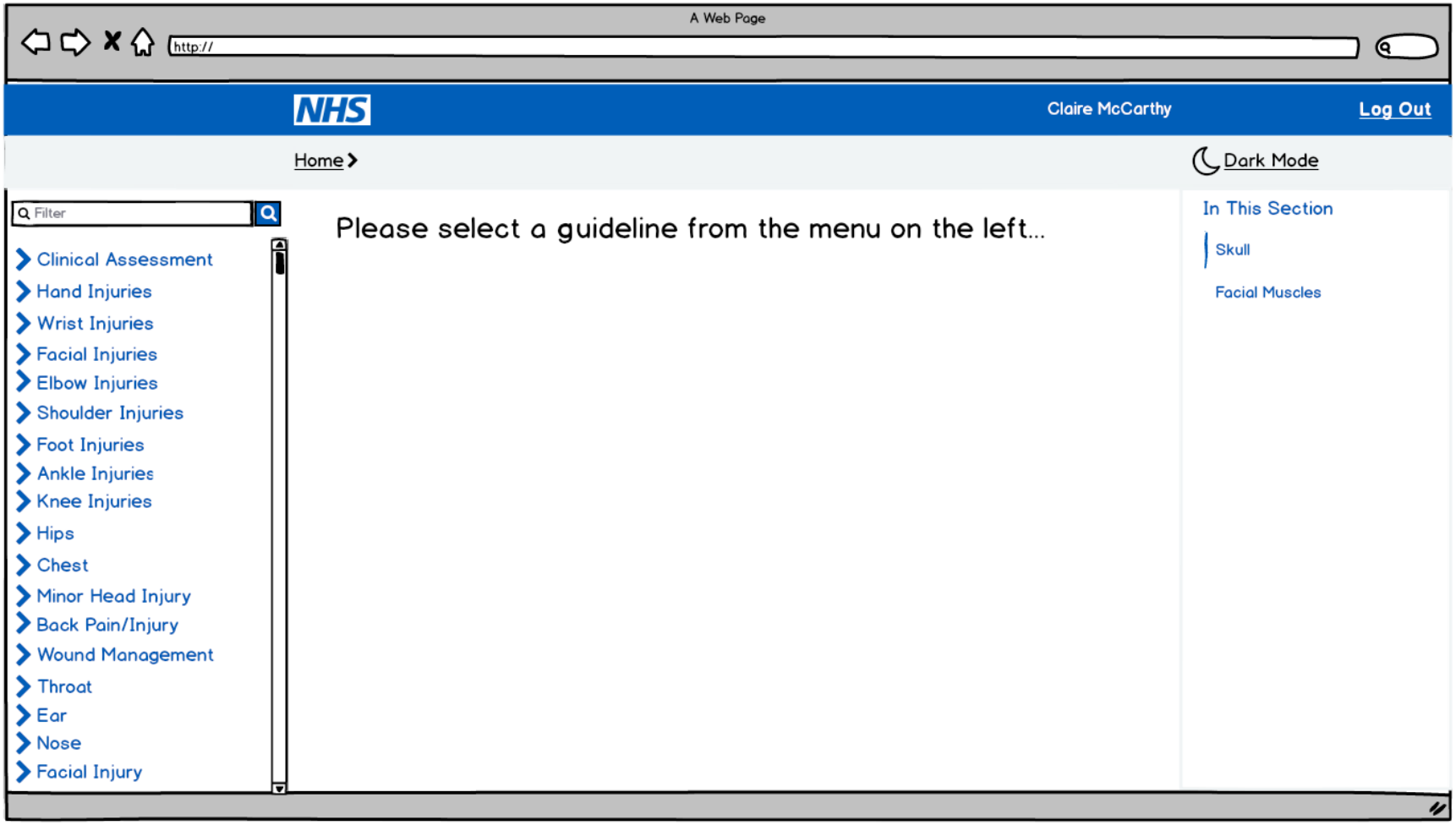

iPad
12:32 PM
NHS
Claire McCarthy
Log Out
Home > Hand Injuries
Dark Mode
Filter
Clinical Assessment
Hand Injuries
Review Clinic
Anatomy
History
Examination
Thumb Movements
Stress Testing
Neurovascular
Fractured Neck of Fifth Metarcarpal
Fractured Metarcarpal Shaft Fractures
Metacarpal Base Fractures
Phalangeal Fractures
Bennett's Fracture
Volar Plate Injury
Interphalangeal Joint Dislocation
Epiphyseal Injuries in Children
Nail Bed Injuries
Subungual Haematoma
Finger Tip Injury
Burns
Flexor Tendon Injury
Hand Injuries/Conditions
In this section
Review Clinic
Anatomy
History
Examination
Thumb Movements
Stress Testing
Neurovascual
Fractured Neck of Fifth Metarparpal
Fractured Metarparpal Shaft
Metacarpal Base Fracture
Phalangeal Fractures
Bennett's Fracture
Volar Plate Injury
Interphalalgeal Joint Dislocation
Epiphyseal Injuries in Children
Nail Bed Injuries
Subungual Haematoma
Finger Tip Injury
Burns
Flexor Tendon Injury
Extensor Tendon
Swan Neck Deformity
Glass Injuries
Injection Injury
Ulnar Collateral Ligament
Digital Nerve Injury
Trigger Thum
Cellultis
Paroncychia
Herpatic
Pulp Space Infection
ORF
Septic Arthritis
Review Clinic
For review of patients suspected to have an occult scaphoid fracture only.
Any fractures / clinically suspected fractures should bebooked into the virtual fracture clinic (unless suitable forDWA). If you think there is a fracture then it goes to # clinic. Donot bring the patient back to Review clinic or fracture clinic justfor a second opinion. If not sure then discuss with a seniordoctor in RGH at the time.
Anatomy
DIPJ
PIPJ
Distal
Middle Phalanges
Proximal


iPod
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Home
Hand Injuries
Stress Testing
Dark Mode
Filter
Clinical Assessment
Hand Injuries
Review Clinic
Anatomy
History
Examination
Thumb Movements
Stress Testing
Ulnar Collateral Nerve
Collateral Ligaments of the Fingers
Median Nerve - Motor Function
Ulna Nerve - Motor Function
Radial Nerve
Metacarpal Base Fractures
Phalangeal Fractures
Bennett's Fracture
Volar Plate Injury
Interphalangeal Joint Dislocation
Epiphyseal Injuries in Children
Nail Bed Injuries
Subungual Haematoma
Finger Tip Injury
Burns
Flexor Tendon Injury
Stress Testing
Ulnar Collateral Ligament
Isolate the 1st metacarpal and stress the thumb laterally.
Collateral Ligaments of the fingers
Located on radial and ulnar aspect of DIPJ and PIPJ
Ulnar collateral ligament
Metacarpal
Proximal phalanx
Median Nerve - Motor Function
Test by asking patient to elevate the thumb against resistance of thumb opposition


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Log Out
Home > Facial Injuries > Anatomy > Skull
Dark Mode
Filter
Clinical Assessment
Hand Injuries
Wrist Injuries
Facial Injuries
Anatomy
Skull
Facial Muscles
History
Examination
Look
Feel
Move
X-Rays
Orbital Floor Fracture
Treatment
Zygoma Fracture
Treatment
Elbow Injuries
Shoulder Injuries
Foot Injuries
Ankle Injuries
Knee Injuries
Hips
Chest
Minor Head Injury
Anatomy
Skull Anatomy
frontal bone
coronal suture
nasal bone
parietal bone
forehead boss
glabella
supraorbital process
supraorbital foramen
temporal bone
sphenoid bone
lacrimal bone
ethmoid bone
zygomatic bone
maxilla
vomer
nasal concha
nasal spine
alveolar process
ramus
angle of jaw
mandible
mental tuberosity
mental protruberance
Facial Muscles
frontalis
corrugator
nasalis
orbicularis oculi
levetor labii


MIU Guidelines - Home
NHS
Claire McCarthy
Log Out
Minor Injury Guidelines
Search MIU Guidelines
Recently Viewed
Hand Injuries
Chest
Minor Head Injury
Wound Management
Chest
Clinical Assessment
Ankle Injuries
Back Pain
Hand Injuries
Knee Injuries
Wound Management
Wrist Injuries
Hips
Throat
Elbow Injuries
Chest
Ear
Shoulder Injuries
Minor Head Injury
Nose
Foot Injuries
Neck Injury
Facial Injury


A Web Page
http://
NHS
Claire McCarthy
Log Out
Home > Facial Injuries > Anatomy > Skull
Dark Mode
Filter
Clinical Assessment
Hand Injuries
Wrist Injuries
Facial Injuries
Anatomy
Skull
Facial Muscles
History
Examination
Look
Feel
Move
X-Rays
Orbital Floor Fracture
Treatment
Zygoma Fracture
Treatment
Elbow Injuries
Shoulder Injuries
Foot Injuries
Ankle Injuries
Anatomy
Skull Anatomy
frontal bone
nasal bone
parietal bone
supraorbital process
temporal bone
lacrimal bone
zygomatic bone
nasal concha
aveolar process
mandible
mental tuberosity
coronal suture
forehead boss
glabella
supraorbital foramen
sphenoid bone
ethmoid bone
maxilla
volmer
nasal spine
ramus
angle of jaw
mental protruberance
In This Section
Skull
Facial Muscles


A Web Page
http://
NHS
Claire McCarthy
Log Out
Home
Dark Mode
Filter
Clinical Assessment
Hand Injuries
Wrist Injuries
Facial Injuries
Elbow Injuries
Shoulder Injuries
Foot Injuries
Ankle Injuries
Knee Injuries
Hips
Chest
Minor Head Injury
Back Pain/Injury
Wound Management
Throat
Ear
Nose
Facial Injury
Please select a guideline from the menu on the left...
In This Section
Skull
Facial Muscles

A Web Page

http://

NHS

Claire McCarthy

Log Out

Home > Hand Injuries

Dark Mode

Filter

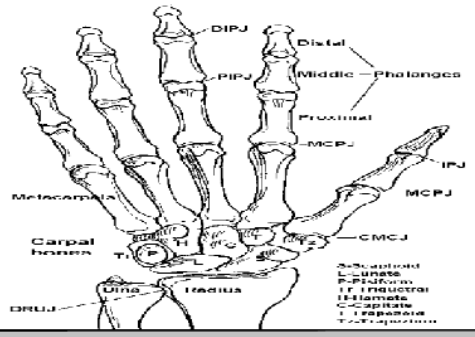
- Clinical Assessment
- Hand Injuries
  - Review Clinic
  - Anatomy
  - History
  - Examination
  - Thumb Movements
  - Stress Testing
  - Neurovascular
  - Fractured Neck of Fifth Metacarpal
  - Fractured Metacarpal Shaft
  - Metacarpal Base
  - Phalangeal Fractures
  - Bennett's Fracture
  - Volar Plate Injury
  - Interphalangeal Joint Dislocation
  - Epiphyseal Injuries in Children
  - Nail Bed Injuries
  - Subungual Haematoma
  - Finger Tip Injury

Hand Injuries/Conditions

Review Clinic

- For review of patients suspected to have an occult scaphoid fracture only.
- Any fractures / clinically suspected fractures should bebooked into the virtual fracture clinic (unless suitable forDWA). If you think there is a fracture then it goes to # clinic. Donot bring the patient back to Review clinic or fracture clinic justfor a second opinion. If not sure then discuss with a seniordoctor in RGH at the time.

