

**Evaluation of the Wave 2 NHS
Test Beds programme: Developing
a schedule for unscheduled care**

Final report: October 2020

Contents

Definitions and abbreviations	7
Definitions	7
Abbreviations	7
1 Executive summary	8
1.1 Process evaluation	9
1.2 Impact evaluation	10
2 Introduction	11
2.1 Overview of the NHS Test Beds programme	11
2.2 Overview of Chelsea and Westminster NHS Foundation Trust Test Bed	11
3 Evaluation approach	13
3.1 Overview of the evaluation approach	13
3.2 Heuristic evaluation summary	13
3.3 Process evaluation summary	13
3.4 Impact evaluation summary	14
4 Heuristic evaluation	15
4.1 DrDoctor	15
4.2 Medopad	20
4.3 WaitLess	24
4.4 Patients Know Best (PKB)	32
5 Process evaluation	44
5.1 Clinician focus group and semi-structured interviews	44
5.2 Patient interviews	47
5.3 Survey	51
5.4 Summary	65
6 Impact evaluation	67
6.1 Data source	67
6.2 Methodology	67
6.3 Results	68
Cost analysis	77
6.4 Limitations	81
6.5 Statistical analysis conclusions and recommendations	81
7 Conclusion and best practice recommendations	82
7.1 Recommendations for future work	82
8 References	83
9 Appendices	84
Appendix 1: Evaluation plan	84
Appendix 2: Logic models	85
Appendix 3: Patient interview protocol (updated with COVID-19 questions)	86
Appendix 4: Clinician interview protocol (updated with COVID-19 questions)	87

Table of tables

Table 1.1 Table with the number of patients extracted from the WSIC database.....	10
Table 5.1 Clinician interview.....	45
Table 5.2 Patient interviews	48
Table 5.3 Question 3: Gender	52
Table 5.4 Question 4: Age	52
Table 5.5 Question 5: What type of patient are you? (Please select all the categories you belong to).....	53
Table 5.6 Question 6: How long have you been using the CASI?	54
Table 5.7 Question 7: What do you expect from using the CASI ? (you can choose more than one option).....	55
Table 5.8 Question 8: How often do you turn to the CASI when you need health-related information?	56
Table 5.9 Question 9: What do you LIKE about the CASI ? (You can choose more than one option).....	57
Table 5.10 Question 10: What BENEFITS do you get from using the CASI ? (You can choose more than one option)	58
Table 5.11 Question 11: What do you DISLIKE about the CASI ? (You can choose more than one option).....	58
Table 5.12 Question 12: Which functions of the CASI do you think are EASY to use? (You can choose more than one option).....	59
Table 5.13 Question 13: Which functions of the CASI do you think are DIFFICULT to use? (You can choose more than one option).....	60
Table 5.14 Question 14: Overall, how useful do you think the CASI is in helping you MANAGE your health?	61
Table 5.15 Question 15: Overall, how useful do you think the CASI is in helping you IMPROVE your wellbeing?	62
Table 5.16 Question 16: Do you find the CASI particularly useful in the COVID-19 situation?	62
Table 5.17 Question 16.1: Which of the following functions do you think are the most useful in the COVID-19 situation? (You can choose more than one option)	63
Table 5.18 Question 17: Overall, are you satisfied with the healthcare experience that the CASI provides?	64
Table 5.19 Question 18: Will you keep using the CASI?	64
Table 5.20: Test Beds outcome table – Appendix 2 Logic Model	66
Table 6.2 Interrupted time series summary results for the chest pain and heart failure cohort	76
Table 6.3 Interrupted time series summary results for the costs in the chest pain and heart failure cohorts	77

Table of figures

Figure 1.1 Evaluation plan	9
Figure 1.2 Data flow	10
Figure 4.1 Principles of heuristics	15
Figure 4.2 Appointment search	17
Figure 4.3 Two-step booking process	18
Figure 4.4 Help section	19
Figure 4.5 Connect to PKB functionality	22
Figure 4.6 Symptoms	22
Figure 4.7 Symptoms history.....	23
Figure 4.8 Search results (types of urgent care services) are described using acronyms that are not further explained	26
Figure 4.9 Three-step how to use the app.....	27
Figure 4.10 Nomenclature on the app's description	28
Figure 4.11 a,b) Search setting options for public transport. c) Current display mechanism	29
Figure 4.12 Search radius input field does not contain a label.....	30
Figure 4.13 Selected values for the input fields for distance and search radius are not displayed.....	30
Figure 4.14 Time estimates for travel and wait time are presented in one line	31
Figure 4.15 Time estimates for travel and wait time are broken down to two lines	31
Figure 4.16 Main menu	34
Figure 4.17 Secondary menu.....	34
Figure 4.18 Icon legends open in new window	35
Figure 4.19 Forgotten password/reset password user flow	36
Figure 4.20 Map for forgotten password help	37
Figure 4.21 Change your password security question	38
Figure 4.22 Notification description	39
Figure 4.23 Read messages page	40
Figure 4.24 Read messages page error	40
Figure 4.25 Unclear actions associated with buttons.....	41
Figure 4.26. a) Read message page. b) Send a message page.....	41
Figure 4.27 Mandatory title field in sharing record user action.....	42
Figure 4.28 Access treatment plan page.....	43
Figure 5.1 Question 3: Gender.....	52
Figure 5.2 Question 4: Age	53
Figure 5.3 Question 5: What type of patient are you?.....	53
Figure 5.4 Question 6: How long have you been using the CASI?	54

Figure 5.5 Question 7: What do you expect from using the CASI?	55
Figure 5.6 Question 8: How often do you turn to the CASI when you need health-related information?	56
Figure 5.7 Question 9: What do you LIKE about the CASI?	57
Figure 5.8: Question 10: What BENEFITS do you get from using the CASI ?	58
Figure 5.9 What do you DISLIKE about the CASI ?	59
Figure 5.10 Question 12: Which functions of the CASI do you think are EASY to use?	59
Figure 5.11 Question 13: Which functions of the CASI do you think are DIFFICULT to use?	60
Figure 5.12 Question 14: Overall, how useful do you think the CASI is in helping you MANAGE your health?	61
Figure 5.13 Question 15: Overall, how useful do you think the CASI) is in helping you IMPROVE your wellbeing?.....	62
Figure 5.14 Question 16: Do you find the CASI particularly useful in the COVID-19 situation?	62
Figure 5.15 Question 16.1: Which of the following functions do you think are the most useful in the COVID-19 situation?.....	63
Figure 5.16 Question 17: Overall, are you satisfied with the healthcare experience that the CASI provides?.....	64
Figure 5.17 Question 18: Will you keep using the CASI ?	64
Table 6.1 Testbed number of medical visits to primary and secondary care.....	67
Figure 6.1 Cumulative number of registered patients in the study period for all cohorts.	69
Figure 6.2 Percentage of registered patients out of the total number of patients for each cohort.	69
Figure 6.3 Chest pain cohort. Time series for standardised GP appointments per 1,000 patients. Lines represent the Poisson regression model fit for the registered (blue) and non-registered cohorts (red). Points are the number of GP appointments per month and group.	70
Figure 6.4 Chest pain cohort. Time series for standardised GP DNAs per 1,000 patients. Lines represent the Poisson regression model fit for the registered (blue) and non-registered cohorts (red). Points are the number of GP DNAs per month and group.	70
Figure 6.5 Chest pain cohort. Time series for standardised A&E visits per 1,000 patients. Lines represent the Poisson regression model fit for the registered (blue) and non-registered cohorts (red). Points are the number of A&E visits per month and group.	71
Figure 6.6 Chest pain cohort. Time series for standardised unattended outpatient appointments per 1,000 patients. Lines represent the Poisson regression model fit for the registered (blue) and non-registered cohorts (red). Points are the number of outpatient DNAs per month and group.....	71
Figure 6.7 Chest pain cohort. Time series for standardised referrals per 1,000 patients. Lines represent the Poisson regression model fit for the registered (blue) and non-registered cohorts (red). Points are the number of referrals per month and group.	72
Figure 6.8 Chest pain cohort. Time series for standardised emergency hospital admissions per 1,000 patients. Lines represent the Poisson regression model fit for the registered (blue) and non-registered cohorts (red). Points are the number of emergency hospital admissions per month and group.....	72

Figure 6.9 Heart failure cohort. Time series for standardised GP appointments per 1,000 patients. Lines represent the Poisson regression model fit for the registered (blue) and non-registered cohorts (red). Points are the number of GP appointments per month and group. 73

Figure 6.10 Heart failure cohort. Time series for standardised unattended GP appointments per 1,000 patients. Lines represent the Poisson regression model fit for the registered (blue) and non-registered cohorts (red). Points are the number of GP DNAs per month and group. 73

Figure 6.11 Heart failure cohort. Time series for standardised A&E visits per 1,000 patients. Lines represent the Poisson regression model fit for the registered (blue) and non-registered cohorts (red). Points are the number of A&E visits per month and group. 74

Figure 6.12 Heart failure cohort. Time series for standardised unattended outpatient appointments per 1,000 people. Lines represent the Poisson regression model fit for the registered (blue) and non-registered cohorts (red). Points are the number of outpatient DNAs per month and group. 74

Figure 6.13 Heart failure cohort. Time series for standardised referrals per 1,000 people. Lines represent the Poisson regression model fit for the registered (blue) and non-registered cohorts (red). Points are the number of referrals per month and group. 75

Figure 6.14 Heart failure cohort. Time series for standardised emergency hospital admissions per 1,000 people. Lines represent the Poisson regression model fit for the registered (blue) and non-registered cohorts (red). Points are the number of emergency hospital admissions per month and group. 75

Figure 6.15 Chest pain cohort. Time series for the average monthly cost per A&E visit. Lines represent the Gaussian regression model fit for the registered (red) and non-registered (blue) cohorts. 78

Figure 6.16 Chest pain cohort. Time series for the average monthly cost per referral. Lines represent the Gaussian regression model fit for the registered (red) and non-registered (blue) cohorts. 78

Figure 6.17 Chest pain cohort. Time series for the average monthly cost per emergency hospital admission. Lines represent the Gaussian regression model fit for the registered (red) and non-registered (blue) cohorts. 79

Figure 6.18 Heart failure cohort. Time series for the average monthly cost per A&E visit. Lines represent the Gaussian regression model fit for the registered (red) and non-registered (blue) cohorts. 79

Figure 6.19 Heart failure cohort. Time series for the average monthly cost per referral. Lines represent the Gaussian regression model fit for the registered (red) and non-registered (blue) cohorts. 80

Figure 6.20 Heart failure cohort. Time series for the average monthly cost per emergency hospital admission. Lines represent the Gaussian regression model fit for the registered (red) and non-registered (blue) cohorts. 80

Definitions and abbreviations

This section provides definitions and abbreviations of commonly used terms throughout this report.

Definitions

Term: Definition

Abbreviations

A&E	Accidents and Emergency
AEC	Ambulatory Emergency Care
CASI	Combinatory App System Innovation
CIE	Care Information Exchange
CWFT	Chelsea & Westminster NHS Foundation Trust
DNA	Did not attend
DHT	Digital Health Technology
ED	Emergency Department
EPR	Electronic patient record
IG	Information governance
ICHP	Imperial College Health Partners
IMD	Index of Multiple Deprivation
IMD	Index Multiple Deprivation
ITS	Interrupted Time Series
IVD	NIHR London IVD Co-op
NHS	National Health Service
PKB	Patients Know Best
WSIC	Whole Systems Integrated Care

1 Executive summary

The Chelsea and Westminster NHS Foundation Trust (CWFT) Test Bed project set out to tackle a key NHS priority, managing demand across urgent care by:

- Reducing demand on A&E and admissions
- Increasing access to other services
- Reducing overall unnecessary unplanned visits

The Combined Application System Innovation (CASI) was introduced to address these issues. The CASI is made of four applications which enable patients to easily access urgent ambulatory care services rather than A&E, while also providing patients with easy access to information about waiting times and their own health records to create operational efficiencies.

The four digital innovators are:

- DrDoctor – enables better scheduling of appointments
- WaitLess – provides local urgent care waiting times
- Patients Know Best – provides personal health and care information
- Medopad – provides remote monitoring

The four applications are combined as a package of applications and are delivered in real clinical settings. Three clinical pathways – heart failure, chest pain, and pre-eclampsia – were identified as in need of better guidance in self-management and available urgent care services, and CWFT's two hospitals, Chelsea and Westminster Hospital and West Middlesex University Hospital, tested the CASI in these areas.

The evaluation team adopted a Systems Approach for Innovation (SAI) to demonstrate the combined impact of all applications on the four levels of evaluation within this study: patients, departments, hospitals and the wider NW London area.

The aim was to understand whether changes in the above levels of evaluation in the three selected pathways can be attributed to the application of this combination of applications.

In particular, the evaluation objectives were:

- To determine the extent to which the CASI impacts key outcomes identified in our logic models (see Appendix 2)
- To evaluate usability and provide design recommendations
- To understand clinicians' and patients' perceptions of the CASI
- To identify the barriers to, risks associated with and facilitators of the effective implementation of the CASI
- To capture the impact of the CASI on the health system

The evaluation team conducted process evaluation and impact evaluation to achieve the evaluation objectives. Process evaluation assessed the design and usability of the CASI and patients' and clinicians' perceptions of the CASI. It also identified the barriers to adoption of the CASI and possible solutions.

The impact evaluation measured the extent to which the CASI impacts key outcomes identified in the logic models (see Appendix 2) and the benefit it could bring to the NHS through health economic evaluation.