Anatomy



In This Section

- Review Clinic
- Anatomy
- History
- Examination
- Thumb Movements
- Stress Testing
- Nuerovascular
- Fractured Neck of Fifth Metacarpal
- Fractured Metacarpal Shaft Fractures
- Metacarpal Base Fractures
- Phalangeal Fractures
- Bennett's Fracture
- Volar Plate Injury
- Interphalangeal Joint Dislocation

A Web Page

http://

NHS

Claire McCarthy Log Out

Home > Hand Injuries > Stress Testing

Dark Mode

Filter

- Clinical Assessment
- Hand Injuries
  - Review Clinic
  - Anatomy
  - History
  - Examination
  - Thumb Movements
  - Stress Testing
    - Ulnar Collateral Nerve
    - Collateral Ligaments of the Fingers
    - Median Nerve - Motor Function
    - Ulna Nerve - Motor Function
    - Radial Nerve
  - Neurovascular
  - Fractured Neck of Fifth Metarcarpal
  - Fractured Metarcarpal Shaft Fractures
  - Metacarpal Base
  - Phalangeal
  - Bennett's Fracture
  - Volar Plate Injury

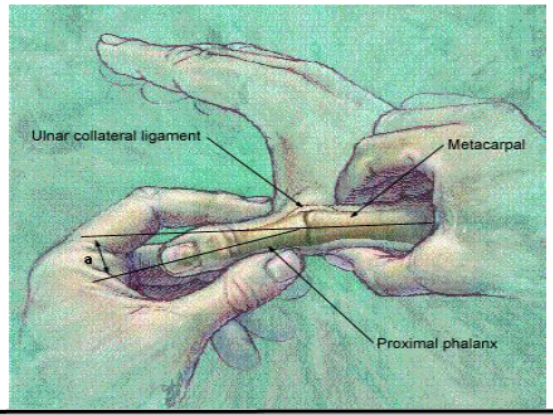
Stress Testing

Ulnar Collateral Ligament

- Isolate the 1st metacarpal and stress the thumb laterally.

Collateral Ligaments of the fingers

- Located on radial and ulnar aspect of DIPJ and PIPJ



In This Section

- Review Clinic
- Anatomy
- History
- Examination
- Thumb Movements
- Stress Testing
- Nuerovascular
- Fractured Neck of Fifth Metacarpal
- Fractured Metacarpal Shaft Fractures
- Metacarpal Base Fractures
- Phalangeal Fractures
- Bennett's Fracture
- Volar Plate Injury
- Interphalangeal Joint Dislocation

C5. Prototype Testing Usability Test Script & Results

C5.1 Test Participant One Script

Consent & Recording Release Form

Thank you for participating in our usability test.

I will be recording your session to allow Peter Davies of UWTSD to thoroughly analyse this session after it has been completed. Additionally, for marking purposes, lecturer's Dr Nicola Whitehead and Dr Kemi Ademoye may also view/listen to the recording as well as any external examiners marking this project/

Please read the statement below and sign where indicated.

I understand that my usability test session will be recorded. I grant the students/lecturers/examiners permission to use this recording, for the purpose of improving the application design.

I understand that participation in this usability study is voluntary and I agree to immediately raise any concerns or areas of discomfort during the session with the study administrator.

I understand that I am being asked to take part in this study because I have the required first aid or higher level of medical training.

Please sign below to indicate that you have read, and you understand the information on this form and that any questions you might have about the session have been answered.

Date: 1/3/19

Please print your name: [redacted]

Please sign your name: [redacted]

Thank you, I appreciate your participation.

Participant Name: [redacted] Date: 1/3/19

System Usability Scale

Instructions: For each of the following statements, mark one box that best describes your reactions to the paper prototype application *today*.

		Strongly Disagree				Strongly Agree	
1.	I think that I would like to use this application frequently.	☐	☐	☐	☑	☐	3
2.	I found this application unnecessarily complex.	☑	☐	☐	☐	☐	4
3.	I thought this application was easy to use.	☐	☐	☐	☑	☐	3
4.	I think that I would need assistance to be able to use this application.	☑	☐	☐	☐	☐	4
5.	I found the various functions in this application were well integrated.	☐	☐	☐	☑	☐	3
6.	I thought there was too much inconsistency in this application.	☑	☐	☐	☐	☐	4
7.	I would imagine that most people would learn to use this application very quickly.	☐	☐	☑	☐	☐	2
8.	I found this application very cumbersome/awkward to use.	☐	☑	☐	☐	☐	3
9.	I felt very confident using this application.	☐	☐	☐	☑	☐	3
10.	I needed to learn a lot of things before I could get going with this application.	☑	☐	☐	☐	☐	4

33

Please provide any comments about this website:

Being able to customise homepages,
- Different styles
- Custom locations of information

SCORE
33 x 2.5
= 82.5

This questionnaire is based on the System Usability Scale (SUS), which was developed by John Brooke while working at Digital Equipment Corporation. © Digital Equipment Corporation, 1986.

Paper Prototyping User Test

2. Pre-test Interview

Before we start using the paper prototype of the application/website, I'd just like to ask you some simple background questions, if that's okay?

Personal questions

Occupation: MECHANICAL ENGINEER.

Where do you live?

SWANSEA.

How do you access the internet? Home? Work? Phone?

ALL OF ABOVE

Do you own a laptop or desktop or tablet?

YES ALL OF ABOVE.

Do you have broadband?

YES.

Do you use apps on your tablet or ~~smartphone~~ DESKTOP PC?

YES

What sort of apps do you use?

SOCIAL MEDIA
FITNESS APPS - GARMIN
EBAY (SHOPPING APPS)

NEWS
TED TALKS
WEATHER
AUDIBLE.

Paper Prototyping User Test

System Usage

Please tell me about any websites you have used when looking for a medical diagnosis?

NHS DIRECT, PUBMED.

What are the main websites you used to find medical information?

SAME AS ABOVE.

Have you used lots of different sites to do this?

NO, GOOGLE IT - THEN WHATEVER COMES UP. WHAT MATCHES BEST.

Is there a site you prefer? Why?

NHS DIRECT - TRUSTWORTHY / VERIFIED.

Describe the last time you searched a medical condition or ailment online?

SEARCHING BACK PROBLEM - FOUND ON YOUTUBE.

What was the scenario?

~~HIP~~ HIP FLEXOR MUSCLES PLAYING-UP. (BAD BACK).

What was most important when you searched for a diagnosis?

e.g. Speed of finding information, trustworthiness?

RELATED SYMPTOMS - SO, WHAT RELATED EXACTLY TO THE SYMPTOMS IS WHAT I CLICKED ON - YOUTUBE.

~~How did you share information if you were looking for a friend?~~

Paper Prototyping User Test

THE TASKS

For the purposes of the test, we'll assume the following:

You are a health professional trying to locate specific medical information in this paper prototype. First, you will need pretend to login using the login screen and navigate your way to a page I will specify in a moment. Do you understand?

YES.

1. *Could you please tell me how you would log in to this system?*
   DT – ~~THE TN USER~~ NO PROBLEMS FOUND.

   iPad -

   What do you think of the login screen?
   CLEAR, SIMPLE, BUT FORGOT "FORGOT PASSWORD"

   SHOW HOME PAGE 1

2. *Look around this page for a few minutes. How do you feel about it?*
   DT – NEEDS PICTURES - POSSIBLY SEE IMAGES REPRESENTING THE INJURIES. TOO MUCH INFO CRAMMED TOGETHER.
   ~~**iPad -**~~ FONT IS NICE + COLOURS. RECENTLY USED LINKS GOOD. SPACING + PHOTOS WOULD IMPROVE IT + MAYBE ALPHA ORDER OR MOST COMMON FIRST.

   SHOW HOME PAGE 2

3. *Look around this page for a few minutes. How do you feel about it?*
   DT – 1ST ONE BETTER - TOO WINDOWS BASED.
   TOO BASIC - NEEDS MORE INFO.
   POSSIBLY SPLIT INTO FURTHER CATS - HEAD, TORSO ETC.
   FIRST ONE BETTER.
4. *From the home page, could you navigate to the Hand Injuries section?*
   DT – FOUND WITHIN 1 SEC - NO PROBLEM.

   iPad -

Paper Prototyping User Test

SHOW BLANK PAGE WITH MENU.

5. *From this page, could you again navigate to the Hand Injuries section?*

DT – YES - NO PROB ON LEFT HAND SIDE -

~~**iPad -**~~ WHY NOT IN ALPHA ORDER?

TO HOME - HE WOULD CLICK HOME IN B.C OR NHS - BUT THOUGHT NHS LOGO WOULD GO TO NHS MAIN SITE. MAYBE HAVE MENU DISAPEAR TO HAVE MORE SPACE FOR DOCUMENT?

6. *How easy is the text on this page to read?*

DT – YES - MAYBE 1.5 SPACING.

~~**iPad -**~~ CLEAR, NICE CONTRAST;

MENU ON RIGHT SHOULD NOT DISPLAY WHOLE DOC JUST WHERE YOU ARE ON CORRECT DOC - LIKE KEMI SAID.

SHOW HAND INJURY PAGE POLYHIERACHY GOOD.

7. *From this Hand Injury Page, could you navigate to the stress testing section? (Note which menu they used Left or Right or Top menu if iPad)*

DT – YES - NP. ON BOTH SIDES

~~**iPad –**~~

SHOW STRESS TESTING PAGE

8. *Could you now locate the Median Nerve – Motor Function section?*

DT – PICTURES OUTDATED - TWO HANDS WHITE - RACIALLY BAD.

~~**iPad –**~~ YES USER KNEW EXACTLY WHERE HE WAS, COLOUR IS GOOD.

SHOW MEDIAN NERVE SCREEN

Paper Prototyping User Test

9. *On this Median Nerve page, is it clear which sections of this document are currently being displayed to you? As in, do you know where you are in the system?*
   (See if they pick up on the highlights on the menus and the breadcrumbs)

DT – STRUGGLED SLIGHTLY – IT WAS TOO SMALL.
POSS CSS TO MAGNFY WHERE MOUSE IS OR WHEN A
~~iPad~~ - CERTAIN SECTION IS SELECTED, LOWER HEIRACHY IS LARGER.
BREADCRUMBS GOOD, SO IS LEFT MENU.
YELLOW GOOD – ~~BUT BOLD~~ RIGHT MENU SHOULD BE OF ACTUAL SECTON.

10. *Can you see anyway you could change the screen colours to a darker setting? (See if they can find the dark mode).*

DT – YES – INSTANTLY QUESTIONING IT.

~~iPad~~ –
→ INSTANTLY REG' TWO-PANEL SELECTOR.
IF YOU CLOSE STRESS TEST WHAT HAPPENS – FOLLOW RES PATTERNS, IT SHOWS SAME THING AFTER FILE IS CLOSED

11. *Could you now navigate back to the homepage please? (See if they click the NHS logo or the breadcrumbs)*

DT – NHS LOGO MAY GO TO NHS MAIN SITE?
~~iPad~~ - MAYBE HAVE HOME BUTTON.-
DIDN'T USE BREADCRUMBS, THEY ARE LAST RESORT.

Thank you for completing those tests, could I now ask you to complete a quick questionnaire which won't take you longer than a few minutes.

GIVE QUESTIIONNAIRE

C5.2 Test Participant One Results

Test one was conducted using the desktop version of the system.

Details

Name	Test Participant 1
Demographic	25 - 35, in a relationship, no children.
Description from Personal Questions	Participant 1 is a first-aid trained mechanical engineer, from Swansea who access the internet through a range of devices. He is a competent, heavy computer user who uses a wide range of applications.
Medical Sites Used	Uses NHS Direct and PubMed for medical information but prefers NHS direct as he feels it can be trusted. He felt related symptoms were most important when searching for a diagnosis and his last medical help came from a video on YouTube.
Question Answers	1. No problems with login but where is 'forgot password' link? 2. Maybe have pictures to illustrate each section. Information looks 'crammed' together', could possibly order sections alphabetically? Liked recently used links and colours of website. 3. Preferred first home page design, thought 2nd was too 'Windows' based. Suggested splitting into further categories (hand, ankle etc. in orthopaedics) to reduce screen business. 4. Located Hand Injuries page with no problem in 2 seconds. 5. No problem with menu on left. Should it be in alphabetical order? 6. Text is easy to read. Suggested 1.5 line spacing. Menu on right should not display whole document, just what is in each page. 7. Navigated with no problems. 8. Located with no problem. Mentioned pictures look outdated.

	9. Located after a little time, didn't notice breadcrumbs, saw highlighted text but commented that text was too small to read – maybe a magnifying feature on mouse over? 10. Located dark mode with no problem. 11. Thought NHS logo may go back to main NHS page, maybe have a home button? Didn't use breadcrumbs until last resort.
SUS	Scored **82.5** on the system usability scale.

C5.3

C5.3 Test Participant Two Script

Consent & Recording Release Form

Thank you for participating in our usability test.

I will be recording your session to allow Peter Davies of UWTSD to thoroughly analyse this session after it has been completed. Additionally, for marking purposes, lecturer's Dr Nicola Whitehead and Dr Kemi Ademoye may also view/listen to the recording as well as any external examiners marking this project/

Please read the statement below and sign where indicated.

I understand that my usability test session will be recorded. I grant the students/lecturers/examiners permission to use this recording, for the purpose of improving the application design.

I understand that participation in this usability study is voluntary and I agree to immediately raise any concerns or areas of discomfort during the session with the study administrator.

I understand that I am being asked to take part in this study because I have the required first aid or higher level of medical training.

Please sign below to indicate that you have read, and you understand the information on this form and that any questions you might have about the session have been answered.

Date: 10/03/19

Please print your name [redacted]

Please sign your name: [redacted]

Thank you, I appreciate your participation.

r Prototyping User Test

2. Pre-test Interview

Before we start using the paper prototype of the application/website, I'd just like to ask you some simple background questions, if that's okay?

Personal questions

Name:

Age: 19 – 25 / (26 – 35) / 36 – 45 / 46 – 55 / 56 – 65 / 66 – 75 / 75+

Occupation: COMMUNITY CAREER

Where do you live? NEWPORT, PEMBROKESHIRE

How do you access the internet? Home? Work? Phone?

ALL OF ABOVE

Do you own a laptop or desktop or tablet?

LAPTOP

Do you use applications on your laptop/pc or tablet?

PHOTOSHOP, ILLUSTRATOR, IN DESIGN. OFFICE. (YES)

What sort of applications do you use?

System Usage

Please tell me about any websites you have used when looking for a medical diagnosis?

GOOGLE SEARCH.
WEB DOCTOR, NHS.

What are the main websites you used to find medical information?

NHS

Have you used lots of different sites to do this?

NOT REALLY

Is there a site you prefer? Why?

NHS – IT'S THE NHS, SHE TRUSTS IT.

Describe the last time you searched a medical condition or ailment online?

MOUTH ULCERS.

What was the scenario?

What was most important when you searched for a diagnosis?

e.g. Speed of finding information, trustworthiness?

TO FIND OUT IF IT'S SOMETHING SERIOUS OR NOT.

Paper Prototyping User Test

THE TASKS

For the purposes of the test, we'll assume the following:

You are a health professional trying to locate specific medical information in this paper prototype. First, you will need pretend to login using the login screen and navigate your way to a page I will specify in a moment. Do you understand?

YES.

1. *Could you please tell me how you would log in to this system?*

   NO PROBLEMS

   What do you think of the login screen?

   VERY CLEAR, SIMPLE (NICE), NOT MUCH GOING ON.

SHOW HOME PAGE 1

2. *Look around this page for a few minutes. How do you feel about it?*

   VERY UNDERSTANDABLE. SPECIFIC TITLES WITH GOOD DESCRIPTIONS UNDERNEATH. CLEAR SEARCH BOX.

SHOW HOME PAGE 2

3. *Look around this page for a few minutes. How do you feel about it?*

   * TOO MUCH GOING ON, NOT AS CLEAR.

4. *From the home page, could you navigate to the Hand Injuries section?*

   YES – CHOSE IN RECENTLY VIEWED AS IT STANDS OUT MORE IN DARK BLUE.

   NO, PROBLEMS FOUND.

er Prototyping User Test

SHOW BLANK PAGE WITH MENU.

5. *From this page, could you again navigate to the Hand Injuries section?*

NO PROBLEMS, FOUND STRAIGHT AWAY.
WOULD ALSO SEARCH IT.

6. *How easy is the text on this page to read?*

~~YES~~ VERY EASY.

SHOW HAND INJURY PAGE

7. *From this Hand Injury Page, could you navigate to the stress testing section? (Note which menu they used Left or Right or Top menu if iPad)*

- STARTED LOOKING IN BIG LIST ON MAIN PAGE. + IS STRUGGLING TO FIND IT. ~~SEE~~ SHOULD BE IN ALPHABETICAL ORDER
- SUGGESTED SEARCH
- FOUND IN IA MENU LAST + SAID SHOULD BE IN ALPHA ORDER.

SHOW STRESS TESTING PAGE

8. *Could you now locate the Median Nerve – Motor Function section?*

FOUND NO PROBLEM IN IA MENU ON THE LEFT.

SHOW MEDIAN NERVE SCREEN

9. *On this Median Nerve page, is it clear which sections of this document are currently being displayed to you? As in, do you know where you are in the system?*
(See if they pick up on the highlights on the menus and the breadcrumbs)

- HIGHLIGHTED BIT IN IA MENU.
- SAW BREADCRUMBS. 2ND.

Paper Prototyping User Test

10. *Can you see anyway you could change the screen colours to a darke setting? (See if they can find the dark mode).*

YES – FOUND D.M INSTANTLY.

11. *Could you now navigate back to the homepage please? (See if they click the NHS logo or the breadcrumbs)*

- CLICKED 'HOME' IN BREADCRUMBS.
- 2ND WOULD TRY NHS BUT WAS UNSURE.
- WOULD CLICK HOME FIRST.

Thank you for completing those tests, could I now ask you to complete a quick questionnaire which won't take you longer than a few minutes.

GIVE QUESTIONNAIRE

Participant Name: _____ Date: 10/03/19.

System Usability Scale

Instructions: For each of the following statements, mark one box that best describes your reactions to the paper prototype application *today*

		Strongly Disagree				Strongly Agree	
1.	I think that I would like to use this application frequently.					✓	4
2.	I found this application unnecessarily complex.		✓				3
3.	I thought this application was easy to use.					✓	4
4.	I think that I would need assistance to be able to use this application.	✓					4
5.	I found the various functions in this application were well integrated.					✓	4
6.	I thought there was too much inconsistency in this application.		✓				3
7.	I would imagine that most people would learn to use this application very quickly.					✓	4
8.	I found this application very cumbersome/awkward to use.	✓					4
9.	I felt very confident using this application.				✓	✓	4
10.	I needed to learn a lot of things before I could get going with this application.	✓					4

38

Please provide any comments about this website:

SCORE
38 × 2.5
= 95

This questionnaire is based on the System Usability Scale (SUS), which was developed by John Brooke while working at Digital Equipment Corporation. © Digital Equipment Corporation, 1986.

C5.4 Test Participant Two Results

Details

Name	Test Participant 2
Demographic	25 - 35, in a relationship, no children.
Description from Personal Questions	Participant 2 is a first-aid trained, community carer from Newport, Pembrokeshire who is also studying Fashion at university. Participant 2 accesses the internet with a wide range of devices, mainly her laptop and smartphone. Participant 2 uses the Adobe suite for design work on her laptop at least 4 times a week.
Medical Sites Used	Participant 2 uses Google to search for medical conditions but is mainly looking for results provided by the NHS as she feels the advice is trustworthy. Quality of advice or guidelines is most important to her.
Question Answers	1. No problems with login. Thought screen was clear and simple. 2. Very understandable home page, liked the descriptions underneath the headings – instantly knew they were conveying information about the link. 3. Preferred first home page design. Thought second had too much going on and wasn't as clear. 4. Located Hand Injuries page with no problems though chose the link in the recently viewed items first as it 'stood out more'. 5. No problems, found immediately although stated she would have used search first. Questioned why it wasn't in alphabetical order. 6. Text is easy to read. 7. Struggled to find the page as was looking in the links on the page and not in the IA menu on the left. Again, suggested both sets of menus should be in alphabetical order.

	8. Located with no problem, used menu on the left. 9. Noticed location through the highlighted menu first then spotted the breadcrumbs. Had no problem identifying her location from either. 10. Located dark mode with no problem. 11. Used 'Home' in breadcrumbs first. 2nd choice was to use NHS logo as was unsure where that would take her.
SUS	Scored **95** on the system usability scale.

C5.5 Test Participant Three Script

Consent & Recording Release Form

Thank you for participating in our usability test.

I will be recording your session to allow Peter Davies of UWTSD to thoroughly analyse this session after it has been completed. Additionally, for marking purposes, lecturer's Dr Nicola Whitehead and Dr Kemi Ademoye may also view/listen to the recording as well as any external examiners marking this project/

Please read the statement below and sign where indicated.

I understand that my usability test session will be recorded. I grant the students/lecturers/examiners permission to use this recording, for the purpose of improving the application design.

I understand that participation in this usability study is voluntary and I agree to immediately raise any concerns or areas of discomfort during the session with the study administrator.

I understand that I am being asked to take part in this study because I have the required first aid or higher level of medical training.

Please sign below to indicate that you have read, and you understand the information on this form and that any questions you might have about the session have been answered.

Date: 11/03/2019

Please print your name: [redacted]

Please sign your name: D N

Thank you, I appreciate your participation.

r Prototyping User Test

2. Pre-test Interview

Before we start using the paper prototype of the application/website, I'd just like to ask you some simple background questions, if that's okay?

Personal questions

Name: [redacted]

Age: 19 – 25 / 26 – 35 / 36 – 45 / 46 – 55 / 56 – 65 / 66 – 75 / 75+

Occupation: EVENTS CO-ORDINATOR (FA TRAINED).

Where do you live?

MUMBLES, SWANSEA

How do you access the internet? Home? Work? Phone?

Do you own a laptop or desktop or tablet?

LAPTOP

WOULD YOU CONSIDER YOURSELF A HEAVY COMPUTER USER?

YES.

Do you use applications on your laptop/pc or tablet?