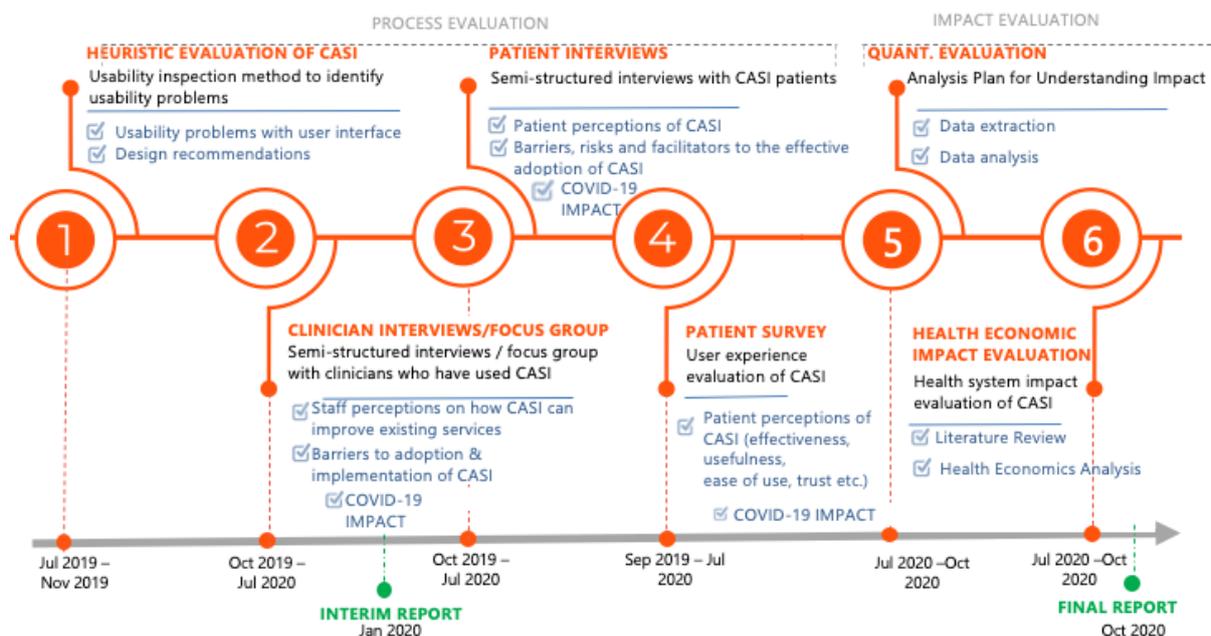


Figure 1.1 Evaluation plan

1.1 Process evaluation

The process evaluation comprised the heuristic evaluation, clinician focus group and interviews, patient interviews and patient survey. The results show that:

- The main benefit that the CASI has brought to the healthcare system is reduction of unnecessary/unplanned hospital attendances.
- Both clinicians and patients believe that using the CASI improves health outcomes thanks to functions such as remote monitoring and in-app communication.
- The clinicians confirmed that adopting the CASI facilitated health service delivery. However, it didn't change the clinical pathways in terms of how patients are diagnosed, treated and managed.
- Patients agreed that reducing unnecessary/unplanned hospital attendances saves them both time and expense.
- Being able to view the test results and communicate with clinicians in-app allow patients to be more proactive in managing their health.
- Both clinicians and patients believe that the CASI played a positive role in the COVID-19 pandemic. It facilitated the continuity of care service delivery, reducing unnecessary/unplanned hospital attendance and helping to keep both clinicians and patients safe.
- The main barriers to clinicians and patients adopting the CASI are usability, time constraints and the complementary devices needed to perform the functionalities.
- Both clinicians and patients believe that the CASI is a valuable innovation for the healthcare system and are looking forward to its improvement or to similar digital health technologies being implemented.

1.2 Impact evaluation

The final data extraction from WSIC took place in July 2020. Data were identified, matched and extracted for 4,009 patients in heart failure, chest pain and pre-eclampsia pathways.

Table 1.1 Table with the number of patients extracted from the WSIC database

July data extraction	Registered for the CASI	Not registered for the CASI	Total
Chest pain	584	1,667	2,251
Heart failure	391	1,233	1,624
Pre-eclampsia	107	17	124
Total	1,082	2,927	4,009

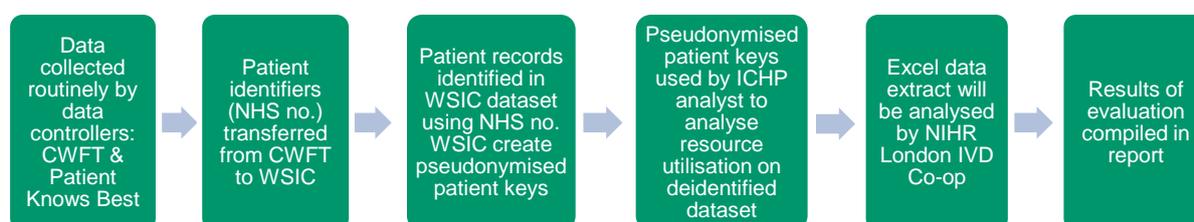


Figure 1.2 Data flow

Interrupted time series models were used to assess the impact of releasing the application. As the date of installation by the patient was not available in the data, we used the 30th of April 2019 as the starting date for all patients. For simplicity and easier interpretation of the modes, we analysed separately patients who registered and those who did not. The data were organised in months. The outcome variables were the number of A&E visits, the number of GP visits, the number of referrals, the number of unattended GP visits, the number of unattended outpatient visits and the number of emergency hospital admissions. The outcome variables were standardised to 1,000 patients. Costs for A&E visits, referrals and unplanned hospital admissions were modelled similarly, assuming a normal distribution. The results show that no significant impact of the use of the CASI can be identified.

2 Introduction

2.1 Overview of the NHS Test Beds programme

The NHS Test Beds programme is a partnership between NHS organisations and a consortium of innovators who seek to tackle key NHS England priorities: to manage demand across urgent care by reducing demand on A&E; to increase access to other urgent care services; and to reduce overall unnecessary unplanned visits. These priorities are centred around the ambition that services can improve the communication between patients and clinical teams and empower patients to manage and schedule their own clinical care.

Test Beds were established to provide an opportunity to test ‘combinatorial’ innovations at scale in the real-world setting of the NHS. The aim was to deliver robust evaluations that could inform the spread of innovations including new technologies and other novel approaches.

The primary aim of the Wave 2 NHS Test Beds programme is to improve patient outcomes and experience of care at the same cost as, or at a lower cost than, current practice, while helping the economy grow.

The Evaluation Plan in Appendix 1 sets out the aims and objectives of the programme in more detail and defines the roles of the local and national evaluation partners.

2.2 Overview of Chelsea and Westminster NHS Foundation Trust Test Bed

The Chelsea and Westminster NHS Foundation Trust (CWFT) Test Bed project set out to tackle a key NHS priority, managing demand across urgent care by:

- Reducing demand on A&E and admissions
- Increasing access to other services; and
- Reducing overall unnecessary unplanned visits

This is key to the Five Year Forward View Next Steps and the NHS.

ICHP was commissioned with NIHR London IVD Co-op to conduct an evaluation to determine the impact of a new intervention in improving the communication between patients and clinical teams and empowering patients to manage and schedule their own clinical care.

The Combined Application System Innovation (CASI) is a package of applications designed to enable patients to easily access urgent ambulatory care services rather than A&E, while also providing patients with easy access to information about waiting times and their own health records to create operational efficiencies.

The four-leading market-ready innovations are combined in the CASI as a package of applications to be delivered in real clinical settings and are designed to scale across the country as hospitals adopt the ambulatory service model. The CASI was introduced to three clinical pathways across CWFT’s two hospitals: Chelsea and Westminster Hospital and West Middlesex University Hospital.

Using the CASI and digitally engaging patients, the Test Bed aims to achieve efficiency savings through integrating traditional urgent and outpatient care and reducing missed appointments and duplicated clinical activity. This contributes towards greater efficiency and increased patient-led digital access.