YES.

IF YES,

What sort of applications do you use?

MS OFFICE

PHOTOSHOP

DVD'S IN LAPTOP

System Usage

Please tell me about any websites you have used when looking for a medical diagnosis?

NHS WEBSITE
GP'S WEBSITE

What are the main websites you used to find medical information?

NHS.

~~Have you used lots of different sites to do this?~~ REPEAT Q.

Is there a site you prefer? Why?

NHS - RELIABLE, TRUSTWORTHY, CERTIFIED.

~~Describe the last time you searched a medical condition or ailment online?~~

Q'S TOO PERSONAL

~~What was the scenario?~~

What was most important when you searched for a diagnosis?

e.g. Speed of finding information, trustworthiness?

DEPARTMENTS - FINDING CONTACT DETAILS
ADDRESS / LOCATION OF CLINICS.

Paper Prototyping User Test

THE TASKS

For the purposes of the test, we'll assume the following:

You are a health professional trying to locate specific medical information in this paper prototype. First, you will need pretend to login using the login screen and navigate your way to a page I will specify in a moment. Do you understand?

1. *Could you please tell me how you would log in to this system?*

   NO PROBLEMS.

   What do you think of the login screen?

   SIMPLE YET EFFECTIVE.

SHOW HOME PAGE 1

2. *Look around this page for a few minutes. How do you feel about it?*

   A LOT OF INFO - MAKES IT EASY TO FIND INFO
   LIKES SIMPLICITY - WOULDN'T WANT PICTURES
   FONT COULD BE BIGGER (MAYBE ADJUSTABLE).

SHOW HOME PAGE 2

   INFO COULD COME OUT OF CONTAINER TO SPREAD IT OUT.

3. *Look around this page for a few minutes. How do you feel about it?*

FONT SEE BETTER. COLOURS BAD/CONFUSING (LOW RISK TO HIGH RISK ORGANISATION
COULD BE MORE SPACED OUT.
MORE INFO UNDER EACH HEADING.

4. *From the home page, could you navigate to the Hand Injuries section?*

   NO PROBLEMS.

er Prototyping User Test

SHOW BLANK PAGE WITH MENU.

5. *From this page, could you again navigate to the Hand Injuries section?*

YES, FOUND NO PROB BUT QUESTIONED IT BEING BY WRIST – TOO SIMILAR.

6. *How easy is the text on this page to read?*

EASY TO UNDERSTAND. FONT SHOULD BE BIGGER.

SHOW HAND INJURY PAGE

7. *From this Hand Injury Page, could you navigate to the stress testing section? (Note which menu they used Left or Right or Top menu if iPad)*

USED LEFT MENU INSTANTLY.
NO PROBLEMS. WAS WHERE EXPECTED.

SHOW STRESS TESTING PAGE

8. *Could you now locate the Median Nerve – Motor Function section?*

FOUND NO PROB BUT FONT TOO SMALL.

SHOW MEDIAN NERVE SCREEN

9. *On this Median Nerve page, is it clear which sections of this document are currently being displayed to you? As in, do you know where you are in the system?*
(See if they pick up on the highlights on the menus and the breadcrumbs)

YES, HIGHLIGHTING IS USEFUL + CAN STILL SEE OTHER GUIDELINES WHICH ARE STILL USEFUL
RIGHT HAND SIDE NOT NEEDED.

Paper Prototyping User Test

10. *Can you see anyway you could change the screen colours to a darker setting? (See if they can find the dark mode).*

FOUND NO PROBLEM.

11. *Could you now navigate back to the homepage please? (See if they click the NHS logo or the breadcrumbs)*

- CLICKED ON HAND INJURIES
~~OR CHOOSE~~ THEN CHOSE BACK BUTTON.
- FINALLY CHOSE HOME IN BREAD CRUMBS.
- DIDN'T CHOOSE NHS LOGO EVEN WHEN PROMPTED.

Thank you for completing those tests, could I now ask you to complete a quick questionnaire which won't take you longer than a few minutes.

GIVE QUESTIIONNAIRE

Participant Name: _____ Date: 11/03/19.

System Usability Scale

Instructions: For each of the following statements, mark one box that best describes your reactions to the paper prototype application *today*

		Strongly Disagree				Strongly Agree	
1.	I think that I would like to use this application frequently.					✓	4
2.	I found this application unnecessarily complex.		✓				3
3.	I thought this application was easy to use.				✓		3
4.	I think that I would need assistance to be able to use this application.	✓					4
5.	I found the various functions in this application were well integrated.					✓	4
6.	I thought there was too much inconsistency in this application.		✓				3
7.	I would imagine that most people would learn to use this application very quickly.				✓		3
8.	I found this application very cumbersome/awkward to use.	✓					4
9.	I felt very confident using this application.					✓	4
10.	I needed to learn a lot of things before I could get going with this application.		✓				3

35

Please provide any comments about this website:

SCORE

35 x 2.5

= 87.5

This questionnaire is based on the System Usability Scale (SUS), which was developed by John Brooke while working at Digital Equipment Corporation. © Digital Equipment Corporation, 1986.

C5.6 Test Participant Three Results

Details

Name	Test Participant 3
Demographic	25 - 35, single, no children.
Description from Personal Questions	Participant 3 is a first-aid trained events co-ordinator from Mumbles, Swansea. Participant 3 accesses the internet through her laptop or smartphone and considers herself a heavy computer user. Participant 3 mainly uses MS office, photoshop and other productivity applications.
Medical Sites Used	Participant 3 uses the NHS websites as well as her GP's website as they are certified and trustworthy. Davina is mainly looking for contact details of certain clinics/hospitals.
Question Answers	1. No problems with login. Thought screen was simple yet effective. 2. A lot of information regarding the headings makes it easy to find information. Liked the simplicity and stated she wouldn't want any pictures, but the font could be bigger, maybe adjustable. Suggested the text could come out of the container to spread width of screen and organising in order of risk. 3. Thought font size was better, but the colours were confusing. Thought it was harder to find information with the lack of labelling. 4. Located Hand Injuries page with no problems, chose link in the IA menu. 5. No problems, found immediately although questioned why it was so close to wrist injuries – could be confusing. 6. Text is easy to read although font should be bigger. 7. Found instantly through the IA menu, everything was where she expected.

	8. Located with no problem, font too small. 9. Noticed location through the highlighted menu, didn't notice breadcrumbs. Stated menu on the right is useless. 10. Located dark mode with no problem. 11. Clicked 'Hand Injuries' link first to get back to where she started then chose the browsers 'back' button. 3rd choice was breadcrumbs. Did not think to choose NHS logo, even when pressed to.
SUS	Scored **87.5** on the system usability scale.

D. Implementation

D1. Timebox One Questions & Answers

D1.2 Questions

Questions from development of timebox one.

1. *Will the Priority column allow for new data to be entered?*

   As data is ordered by priority in each table, as well as in the *Guideline Heading* table (which the above results are ordered by), will this allow for new data to be entered without having to re-order every priority single record in each table if, for example, a new guideline needed to be inserted in-between another?

2. *The Priority column may need to be implemented for each page, rather than the whole document?*

   Although ordering by the priority column in the *Guideline Heading* table has proved to return results in the right order, it may be more suitable to order each property (guidelines and images) independently of the page they are displayed.

3. *Images may need their own heading to avoid being repeated?*

   As shown in the above example, the two images are displayed under a new heading, as currently each image being returned has the additional guideline attached to the related heading. This is because they both share the same *Guideline Heading* ID (*GlhID*).

4. *Each heading is being returned with every guideline or image.*

   As every guideline or image has a heading associated with it, this means the current query returns a heading with every guideline or image in the database, which would result in the heading being repeated multiple times.

D1.2 Answers

Timebox one presented questions about the design, which research has answered:

1. *Will the Priority column allow for new data to be entered?*

   The use of an SQL transaction to update the database can be used to insert data into any position in the table and update the priority column in any records after it.

2. *The Priority column may need to be implemented for each page, rather than the whole document?*

   To be able to correctly order ever item in the database, the current design works well and given that the priority column is a simple INT datatype holding a small amount of data, performance is not affected.

3. *Images may need their own heading to avoid being repeated and each heading is being returned with every guideline or image.*

   The answer to questions 3 & 4 is answered by the same solution: a front-end framework such as Angular, Vue or React all contain built filter components which allow for limiting of displayed results.

D2. Acceptance Test Design

Date	***Product Name***
	MIU Clinical Decision Support System API
Version No.	***Created By***
1.0	

i. Scope

-

ii. Resources

Test Participants: Project Manager

Operating System: Windows 7 / 8 / 10 | OsX 10.10 / 10.11 / 10.12 / 10.13 / 10.14

Browser Used: Chrome / Edge / Firefox / Internet Explorer / Opera

Comments:

iii. Roles / Names

Role	***Name***
Tester	

iv. Tests

1.	**10.**
2.	1.

vi. Expected Results/Results

Test	***Expected Result***	***Pass/Fail***
1.	1.	1.
2.	1.	1.

vii. Comments

Test	***Comments***
1.	
2.	

D3. Timebox Two Acceptance Test Results

Date	*Product Name*
	MIU Clinical Decision Support System
Version No.	*Created By*
1.0	Peter Davies (Project Manager)

i. Scope

- Displaying Throat guidelines on laptop / desktop / tablet.
- Following in text links to other pages.
- Accordion menu working.
- Dynamic page location indicator working.

ii. Resources

Test Participants:

Operating System: Windows 7 / 8 / 10 | OsX 10.10 / 10.11 / 10.12 / 10.13 / 10.14

Browser Used: Chrome / Edge / Firefox / Internet Explorer / Opera

Comments:

iii. Roles / Names

Role	*Name*
Tester	Peter Davies (Project Manager)
Test Participant One	TEST PARTICIPANT ONE.

iv. Tests

1.	1. Open the Throat guidelines page. 2. Return to home page using the NHS logo. 3. Open the Throat guidelines page. 4. Return to home using the breadcrumb 'Home' link. 5. Open the Throat guidelines page.
2.	1. Visit Throat guideline page. 2. Follow ENT department link from in text links. 3. Open Throat guidelines page. 4. Find Throat guidelines in accordion menu. 5. Navigate to Glandular Fever section in document from accordion. 6. Navigate back to Anatomy section from right hand menu.

vi. Expected Results/Results

Test	*Expected Result*	*Pass/Fail*
1.	1. Throat guideline page appears. 2. Home page appears. 3. Throat page appears.	1. PASS 2. PASS 3. PASS

	5. Home page appears. 6. Throat guideline page appears.	4. PASS 5. PASS
2.	1. Throat guideline page appears. 2. Coming soon information page appears. 3. Throat guidelines page appears. 4. Accordion menu opens as expected. 5. Page scrolls to Glandular Fever section. 6. Auto scrolls to Anatomy section & highlights.	1. PASS 2. PASS 3. PASS 4. PASS 5. PASS 6. PASS

vii. Comments

Test	*Comments*
1.	ALL TESTS PASSED ON CHROME BROWSER. – SUGGEST TRYING DIFF BROWSER.
2.	

D4. Timebox Two Usability Test Script

Paper Prototyping User Test

2. Pre-test Interview

Before we start using the paper prototype of the application/website, I'd just like to ask you some simple background questions, if that's okay?

Personal questions

Name:

Age: 19 – 25 / 26 – 35 / 36 – 45 / 46 – 55 / 56 – 65 / 66 – 75 / 75+

Occupation:

Where do you live?

How do you access the internet? Home? Work? Phone?

Do you own a laptop or desktop or tablet?

Do you consider yourself a heavy computer user?

Do you use applications on your laptop/pc or tablet?

What sort of applications do you use?

Paper Prototyping User Test

System Usage

Please tell me about any websites you have used when looking for a medical diagnosis?

What are the main websites you used to find medical information?

Is there a site you prefer? Why?

What was most important when you searched for a diagnosis?
e.g. Speed of finding information, trustworthiness?

Paper Prototyping User Test

THE TASKS

For the purposes of the test, we'll assume the following:

You are a health professional trying to locate specific medical information in this paper prototype. First, you will need pretend to login using the login screen and navigate your way to a page I will specify in a moment. Do you understand?

1. *Could you please tell me how you would log in to this system?*

   What do you think of the login screen?

2. *Look around this page for a few minutes. How do you feel about it?*

3. *Look around this page for a few minutes. How do you feel about it?*

4. *Using the mouse, hover over the links. What do you think of the design features?*

5. *Does the design feel familiar at all?*

6. *Now, on this Throat Condition page, explore it for a minute and tell me how you feel about it?*

7. *If not picked up left-hand menu – ask about them*

8. *If not picked up on right-hand menu – ask about it.*

9. *Although you are already on this page, using the menu on the left, could you find the Throat Conditions Injury page again?*

10. *How easy is the text on this page to read?*

11. *Do you have any other comments regarding the body content on this page? It's layout and style?*

12. *Does the layout on this page feel familiar at all?*

13. *Scroll to the top of the page, from here could you quickly locate the Glandular Fever section of the page without scrolling down?*

14. *Now you have found it, is it clear where you are on this page?*

15. *In the Glandular fever section, can you see a way you could navigate to the A&E departments contact details?*

16. *Could you now navigate back to the homepage please? (See if they click the NHS logo or the breadcrumbs)*

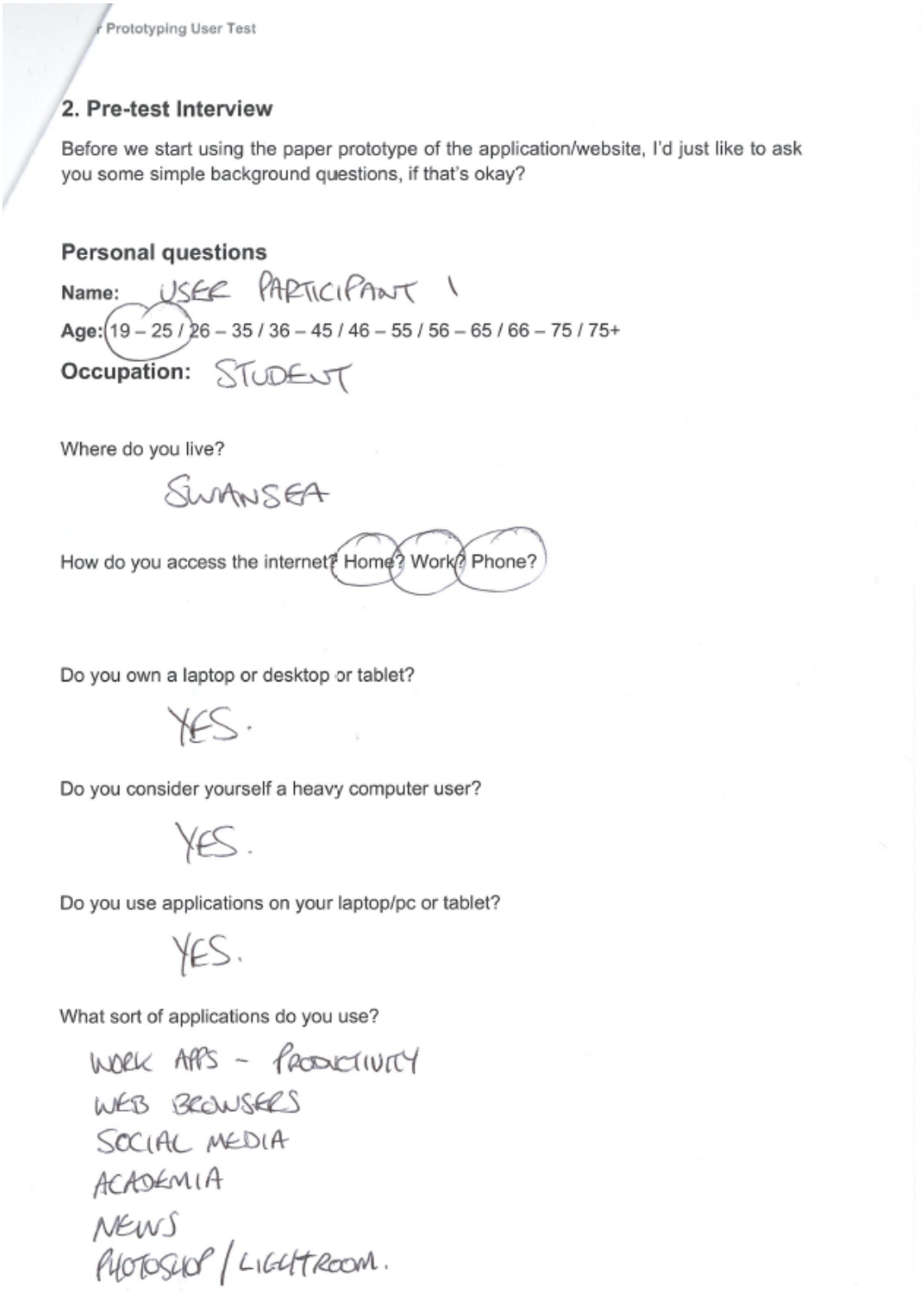
17. *Finally, could you please logout of the system?*

Thank you for completing those tests, could I now ask you to complete a quick questionnaire which won't take you longer than a few minutes.

GIVE SUS QUESTIONNAIRE

D5. Timebox Two Usability Test Script & Results

D5.1 Test Participant One Script



r Prototyping User Test

2. Pre-test Interview

Before we start using the paper prototype of the application/website, I'd just like to ask you some simple background questions, if that's okay?

Personal questions

Name: USER PARTICIPANT 1

Age: 19 – 25 / 26 – 35 / 36 – 45 / 46 – 55 / 56 – 65 / 66 – 75 / 75+

Occupation: STUDENT

Where do you live?

SWANSEA

How do you access the internet? Home? Work? Phone?

Do you own a laptop or desktop or tablet?

YES.

Do you consider yourself a heavy computer user?

YES.

Do you use applications on your laptop/pc or tablet?

YES.

What sort of applications do you use?

WORK APPS - PRODUCTIVITY
WEB BROWSERS
SOCIAL MEDIA
ACADEMIA
NEWS
PHOTOSHOP / LIGHTROOM.

Paper Prototyping User Test

System Usage

Please tell me about any websites you have used when looking for a medical diagnosis?

NONE - TEND TO GO GP.

What are the main websites you used to find medical information?

N/A

Is there a site you prefer? Why?

N/A

What was most important when you searched for a diagnosis?

e.g. Speed of finding information, trustworthiness?

TRUSTWORTHINESS - NOT FUSSED ON SPEED.

ACCURACY OVER SPEED.

THE TASKS

For the purposes of the test, we'll assume the following:

You are a health professional trying to locate specific medical information in this paper prototype. First, you will need pretend to login using the login screen and navigate your way to a page I will specify in a moment. Do you understand?

1. *Could you please tell me how you would log in to this system?*
   CLEAR HOW TO DO IT

   What do you think of the login screen?
   PERFECTLY USABLE - FITS PURPOSE.
   CLEAR.

2. *Look around this page for a few minutes. How do you feel about it?*
   - LOTS OF GUIDELINES.
   - LIKED SUB LABELS.
   - LIKED RECENT VIEWS.
   - COLOURS ARE GOOD - LIKES HOVER.

3. ~~*Look around this page for a few minutes. How do you feel about it?*~~
   - TEXT IS GOOD SIZE.
   - DESIGN IS GOOD.

4. *Using the mouse, hover over the links. What do you think of the design features?*
   LIKED IT. GAVE GOOD FEEDBACK.

5. *Does the design feel familiar at all?*
   YES - GRID LAYOUT FAMILIAR + RECENTS + SEARCH.

5A. COULD YOU PLEASE NAVIGATE TO THROAT CONDITIONS?
FOUND NO PROBLEMS - FAST, LARGE TEXT, PERFECTLY USABLE.

er Prototyping User Test

6. *Now, on this Throat Condition page, explore it for a minute and tell me how you feel about it?* LIKED COLOUR SCHEME.
   CLEAR, NICE FONT, EASY TO READ.
   HIGHLIGHTED SECTION OF PAGE GOOD
7. *If not picked up left-hand menu – ask about them*
   – NOTICED THAT HE COULD OF PICKED ANY GL' ON HOME PAGE AND THEN USED LEFT MENU.
8. *If not picked up on right-hand menu – ask about it.*
   – LIKED THIS FEATURE.
9. *Although you are already on this page, using the menu on the left, could you find the Throat Conditions Injury page again?*
   – YES NO PROB
   – LIKED THE SECTIONS BEING AVAILABLE IN SUB MENU AS WELL
   – VERY CLEAR.
10. *How easy is the text on this page to read?*
    CLEAR
    BULLET POINT TEXT A LITTLE SMALL NEXT TO BIG HEADINGS
11. *Do you have any other comments regarding the body content on this page? It's layout and style?*
    – ON BIGGER SCREEN SHOULD ~~BE~~ HAVE BIGGER TEXT
    – A LOT OF WHITESPACE SEEMS A WASTE.
    – ALTHOUGH EASY TO USE STILL.
12. *Does the layout on this page feel familiar at all?*
    YES – PAGE SECTIONS + MENU ON LEFT
    VERY FAMILAR
    HAS SEEN DESIGN A LOT ON WEB
    – PINPOINTED MS USING RIGHT-HAND MENU.

13. *Scroll to the top of the page, from here could you quickly locate the Glandular Fever section of the page without scrolling down?*

- YES, USED RIGHT HAND MENU. ✓
  R CHOSE IT BECAUSE IT WAS QUICKER THAN USING LEFT MAN MENU.

14. *Now you have found it, is it clear where you are on this page?*

YES - HEADING IS CLEAR AND BLUE TAB IS GOOD INDICATOR.

15. *In the Glandular fever section, can you see a way you could navigate to the A&E departments contact details?*

- FOUND LINK BUT SHOULD BE UNDERLINED SEE EG EVEN WHEN NOT ON HOVER.
- HIGHLIGHTING WAS GOOD.