CWFT worked hand-in-hand with local stakeholders (patients, GPs, hospital clinicians and commissioners) to deliver a new offering for patients.

The four digital companies whose applications form the CASI have market-ready products tackling different elements of patient pathways. The four applications are:

- **DrDoctor** – DrDoctor is a referral and appointment management application that enables patient-led booking, cancellation and rescheduling of appointments to ambulatory care.
- **Medopad** – Medopad is a remote symptom monitoring application that allows patients to track and monitor their symptoms independently.
- **Patients Know Best (PKB)** – PKB allows patients to access their personal healthcare record at any time.
- **WaitLess** – WaitLess shows patients emergency urgent care (e.g. A&E, UCC) wait times, locations and distances to allow them to decide where best to go if they need to be seen urgently.

The CASI is delivered to allow:

1. Patients access to and management of their information, scheduling, communication and behaviour change prompts: making patients aware of non-A&E urgent care services for greater adoption.
2. Efficiencies: linking systems and improving processes to save time and money, enabling resource for the new services to be successful.

Digital companies have been successful in their area of the market, and CWFT has worked with commissioners to understand the population's biggest health problems. Cardiac diseases are a top cause of mortality and disproportionately affect the lower socio-economic population. Therefore, work was carried out in the three following pathways:

1. Heart failure
2. Chest pain
3. Pre-eclampsia

The evaluation is being delivered in partnership between Imperial College Health Partners (IHP) and NIHR London IVD Co-op (IVD). The evaluation partner responsibilities are detailed in the Evaluation Plan in Appendix 1.

3 Evaluation approach

3.1 Overview of the evaluation approach

The NIHR London IVD Co-op adopted a mixed methodology approach by combining both qualitative methods (e.g. interviews and focus group meetings) and quantitative methods (e.g. a quasi-experimental difference-in-differences, and health economic impact assessment in terms of hospital resource consumption) to analyse patient-level data.

In particular, the evaluation objectives were the following:

- To determine the extent to which the CASI impacts key outcomes identified in our logic models (see Appendix 2)
- To evaluate usability and provide design recommendations
- To understand clinicians' and patients' perceptions of the CASI
- To identify the barriers to, risks associated with and facilitators of the effective implementation of the CASI
- To capture the impact of the CASI on the health system

Target patients were those accessing hospital services for chest pain and heart failure within cardiology and for pre-eclampsia within maternity.

3.2 Heuristic evaluation summary

The NIHR London IVD Co-op carried out a heuristic inspection to identify potential usability problems with each of the four applications' user interfaces. The overall user experience was evaluated by the extent to which the interface and tasks met established principles of heuristics described in the corresponding section. Design recommendations were made and shared with the app developers.

The methodology, results and recommendations are described for each CASI app in this report.

3.3 Process evaluation summary

The NIHR London IVD Co-op process evaluation focused on three primary outcomes:

- Understand users' perceptions of the CASI and how it changes the existing service (usability; usefulness in managing and improving their health)
- Identify perceived barriers to, risks associated with and facilitators of the effective adoption of the CASI, and how these may be built on or addressed
- Understand the impact of COVID-19 on delivering and using the service

Process evaluation was carried out through stakeholder analysis and a series of stakeholder interviews:

1. Clinician focus groups and semi-structured interviews: to understand clinicians' perceptions of the CASI, how it adds value to the existing pathway and service, and what the barriers to adoption and implementation are.
2. Patient interviews: semi-structured interviews to assess patient perceptions and ask about any problems and unmet needs that might exist in current pathways and processes.

3. Patient survey: an online survey based on the output of the interviews to further explore patient experience and activation. The survey link was distributed by PKB and clinicians.

Overall, we aimed to assess and understand factors including patient acceptability, usability, demand, implementation, practicability and integration. Global impact was also assessed by considering that the uptake rate may vary, based on human factors evidence extracted from the qualitative analysis.

The methodologies and the results of the process evaluation are detailed later in this report.

3.4 Impact evaluation summary

In order to evaluate the impact and to attribute any of the observed changes in outcomes to the CASI, it is essential to have a credible counterfactual. We approached the impact evaluation using:

1. An interrupted time series (ITS) methodology to evaluate the intervention in the target patient cohort using longitudinal data
2. A health economics impact assessment to estimate the cost impact on the NHS by extracting cost data from WSIC

Ultimately, the analysis was used to:

- Determine impact on outcomes against targets set by CWFT (as per the original research questions specified in advance)
- Assess quantifiable and global changes potentially attributable to the introduction of the CASI in line with the design aim of the apps

Before engaging in the methodologies outlined above, NIHR London IVD Co-op and ICHP worked together on extracting the outcome measures for impact evaluation identified in the logic models (see Appendix 2) in the three clinical areas, and on assessing the quality and completeness of the data extracted.

The methodologies and the results of the impact evaluation are detailed later in this report.

4 Heuristic evaluation

NIHR London IVD Co-op conducted heuristic evaluations of each of the four digital applications that form the CASI. Each evaluation outlined below highlights the methodology used, issues found and recommendations for improving the applications. They all follow the principles of heuristics outlined in Figure 4-1 below.

Heuristics	
Name	Description
1. Make product efficient to use	Optimise the UI by reducing the number of steps required to use the device. Safety-related and frequent functions should be easily accessible. Automating functions can be an effective strategy to reduce user-interactions and to fix error-prone aspects.
2. Make the product state visible with appropriate feedback	Safety-critical and frequently referred to information should be communicated clearly to aid task performance. The product should always keep users informed about what is going on through appropriate feedback within reasonable time.
3. Make the product intuitive and simple	The design of the UI should convey (i) the correct steps required to accomplish goals with the product, and (ii) steps that could be unsafe. Using Miller's Law (7 +/- 2), simplify the UI by organising elements into logical groups. Use the user's language rather than system-oriented terms.
4. Follow design conventions and mental models	UIs should not diverge substantially from conventional design practice or from users' mental models (i.e. an understanding of how a product might be used - often formed from using similar products) unless there is objective evidence that a deviation results in usability improvements.
5. Provide user control and support rapid recovery from use errors	Let users dictate the pace at which steps are performed and allow them flexibility to familiarise with product functions. While use errors should be eliminated or minimised through UI design, they will still occur. Make the UI resilient by making use errors easy to detect, diagnose and resolve. Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution. Ensure users confirm critical adjustments to product state.
6. Make components and functions easily detectable	UI components, such as controls or software interactive elements, should be visually grouped if there is a functional relationship between them. If one UI component might be accidentally used over another, coding mechanisms should be used to visually distinguish them, particularly if there is a hazardous consequence (e.g. size, colour, texture, etc).
7. Incorporate effective safety mechanisms	If design modifications to the UI are not possible or not practical, incorporate effective safety mechanisms, which include either: (i) physical safety guards, shielded elements, or software or hardware interlocks, (ii) warning screens to advise the user of essential conditions that should exist prior to proceeding with device use, or (iii) alerts for hazardous conditions when an unexpected loss of the device's operation could cause harm or death.
8. Provide clear information on product use and safety	Design solutions to the UI are generally more effective for addressing use-related issues than strategies that focus on providing information to the user, such as help, labelling, documentation/user manuals and training. However, this information can support users to use devices more safely and effectively. Information should be scenario-focused, concise, and easy to access, find and understand.

Figure 4.1 Principles of heuristics

4.1 DrDoctor

DrDoctor is a referral and appointment management application that enables patient-led booking, cancellation and rescheduling of appointments to ambulatory care. The aim is to increase a patient's awareness of ambulatory care as an option when they need to be seen urgently but do not feel they require immediate emergency support from NHS A&E services.

The evaluation was conducted in October 2019.

4.1.1 Summary

During the review we found a number of issues with the DrDoctor app, which would likely negatively impact the overall user experience of the CASI.

The most serious issues with the process included:

- Lack of availability of additional search filters for appointments
- Lack of information on the two-step process of booking an appointment to manage users' expectations

In addition, there were a number of issues relating to the navigation and visual presentation, which could be due to the fact that this heuristic evaluation was performed on an inVision prototype of the app with limited functionality.

It should be noted that although some of the reported issues may appear relatively minor, encountering a number of minor issues creates a cumulative effect, which can negatively impact the user's experience when using the app.

Due to the fact that at the time of the heuristic evaluation, the app was not fully functioning, we would strongly recommend that this evaluation is repeated once the app is live.

4.1.2 Positive aspects

While the main focus of this report is to highlight issues with the DrDoctor app which may negatively impact the experience of users, a number of aspects and features which positively support the user experience were detected.

- The visual design is aesthetically pleasing, and the use of appropriate colours make the app appear credible and trustworthy.
- We were able to partially complete the task as described in the methodology section. Where we experienced issues, we were able to investigate and understand the reason for this and provide a recommendation.

4.1.3 Methodology

The focus of this investigation was to evaluate the usability of the user interface of the DrDoctor application, assessing common tasks which would be completed, particularly the booking and rescheduling appointments. The overall user experience was evaluated by the extent to which the interface and tasks met established principles of usability, or heuristics:

- Navigation and user journeys (signposting and labels)
- Consistency and standards (use of design patterns and known conventions)
- Aesthetics (visual design, imagery, iconography, page layout)
- Help and documentation (guidance to help users with key issues and questions)
- Error prevention and handling (prevent user error where possible, or help users identify and recover from errors easily)
- Task orientation (help the user identify where they are, what action they should take and where they should go next)
- Trust and credibility (provide the user with confidence and reassurance)

The issues described in this report can usually be related to these principles, although we highlight other issues where appropriate. We combined elements of heuristic evaluation and cognitive walkthrough into a bespoke task-orientated interaction walkthrough method. Interaction walkthrough is a task-orientated inspection method which examines each user interaction point and examines how well the application supports the user in effective task completion. By adopting a mixed-method approach we ensured that not only was the application evaluated against a range of recognised usability principles or heuristics but that we also examined whether it supported the needs of the patients in the Test Beds programme.

It should be noted that this evaluation was carried out when the app was still not available in app stores, so we were only able to carry out the evaluation on an interactive prototype of the app in inVision. We would strongly recommend the process is repeated in order to conduct a more thorough review once the app is finalised and launched in the app stores.

The prototype version of the app was evaluated by three human factors experts on a Chrome web browser.

Tasks completed

The following task was completed as part of this investigation:

- Request to book an appointment

Severity of issues

For the purposes of this investigation, we categorised the severity of usability issues based on the following scale:

 **High priority:** Likely to **severely restrict** users from effectively and efficiently completing tasks.

 **Medium priority:** Likely to **limit** what target users can achieve.

 **Low priority:** Likely to cause **some inconvenience** to target users.

4.1.4 Issues

Issue 1: Lack of clarity for default search filter



When allowing the user to search for an available appointment, let them search by preferred date, preferred day, preferred time (e.g. morning, afternoon), preferred clinician (if appropriate), location (if that's appropriate) and earliest appointment available. Use the 'search by earliest appointment available' option as the default search option for the context of the Test Beds programme, but also allow for the other search options to be available.

Recommendations

- Signpost the available appointments shown as 'earliest available appointment to book'.
- Allow for additional search filters to improve the user experience of the appointment search function.

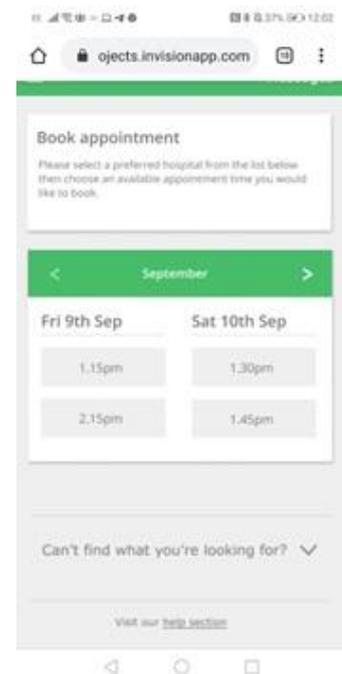


Figure 4.2 Appointment search

Issue 2: Lack of clarity on two-step booking process



The app currently offers a two-step booking process, where users select their preferred appointment and then 'request' it, prior to successfully booking it. This process needs additional information to be communicated to the user. This option might also not be appropriate for urgent care appointment booking where the users might not have time to wait for a confirmation of their appointment booking.

Recommendations

- Explain the usual timeframe for receiving booking confirmation (two hours? one working day? etc.).
- Explain how the confirmation will be communicated to the user, e.g. text message.
- Explain whether users are allowed to submit more than one request for an appointment and whether they are allowed to cancel a request for an appointment.

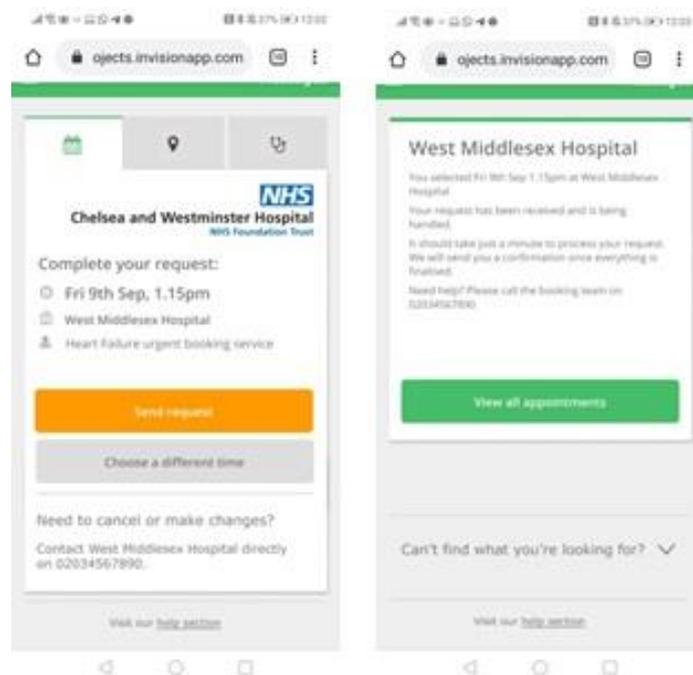


Figure 4.3 Two-step booking process

Issue 3: Help and documentation



A dedicated page called 'Help section' and an additional one called 'Can't find what you're looking for?' are currently available on the app, but they had not yet been implemented on the prototype version that was evaluated. Clarify the difference between those two sections and the different types of help they might offer to the user.