16. *Could you now navigate back to the homepage please? (See if they click the NHS logo or the breadcrumbs)*

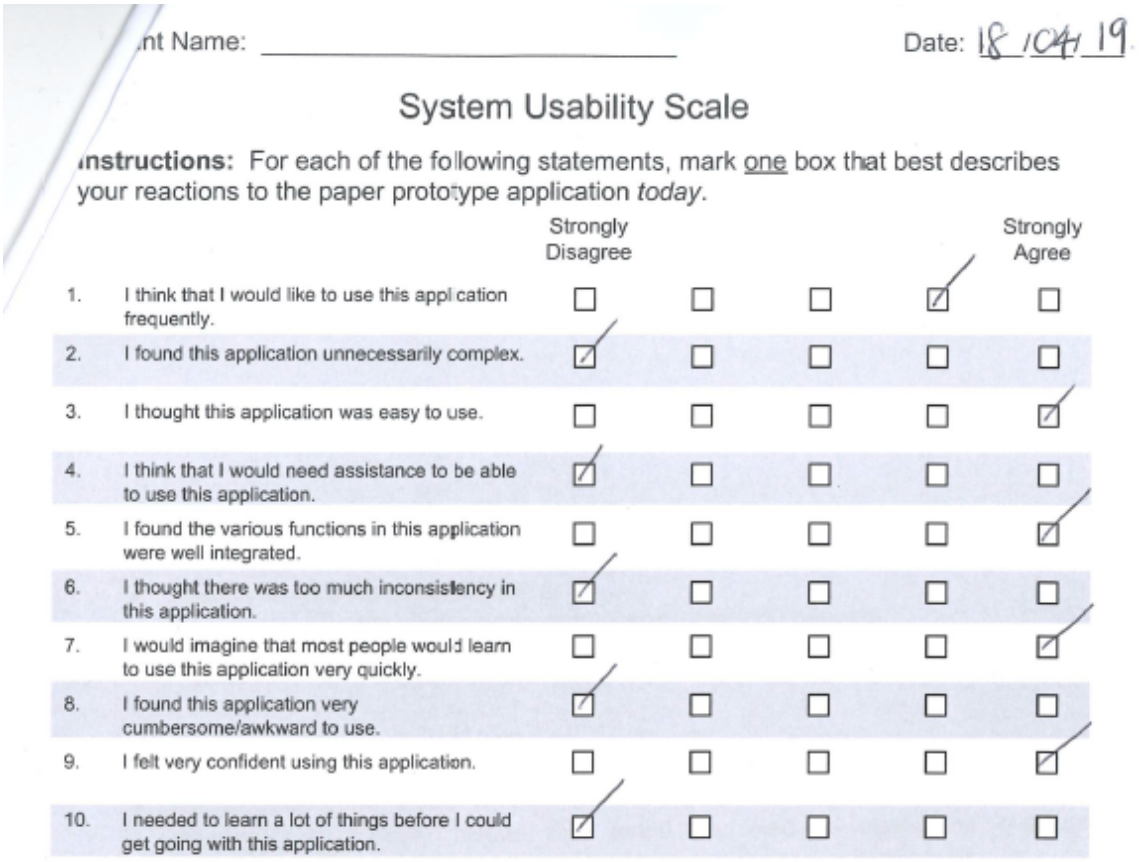
- USED BREADCRUMBS, NO PROBLEMS.

17. *Finally, could you please logout of the system?*

YES - NO PROBLEM, SAW THIS BUTTON AT THE BEGINNING.

Thank you for completing those tests, could I now ask you to complete a quick questionnaire which won't take you longer than a few minutes.

GIVE SUS QUESTIONNAIRE



nt Name: _____ Date: 18/04/19

System Usability Scale

nstructions: For each of the following statements, mark one box that best describes your reactions to the paper prototype application *today*.

		Strongly Disagree				Strongly Agree
1.	I think that I would like to use this application frequently.	☐	☐	☐	☑	☐
2.	I found this application unnecessarily complex.	☑	☐	☐	☐	☐
3.	I thought this application was easy to use.	☐	☐	☐	☐	☑
4.	I think that I would need assistance to be able to use this application.	☑	☐	☐	☐	☐
5.	I found the various functions in this application were well integrated.	☐	☐	☐	☐	☑
6.	I thought there was too much inconsistency in this application.	☑	☐	☐	☐	☐
7.	I would imagine that most people would learn to use this application very quickly.	☐	☐	☐	☐	☑
8.	I found this application very cumbersome/awkward to use.	☑	☐	☐	☐	☐
9.	I felt very confident using this application.	☐	☐	☐	☐	☑
10.	I needed to learn a lot of things before I could get going with this application.	☑	☐	☐	☐	☐

Please provide any comments about this website:

D5.2 Test Participant One Results

Details

Name	Test Participant 1
Demographic	19 - 25, single, no children.
Description from Personal Questions	Participant 1 is a non-first aid trained student from Exeter, living in Swansea. He uses a range of devices to access the internet and considers himself a heavy, computer literate, user who uses a wide range of applications on all platforms.
Medical Sites Used	Participant 1 does not use the internet to search for medical diagnoses, instead prefers to use GP directly. However, if they did, trustworthiness would be a key factor in their choice of application used.
Question Answers	1. No problems with login, very clear and simple to use. 2. Liked all aspects of the home page, very clear and concise. Descriptions under main links. 3. Liked the hover features and visited links changing colour. 4. Located Hand Injuries page with no problem in 2 seconds. 5. Found grid layout very familiar. 5A. Found Throat guidelines with no problems. Commented that text was good size and clear font. 6. Liked the colour scheme, font easy to read. Highlighting what section was in view a good idea. 7. Commented that no matter what menu he chose on the home page he could still choose again from accordion menu – a good feature if a guideline was chosen by mistake. 8. Right-hand menu/section indicator a good idea.

	10. Located Throat guideline in accordion no problem. Like the different sections of each guideline being available under the main heading. 11. Commented that bullet points were too small, and text should maybe be larger or in bold. A lot of unused space on main body content. 12. Found layout very familiar, commented he has seen it used a lot on other websites. Recognised right-hand menu from Microsoft's website. 13. Used right-hand menu. Chose because it was a quicker route to access the correct section. 14. Headings were clear and bold and blue tab indicated exactly where he was in the document. 15. Found in-text link but commented it should be always underlined. 16. Used breadcrumb home button link. 17. Instantly went to top right-hand corner to log-out.
SUS	Scored **97.5** on the system usability scale.

D5.3 Test Participant Two Script

r Prototyping User Test

2. Pre-test Interview

Before we start using the paper prototype of the application/website, I'd just like to ask you some simple background questions, if that's okay?

Personal questions

Name: USER PARTICIPANT TWO.

Age: 19 – 25 / 26 – 35 / 36 – 45 / 46 – 55 / 56 – 65 / 66 – 75 / 75+

Occupation: CARER. (COMMUNITY).

Where do you live?

NEWPORT, PEMBS.

How do you access the internet? Home? Work? Phone?

Do you own a laptop or desktop or tablet?

LAPTOP.

Do you consider yourself a heavy computer user?

MODERATE.

Do you use applications on your laptop/pc or tablet?

YES.

What sort of applications do you use?

ADOBE, PHOTOSHOP, ILLUSTRATOR/INDESIGN.

WEB BROWSERS

WORD.

Paper Prototyping User Test

System Usage

Please tell me about any websites you have used when looking for a medical diagnosis?

NHS WALES.
WEBMD.

What are the main websites you used to find medical information?

AS ABOVE.

Is there a site you prefer? Why?

NHS – TRUST.

What was most important when you searched for a diagnosis?

e.g. Speed of finding information, trustworthiness?

TRUST. QUALITY OF INFO.

THE TASKS

For the purposes of the test, we'll assume the following:

You are a health professional trying to locate specific medical information in this ~~paper prototype~~ system. First, you will need pretend to login using the login screen and navigate your way to a page I will specify in a moment. Do you understand?

1. *Could you please tell me how you would log in to this system?*

   TYPE USERNAME + PASSWORD

   What do you think of the login screen?

   VERY SIMPLE, CLEAR. NO CHANGES NEEDED.

2. *Look around this page for a few minutes. How do you feel about it?*

   - FOOTER IS FIXED - CONTENT ISN'T VISIBLE.
   - ALPHABETICAL ORDER IN COLUMNS NOT ROWS.
   - HIGHLIGHT ON HOVER IS NICE

~~3. *Look around this page for a few minutes. How do you feel about it?*~~

   - EXTRA CATORGORISATION LABELS ARE NICE.

4. *Using the mouse, hover over the links. What do you think of the design features?*

   - GOOD.

5. *Does the design feel familiar at all?*

   - FEELS LIKE NHS!

5A. COULD YOU PLEASE NAVIGATE TO THROAT CONDITIONS PAGE?

- FINDING IT DIFFICULT BECAUSE OF ORDER.
- NEED TO CHANGE THAT.

er Prototyping User Test

6. Now, on this Throat Condition page, explore it for a minute and tell me how you feel about it?
   - RIGHT HAND MENU SHOULD MAKE <LI> AS THE CLICKABLE LINK NOT JUST THE <A>
   - IF YOU'RE GOING TO HIGHLIGHT THEN IT SHOULD BE CLICKABLE.
7. If not picked up left-hand menu – ask about them
   - CUTTING OFF BOTTOM
   - MINOR CHEST INJURIES NOT ALPHABETICAL
   - AGAIN, WHOLE CONTAINER SHOULD BE CLICKABLE.
8. If not picked up on right-hand menu – ask about it.
   - SHOULD BE ALPHABETICAL.

9. Although you are already on this page, using the menu on the left, could you find the Throat Conditions Injury page again?
   - NO PROBS, BUT WHEN CLICKED THE MENU POSITION DID NOT MOVE, SHOULD MOVE WHEN MENU IS EXPANDED.
   - SHOULD BE ALPHABETICAL.
10. How easy is the text on this page to read?
    - VERY EASY.
    - MAIN BODY TEXT SHOULD BE BOLDER OR BIGGER.
    - DOESN'T ALLOW FOR GU'S UNDER THROAT TO BE SEEN. MARGINS?
11. Do you have any other comments regarding the body content on this page? It's layout and style?
    - JUST BOLDER WRITING, MENU ON LEFT IS GOOD + CLEAR BUT BODY TEXT IS TOO HARD TO READ.
12. Does the layout on this page feel familiar at all?
    YES - LIKE FACEBOOK.
    \ SEE COMMENTS.

Paper Prototyping User Test

13. *Scroll to the top of the page, from here could you quickly locate the Glandular Fever section of the page without scrolling down?*

- YES, BUT NEEDS WHOLE <LI> TO BE CLICKABLE - DID NOT CLICK ON LINK, ONLY CONTAINER.

14. *Now you have found it, is it clear where you are on this page?*

YES - BECAUSE G.F WAS THE HEADING, ALTHOUGH THE THROAT TABLE CAUGHT EYE.

RIGHT HAND MENU IS GOOD.

15. *In the Glandular fever section, can you see a way you could navigate to the A&E departments contact details?*

YES - HIGHLIGHTED BUT NEEDS TO STAND OUT MORE. - MAYBE UNDERLINED? WOULD BE MORE FAMILIAR.
- MAYBE BOLDER.

16. *Could you now navigate back to the homepage please? (See if they click the NHS logo or the breadcrumbs)*

USED NHS, THE HIGHLIGHTING WAS INDICATIVE

17. *Finally, could you please logout of the system?*

FOUND LOG-IN N.P. - LIKE FACEBOOK.

* LOG-IN ALSO LOOK LIKE FACEBOOK.

Thank you for completing those tests, could I now ask you to complete a quick questionnaire which won't take you longer than a few minutes.