Given the nature of the app and the context that it might be used in (under stress), the content of these sections needs to be carefully designed to include the information that users might need presented in a clear and easy to understand format.

Recommendation

- Consider providing a 'How to use' page to explain to users how to carry out the main actions of the app such as how to search, book, and cancel an appointment.

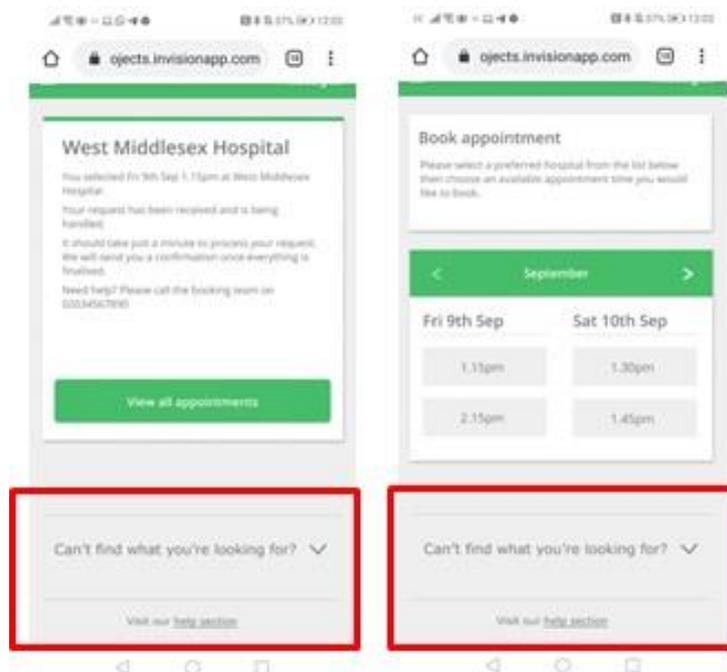


Figure 4.4 Help section

4.1.5 Conclusion

The focus of this investigation was to evaluate the usability of the user interface of the DrDoctor app, as part of the CASI.

We found a number of issues with the app that could negatively impact the user experience. During the review we encountered a number of barriers to usability, especially during the search process, which is an integral part of the app and the CASI.

We present a summary of issues detected:

- The appointment search process can be further improved to allow for more clarity regarding the search filter (e.g. search by earliest available appointment or search by date).
- The two processes of booking and confirming an appointment should be better communicated to the user, especially in regard to their expectations for the timeframe of confirmation of the appointment and the next step for the eventuality of not being able to receive confirmation in time.

- A number of sections of the app are not currently implemented (e.g. viewing appointment, cancelling appointments, login, help section, etc). We strongly recommend these sections are tested at a later date.

4.2 Medopad

Medopad is a remote symptom monitoring application that allows patients to track and monitor their symptoms independently. It flags symptom flare-ups and updates the patient's PKB care record automatically.

The evaluation was conducted in October 2019.

4.2.1 Summary

During the review we found a number of issues with the Medopad app which would likely negatively impact the overall user experience of the CASI.

The most serious issues with the search process included:

- Lack of information as to why the user should connect to PKB and how
- Lack of intuitive method of accessing symptoms history
- Challenges with the visual design of the self-reported symptoms history/summary

Although some of the reported issues may appear relatively minor, encountering a number of minor issues creates a cumulative effect which can negatively impact the user's experience when using the app.

The heuristic evaluation was carried out by human factors experts who were not necessarily representatives of the intended end-user population. For this reason, we strongly recommend further user testing with 'real' end users.

4.2.2 Positive aspects

While the main focus of this report is to highlight issues with the Medopad app which may negatively impact the experience of users, a number of aspects and features which positively support the user experience were detected.

- Very comprehensive landing page with clear information that is specifically tailored to Test Bed patients
- Support for first time users (including a mini 'how to use' tutorial)
- Informative text about privacy, consent and data sharing
- Easy and clear way to describe severity of symptoms
- Extensive (and exemplary) help and support on how to use the app
- The visual design is aesthetically pleasing, and the use of appropriate colours make the app appear credible and trustworthy

4.2.3 Methodology

The focus of this investigation was to evaluate the usability of the user interface of Medopad, assessing common tasks which would be completed, the focus being on the search for waiting times and location of urgent care services. The overall user experience was evaluated by the extent to which the interface and tasks met established principles of usability, or heuristics as outlined in the DrDoctor evaluation (above). The issues described in this report can usually be related to these principles, although we highlight other issues where appropriate. We also adopted the same mixed-method approach that was used to evaluate the other DrDoctor app. Medopad was tested on an Android phone and the following tasks were attempted.

Tasks completed

The following tasks were completed as part of this investigation:

- Download, access and log in
- Connect to PKB
- Input symptoms and view symptoms history
- Access care plan

Severity of issues

For the purposes of this investigation, we categorised the severity of usability issues based on the following scale:



High priority: Likely to **severely restrict** users from effectively and efficiently completing tasks.



Medium priority: Likely to **limit** what target users can achieve.



Low priority: Likely to cause **some inconvenience** to target users.

4.2.4 Issues

Issue 1: Connect to PKB – lack of clarity

When users are prompted to connect to their care record to get started, they are taken to another screen where they need to input their email address and password. There is no information as to what this email address and password is – for example, is this the same email address/password combination they used to log in?

Recommendations

- Include explanatory text to inform the user of the benefits of connecting to PKB.
- Include explanatory text to inform users that they need to enter the email address/password combination that they used to log in to PKB.
- Offer an option for password reminder if they have forgotten this.

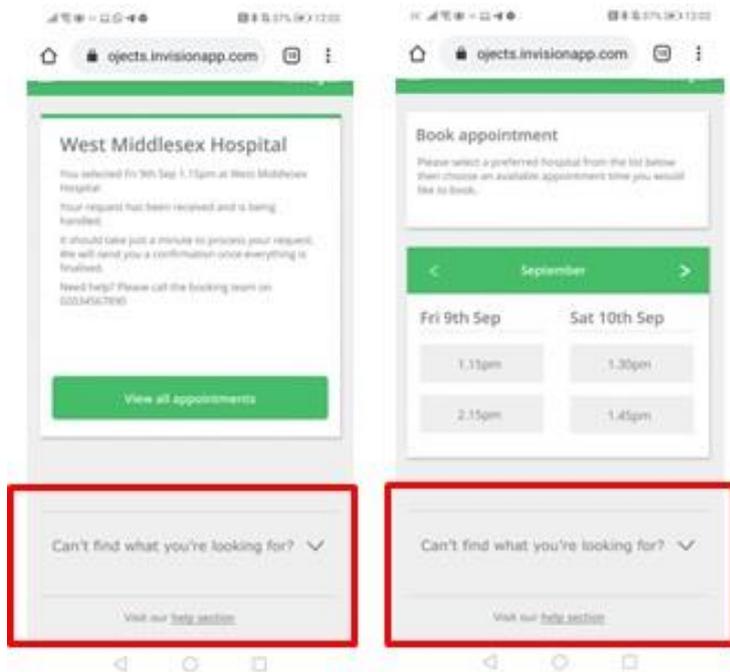


Figure 4.5 Connect to PKB functionality

Issue 2: Clear access to symptoms history

Once symptoms were successfully inputted, it was not clear how the user can access their symptoms history. In order to do so, the user needs to tap on each of the symptom categories (e.g. blood pressure, weight etc.) and this is not very intuitive.

Recommendation

- Provide a clear and intuitive way for the user to access their symptoms history

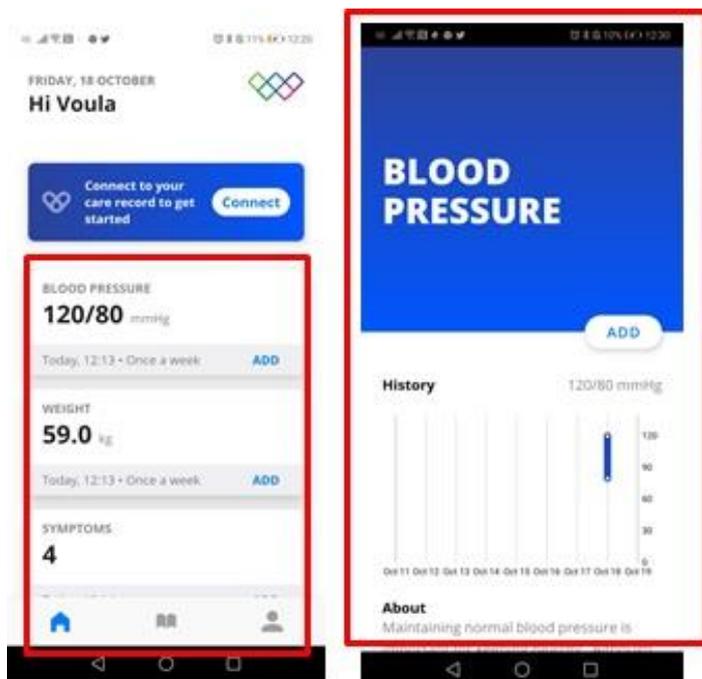


Figure 4.6 Symptoms

Issue 3: Symptoms history summary



The history of symptoms that users self-report on a scale (e.g. pain chest, palpitations) is not very clear. The summary shows each of the symptoms and its accompanying scale, but it does not display the severity of symptoms. For example, if the user reports that their chest pain is moderate or high, this should be communicated in the symptoms summary chart.

Recommendation

- Use colour to reflect the severity of symptoms as reported by patients.

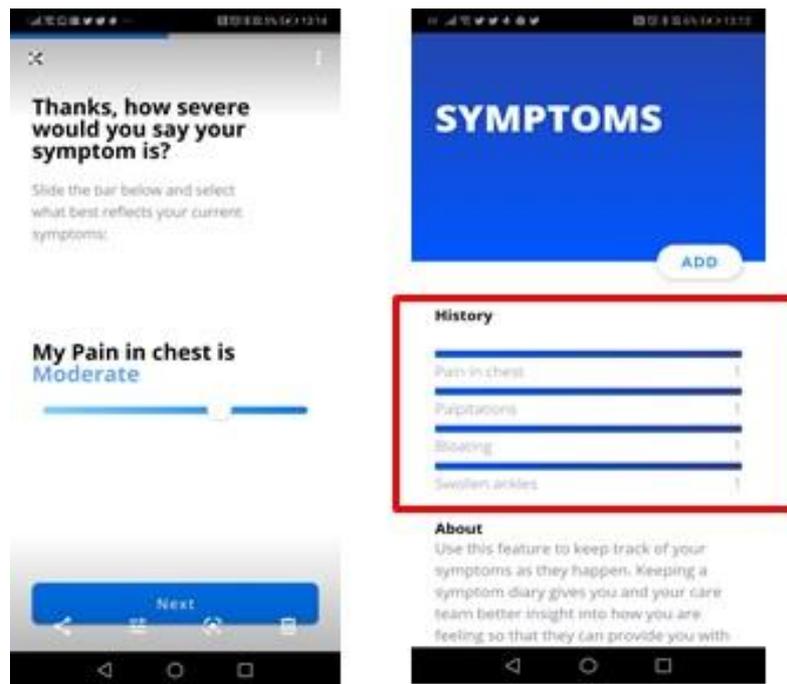


Figure 4.7 Symptoms history

4.2.5 Conclusion

The focus of this investigation was to evaluate the usability of the user interface of the Medopad app, as part of the CASI.

This review found that there are a number of issues with the app that could negatively impact the user experience. During the review we encountered a number of barriers to usability, especially during the search process, which is an integral part of the app and the CASI.

We recommend taking the following steps to improve the app heuristics:

Include more information as to how AND why the user can connect to their PKB.

Make the access to symptoms history more intuitive.

Improve the visual design of symptoms history to reflect the severity reported by users.

4.3 WaitLess

WaitLess shows patients emergency urgent care (e.g. A&E, UCC) wait times, locations and distances to allow them to decide where best to go if they need to be seen urgently. It integrates with DrDoctor and PKB to allow patients to book their own appointments to ambulatory care, reducing the demand on A&E services.

The evaluation was conducted in October 2019.

4.3.1 Summary

During the review we found a number of issues with the WaitLess app which would likely negatively impact the overall user experience of the CASI.

The most serious issues with the search process include:

- A lack of information on different types of urgent care services. This could negatively impact the patient's experience as they might not understand whether a specific urgent care centre could provide appropriate care for them.
- A lack of instructions on filtering search results, to allow users to search by distance, waiting time, parking facilities and care options provided etc.

In addition, there were a number of issues relating to the navigation and visual presentation which, if resolved, would allow users to better orientate themselves on a page and find the most relevant information.

Although some of the reported issues may appear relatively minor, encountering a number of minor issues creates a cumulative effect which can negatively impact the user's experience when using the app.

4.3.2 Positive aspects

While the main focus of this report is to highlight issues with the WaitLess app which may negatively impact the experience of users, a number of aspects and features which positively support the user experience were detected.

- We were able to complete the majority of tasks as described in the methodology section. Where we experienced issues, we were able to investigate and understand the reason for this and provide a recommendation.
- Due to the fact it is primarily focussed on one task (search for urgent care services), the WaitLess app generally provides a positive user experience.
- The visual design is aesthetically pleasing, and the use of appropriate colours makes the app appear credible and trustworthy.

4.3.3 Methodology

The focus of this investigation was to evaluate the usability of the user interface of WaitLess, assessing common tasks which would be completed, the focus being on the search for waiting times and location of urgent care services. The overall user experience was evaluated by the extent to which the interface and tasks met established principles of usability, or heuristics as outlined in the DrDoctor evaluation (above). The issues described in this report can usually be related to these principles, although we highlight other issues where appropriate. We also adopted the same mixed-method approach that was used to evaluate the DrDoctor app.

It should be noted that this evaluation was carried out when the app was still not working for the London area, so we were only able to complete our search tasks for other areas outside London (e.g. Kent). We would strongly recommend the process be repeated in order to conduct a more thorough review once the app is launched for the London area.

WaitLess was tested on an Android phone.