GIVE SUS QUESTIONNAIRE

nt Name: _____ Date: 18/04/19

System Usability Scale

Instructions: For each of the following statements, mark one box that best describes your reactions to the paper prototype application *today*.

		Strongly Disagree				Strongly Agree
1.	I think that I would like to use this application frequently.	☐	☐	☐	☐	☑
2.	I found this application unnecessarily complex.	☑	☐	☐	☐	☐
3.	I thought this application was easy to use.	☐	☐	☐	☐	☑
4.	I think that I would need assistance to be able to use this application.	☑	☐	☐	☐	☐
5.	I found the various functions in this application were well integrated.	☐	☐	☐	☐	☑
6.	I thought there was too much inconsistency in this application.	☑	☐	☐	☐	☐
7.	I would imagine that most people would learn to use this application very quickly.	☐	☐	☐	☐	☑
8.	I found this application very cumbersome/awkward to use.	☑	☐	☐	☐	☐
9.	I felt very confident using this application.	☐	☐	☐	☐	☑
10.	I needed to learn a lot of things before I could get going with this application.	☑	☐	☐	☐	☐

Please provide any comments about this website:

- On the main menu, type was not big enough compaired to side bar menu's.
- alphabetical order in everything is a must, but has to be vertical – not horizontal.
- On a highlighted box – be able to click the box – not just the wrighting.

This questionnaire is based on the System Usability Scale (SUS), which was developed by John Brooke while working at Digital Equipment Corporation. © Digital Equipment Corporation, 1986.

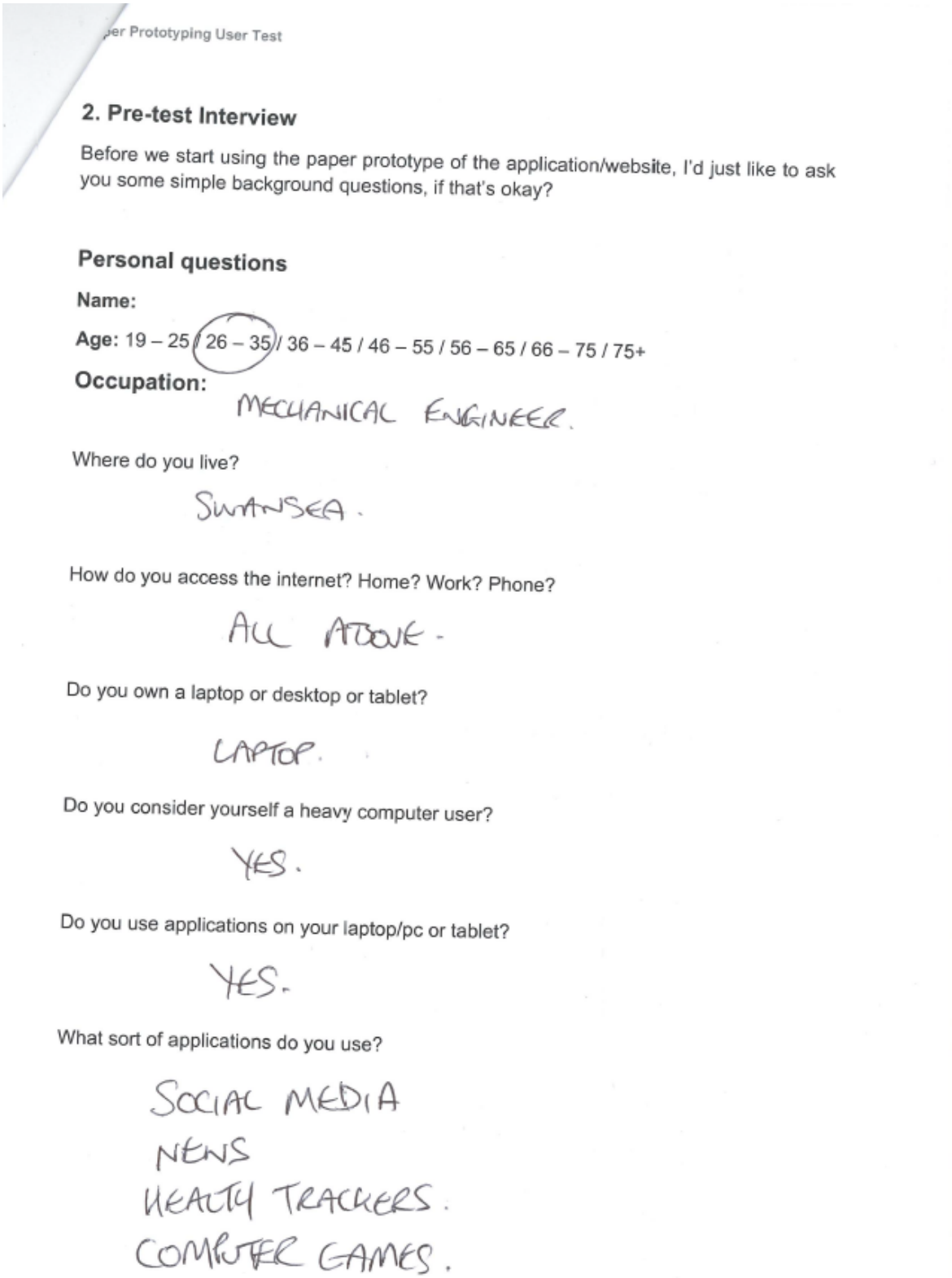
D5.4 Test Participant Two Results

Details

Name	Test Participant 2
Demographic	26 - 35, in a relationship, no children.
Description from Personal Questions	Participant is a first-aid trained, community carer from Newport, Pembrokeshire. Participant 2 accesses the internet with a wide range of devices, mainly her laptop and smartphone. Participant 2 uses the Adobe suite for design work on her laptop at least 4 times a week.
Medical Sites Used	Participant 2 uses NHS Wales and WebMD to search for medical conditions but is mainly looking for results provided by the NHS as she feels the advice is trustworthy. Quality of advice or guidelines is most important to her.
Question Answers	1. No problems with login, very clear and simple to use. 2. Discovered that the footer was cutting off content. Felt that alphabetical ordering of guidelines should be top to bottom, not left to right. Highlight on hover is a good feature along with descriptions of each section. 3. Liked the hover features and visited links changing colour. 4. Good. 5. Found grid layout very familiar – commented that it looks exactly like other NHS websites. 5A. Found Throat guidelines more difficult to locate because of alphabetical ordering but found within acceptable time. 6. Links on the right-hand menu should be accessible through the whole highlighted container, not just the text.

	7. The accordion menu cuts of the bottom of the page, possibly due to footer. Minor chest injuries are not in correct order. Whole link container should be clickable, not just the text. 8. Right-hand menu/section good but should be alphabetical. 9. No problems located but commented that as accordion opens it should scroll down the page to accommodate it rather than user having to scroll. Also, should be alphabetical. 10. Heading very clear but body text should be bigger. 11. Body text is too small. 12. Commented that layout looks like Facebook. 13. Used right-hand menu, no problems apart from link containers previously mentioned. 14. Yes – because the heading instantly came to focus at top of the page. 15. Found in-text link but commented it should stand out more. 16. Used NHS logo to navigate home, liked the highlighting as it looked 'clickable'. 17. Instantly went to top right-hand corner to log-out, like Facebook!
SUS	Scored **100** on the system usability scale.

D5.5 Test Participant Three Script



per Prototyping User Test

2. Pre-test Interview

Before we start using the paper prototype of the application/website, I'd just like to ask you some simple background questions, if that's okay?

Personal questions

Name:

Age: 19 – 25 / 26 – 35 / 36 – 45 / 46 – 55 / 56 – 65 / 66 – 75 / 75+

Occupation: MECHANICAL ENGINEER.

Where do you live?

SWANSEA.

How do you access the internet? Home? Work? Phone?

ALL ABOVE.

Do you own a laptop or desktop or tablet?

LAPTOP.

Do you consider yourself a heavy computer user?

YES.

Do you use applications on your laptop/pc or tablet?

YES.

What sort of applications do you use?

SOCIAL MEDIA
NEWS
HEALTH TRACKERS.
COMPUTER GAMES.

System Usage

Please tell me about any websites you have used when looking for a medical diagnosis?

NCMH. GOOGLE.
NHS DIRECT

What are the main websites you used to find medical information?

NCMH – PUBMED
NHS DIRECT.

Is there a site you prefer? Why?

NHS DIRECT – SIMPLER, NOT AS ACADEMIC
MORE USER FRIENDLY

What was most important when you searched for a diagnosis?

e.g. Speed of finding information, trustworthiness?

CLEAR SYMPTOM ADVICE
EASY ACCESS + CLEAR TO READ ADVICE.

THE TASKS

For the purposes of the test, we'll assume the following:

You are a health professional trying to locate specific medical information in this paper prototype. First, you will need pretend to login using the login screen and navigate your way to a page I will specify in a moment. Do you understand?

1. *Could you please tell me how you would log in to this system?*

USERNAME + PWORD
+ CLICK LOG-IN

What do you think of the login screen?

AS IT SHOULD BE - SIMPLE
ALL YOU NEED BUT WHERE IS
FORGOT LOGINS.

2. ~~*Look around this page for a few minutes. How do you feel about it?*~~

2. PLEASE NOW LOGIN USING LOG-IN BUTTON.

3. *Look around this page for a few minutes. How do you feel about it?*

- FOOTER IS CUTTING OFF CONTENT.
- ALPHABET ORDER - MINOR HEAD INJURIES IN WRONG PLACE. REMOVE MINOR.
- ALPHABET IS RIGHT ~~ORDER~~ WAY - LEFT TO RIGHT
- AS EXPECTED, NICE + CLEAR

4. *Using the mouse, hover over the links. What do you think of the design features?*

LIKES DESCRIPTIONS UNDER LINKS.
- LIKES HOVER ALTHOUGH SHOULD BE BIGGER HIGHLIGHTS.
- QUESTIONED VISITED LINKS - ALL WILL BE PURPLE UNLESS CACHE CLEARED.

5. *Does the design feel familiar at all?*

YES - FORD INTRANET (MAXIMO - IT).
WAS SEEN BEFORE BUT CAN'T REMEMBER.

5A. COULD YOU PLEASE NAVIGATE TO THROAT CONDITIONS PAGE?

NO PROBS - BUT WAS 'VISITED' LINK SO HIGHLIGHTED!

per Prototyping User Test

6. *Now, on this Throat Condition page, explore it for a minute and tell me how you feel about it?*

SECTIONS SHOULD BE MORE DEFINED. MAYBE LINE BREAKS OTHERWISE NICE.

7. *If not picked up left-hand menu – ask about them*

MENU GOOD, VERY NICE.

8. *If not picked up on right-hand menu – ask about it.*

- PERFECT - REALLY LIKED IT, SIMPLE + ALLOWS QUICK ACCESS TO SECTIONS.
- SHOULD BE ALPHABETICAL ORDER?

9. *Although you are already on this page, using the menu on the left, could you find the Throat Conditions Injury page again?*

YES - NO PROBLEM

10. *How easy is the text on this page to read?*

AS IT SHOULD BE - GOOD SIZE.
PERFECT.

11. *Do you have any other comments regarding the body content on this page? It's layout and style?*

AS ABOVE.

12. *Does the layout on this page feel familiar at all?*

NO, BUT COMMENTED THAT BTS ARE FAMILIAR TO OTHER SITES BUT CAN'T RECALL NAMES.

Paper Prototyping User Test

13. *Scroll to the top of the page, from here could you quickly locate the Glandular Fever section of the page without scrolling down?*

USED RIGHT MENU, FOUND INSTANTLY.

14. *Now you have found it, is it clear where you are on this page?*

YES - TITLE AND TAB INDICATOR GIVING INDICATORS.

15. *In the Glandular fever section, can you see a way you could navigate to the A&E departments contact details?*

YES - FOUND N.P - INSTANTLY RECOGNISED AS A LINK AS BLUE IN COLOUR BUT SHOULD BE UNDERLINED.

16. *Could you now navigate back to the homepage please? (See if they click the NHS logo or the breadcrumbs)*

USED LOGO - FOUND NO PROBLEM.

17. *Finally, could you please logout of the system?*

FOUND NO PROBLEM - TOP RIGHT CORNER WITH OUT EVEN LOOKING AT PAGE - KNEW IT WOULD BE THERE.
LIKED THE DARKER HIGHLIGHT ON HOVER.

Thank you for completing those tests, could I now ask you to complete a quick questionnaire which won't take you longer than a few minutes.

GIVE SUS QUESTIONNAIRE

nt Name: _____ Date: ___/___/___

System Usability Scale

Instructions: For each of the following statements, mark one box that best describes your reactions to the paper prototype application *today*.

		Strongly Disagree				Strongly Agree
1.	I think that I would like to use this application frequently.	☐	☐	☐	☑	☐
2.	I found this application unnecessarily complex.	☑	☐	☐	☐	☐
3.	I thought this application was easy to use.	☐	☐	☐	☐	☑
4.	I think that I would need assistance to be able to use this application.	☑	☐	☐	☐	☐
5.	I found the various functions in this application were well integrated.	☐	☐	☐	☑	☐
6.	I thought there was too much inconsistency in this application.	☑	☐	☐	☐	☐
7.	I would imagine that most people would learn to use this application very quickly.	☐	☐	☑	☐	☐
8.	I found this application very cumbersome/awkward to use.	☑	☐	☐	☐	☐
9.	I felt very confident using this application.	☐	☐	☐	☐	☑
10.	I needed to learn a lot of things before I could get going with this application.	☑	☐	☐	☐	☐

Please provide any comments about this website:

This questionnaire is based on the System Usability Scale (SUS), which was developed by John Brooke while working at Digital Equipment Corporation. © Digital Equipment Corporation, 1986.

D5.6 Test Participant Three Results

Details

Name	Test Participant 3
Demographic	25 - 35, in a relationship, no children.
Description from Personal Questions	Participant 3 is a first-aid trained mechanical engineer, from Swansea who access the internet through a range of devices. He is a competent, heavy computer user who uses a wide range of applications.
Medical Sites Used	Uses NHS Direct and PubMed (NCMH) for medical information but prefers NHS direct as he feels it can be trusted and isn't as academic. He felt simple and clear advice was most important with easy access also a factor.
Question Answers	1. No problems with logins. 2. Simple page, exactly what is needed, no clutter. 3. Also noticed footer is cutting off content. Minor Head Injuries in wrong place, thought alphabetical ordering was correct left to right. Nice and clear page overall. 4. Highlight on hover should be bigger – increase padding? Questioned usefulness of visited links if browser cache isn't cleared all will be purple after a while! 5. Has seen design before but couldn't recall where. Felt very familiar. 5A. No problems in locating Throat guidelines. 6. Commented that sections were not clearly defined – maybe line breaks? 7. Thought left-hand menu was very good. 8. Liked right-hand menu but also commented it should be alphabetical. 9. No problems found.

	10. Text as it should be. No comments on font size. 11. No comments made. 12. Again, felt layout was familiar but couldn't recall where. 13. Found correct section instantly using right-hand menu. 14. Knew position on page through good headings and tab indicator on right-hand menu. 15. Found link instantly but commented it should be underlined. 16. Instantly used NHS logo to navigate home. 17. Found log-in instantly, without even looking, knew it would be there.
SUS	Scored **90** on the system usability scale.

D6. Timebox Three Acceptance Tests

Date	*Product Name*
	MIU Clinical Decision Support System API
Version No.	*Created By*
1.0	Peter Davies (Project Manager)

i. Scope

- Displaying Throat guidelines API
- Displaying Nose guidelines API
- Displaying Ear guidelines API

ii. Resources

Test Participants: Project Manager

Operating System: Windows OsX 10.13

Browser Used: Chrome

Comments:

iii. Roles / Names

Role	*Name*
Tester	Peter Davies (Project Manager)

iv. Tests

1.	1. Visit throat guideline API endpoint 2. Visit throat guideline API endpoint with ID 3 3. Visit nose guideline API endpoint 4. Visit nose guideline API endpoint with ID 5 5. Visit ear guideline API endpoint 6. Visit ear guideline API endpoint with ID 6

vi. Expected Results/Results

Test	*Expected Result*	*Pass/Fail*
1.	1. JSON response for all throat guidelines appears. 2. JSON response for throat guideline 3 appears. 3. JSON response for all nose guidelines appears. 3. JSON response for throat guideline 5 appears. 5. JSON response for all ear guidelines appears. 6. JSON response for throat guideline 6 appears.	1. PASS 2. PASS 3. PASS 4. PASS 5. PASS 6. PASS

vii. Comments

Test	*Comments*
1.	

D7. Timebox Four Acceptance Tests

Date	*Product Name*
	MIU Clinical Decision Support System API
Version No.	*Created By*
1.0	Peter Davies (Project Manager)

i. Scope

- Display nose guidelines page
- Display ear guidelines page
- Navigate to sections on nose guidelines using accordion menu and right-hand menu
- Navigate to section on ear guidelines page using accordion and right-hand menu

ii. Resources

Test Participants: Project Manager

Operating System: Windows OsX 10.13

Browser Used: Chrome & Safari

Comments:

iii. Roles / Names

Role	*Name*
Tester	Peter Davies (Project Manager)

iv. Tests

1.	1. Visit nose guideline page using home page links 2. Navigate to every section of the nose guidelines using accordion menu 3. Navigate to every section of the nose guidelines using right-hand menu 4. Navigate back to home page using NHS logo 5. Visit ear guideline page using home page links 6. Navigate to every section of the ear guidelines using accordion menu 7. Navigate to every section of the ear guidelines using right-hand menu 8. Navigate back to home page using breadcrumb link 9. Logout of the system

vi. Expected Results/Result

Test	*Expected Result*	*Pass/Fail*	
		Chrome	*Safari*
1.	1. Nose guideline page appears. 2. Each section comes into focus at top of page. 3. Each section comes into focus at top of page. 3. Home page appears. 5. Ear guidelines page appears. 6. Each section comes into focus at top of page.	1. PASS 2. PASS 3. PASS 4. PASS 5. PASS 6. FAIL	1. PASS 2. PASS 3. PASS 4. PASS 5. PASS

	7. Each section comes into focus at top of page. 8. Home page appears 9. Log-in screen appears	7. FAIL 8. PASS 9. PASS	6. FAIL 7. FAIL 8. PASS 9. PASS

vii. Comments

Test	*Comments*
1.	6. Screen does not scroll into view using Red Flags & Pitfalls link in accordion. 7. There is no Red Flags & Pitfalls Link in the right-hand menu.
2.	

D8. Cognitive Walkthrough Results

D8.1 Task One

`Task One

- *Find the guidelines for a patient presenting with a foreign body in their throat.*

e. Enter username and password. (Any)

f. Click log-in button.

g. Click on 'Throat Conditions'

h. Click on 'Foreign Body in Throat'

Task 1a.

Enter Username & Password	*Success?*	*Comments*
Does the user know what they want to do?	*Yes*	Yes, they want to input their login details.
Can they see a control that will do the job?	*Yes*	Yes, clear web text input boxes.
Is it clear how to operate the control?	*Yes*	Yes, known design pattern, very familiar.
Is the immediate feedback understandable?	*Yes*	Yes, can see text being entered using keyboard.

Task 1b.

Click log-in button	*Success?*	*Comments*
Does the user know what they want to do?	*Yes*	They would like to proceed to next stage of login process.
Can they see a control that will do the job?	*Yes*	Yes, clearly marked and designed 'button' with type reading 'log-in'

Is it clear how to operate the control?	*Yes*	Yes, styled to look like button.
Is the immediate feedback understandable?	*Yes*	Yes, user is taken to home page.

Task 1c.

Click on 'Throat Condition'	*Success?*	*Comments*
Does the user know what they want to do?	*Yes*	Yes, find the throat condition guidelines.
Can they see a control that will do the job?	*Yes*	Yes, sections listed alphabetically and styled using known web conventions: underlines and highlights on hover.
Is it clear how to operate the control?	*Yes*	Yes, underlined and blue in colour, following web standard link conventions.
Is the immediate feedback understandable?	*Yes*	Yes, user is taken to the throat condition page.

Task 1d.

Click on 'Foreign Body in Throat'	*Success?*	*Comments*
Does the user know what they want to do?	*Yes*	Yes, user wants to find a particular section on the page.
Can they see a control that will do the job?	*Yes*	Yes, menu on right has link to right section. However, no link is visible in the main menu.
Is it clear how to operate the control?	*Yes*	Yes, links are underlined, blue in colour and highlighted on hover. Web conventions.

Is the immediate feedback understandable?	*Yes*	Yes, page automatically scrolls to the correct section on the page.

D8.2 Task Two

Task Two

- *From the Throat Guidelines page find guidelines for Epistaxis in the Nose*

a. Click on Nose Guidelines section in main menu.

b. Scroll through menu.

c. Click on 'Epistaxis'.

Task 2a.

Click on Nose Guidelines in main menu	*Success?*	*Comments*
Does the user know what they want to do?	*Yes*	Yes, they want to locate the nose guidelines section in the main menu.
Can they see a control that will do the job?	*Yes*	Yes, accordion menu lists all guidelines in the system.
Is it clear how to operate the control?	*Yes*	Yes, chevron indicates that the menu will expand, a known design pattern.
Is the immediate feedback understandable?	*Yes*	Yes, accordion menu expands revealing child links for sections in the nose guidelines.

Task 2b.

Scroll through menu	*Success?*	*Comments*
Does the user know what they want to do?	*Yes*	Yes, they want to scroll down the menu to find the Epistaxis guidelines.

Can they see a control that will do the job?	*Yes*	Yes, scroll bar appears, in blue when content overflows the container.
Is it clear how to operate the control?	*Yes*	Yes, well-known scroll bar design pattern.
Is the immediate feedback understandable?	*Yes*	Sidebar menu scrolls independently of the main body content. .

Task 2c.

Click on Epistaxis	*Success?*	*Comments*
Does the user know what they want to do?	*Yes*	Yes, they want to click the Epistaxis link.
Can they see a control that will do the job?	*Yes*	Yes, links to each section follow web conventions.
Is it clear how to operate the control?	*Yes*	Yes, links are underlined, blue in colour and highlighted on hover.
Is the immediate feedback understandable?	*No*	No, link for Epistaxis scrolls to ‘Sore Throat’ on current Throat Guidelines page.