Tasks completed

The following tasks were completed as part of this investigation:

- Input symptoms
- Review treatment plan and medications
- Send a message to a healthcare professional
- Invite a healthcare professional to access patients' data

Severity of issues

For the purposes of this investigation, we categorised the severity of usability issues based on the following scale:



High priority: Likely to **severely restrict** users from effectively and efficiently completing tasks.



Medium priority: Likely to **limit** what target users can achieve.



Low priority: Likely to cause **some inconvenience** to target users.

4.3.4 Issues



Issue 1: No labels on urgent care type icons

When displaying the results of a search for urgent care services, acronyms are being displayed to describe the type of services, for example A&E. Users might not be familiar with some of those acronyms (e.g. ECC, MIU) and this might be confusing to them.

Recommendation

- Make the element clickable and provide additional information to explain the acronym and the type of urgent care service it represents.

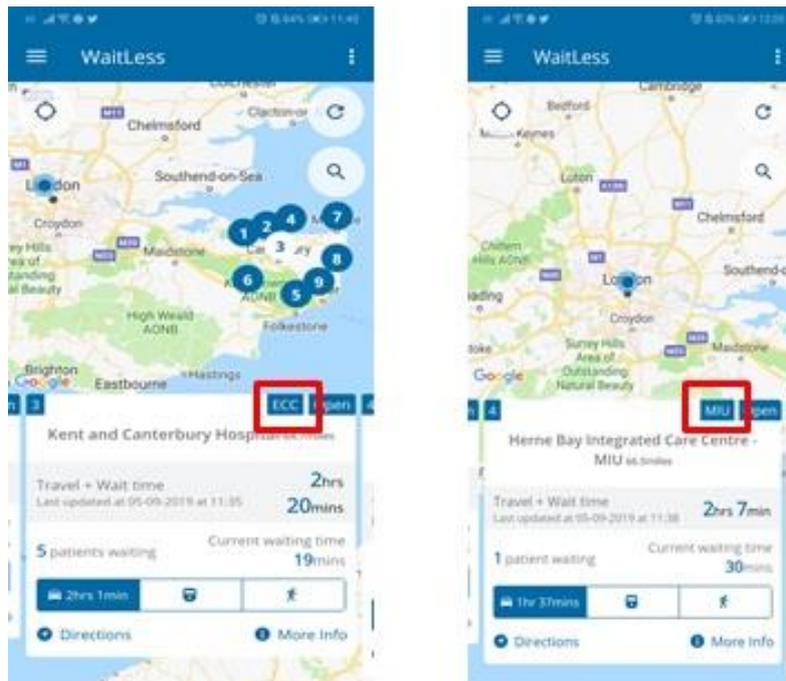


Figure 4.8 Search results (types of urgent care services) are described using acronyms that are not further explained

Issue 2: Help and documentation

A dedicated page on 'How to use the app' is currently available but this only provides a three-step animation of three actions (Focus, Refresh and Search).

Given the nature of the app and the context in which it might be used (under stress), the interface might be confusing to some users who might not be technology adept and frequent app users.

Recommendation

- Consider providing a 'How to use' page to explain to users how to carry out the main actions of the app such as searching, and how results are calculated and displayed.

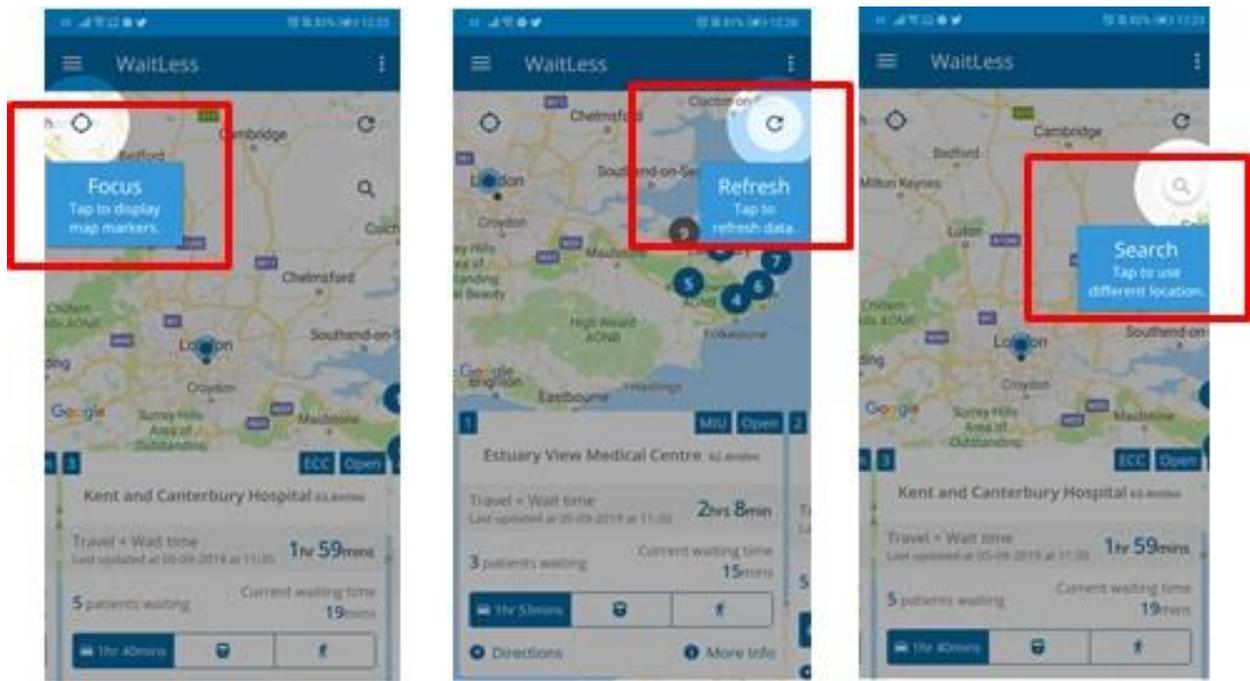


Figure 4.9 Three-step how to use the app

Issue 3: Orientation back to search page

Once a search is complete, a clear mechanism for users to navigate back to making another search query should be provided.

Recommendation

- A consistent means to navigate back to carry out another search should be included.

Issue 4: Nomenclature for Test Bed patients



The app uses the strapline ‘for minor emergencies’ throughout the app, and this might not be appropriate for the Test Beds programme users. As the clinical areas that the programme supports are heart failure, chest pain and pre-eclampsia, the prospective users affected by these conditions might not consider the app appropriate for them, as their conditions are not regarded as ‘minor’, but serious and life-threatening.

Recommendation

- Additional user testing might be required to explore Test Bed users’ views on whether the nomenclature of ‘minor emergencies’ would affect their decision to use the app.



Figure 4.10 Nomenclature on the app’s description

Issue 5: Preferred mode of transport settings



The search settings currently allow the user to edit their search according to travel mode (public transport, driving, walking), but they don't allow for a preferred mode of public transport.

Once the search results are presented to the user, it is not possible to see what the public transport journey will consist of (e.g. a train only journey, a one-bus, two-bus journey etc.).

Recommendations

- Provide specific options for preferred mode of public transport (e.g. bus, train, underground etc.) (Figure 6.4a)
- Provide additional information and a breakdown of the public transport mode in the search results.
- Display the selected measurement for distance unit and search radius on the main settings page (Figure 6.4b)

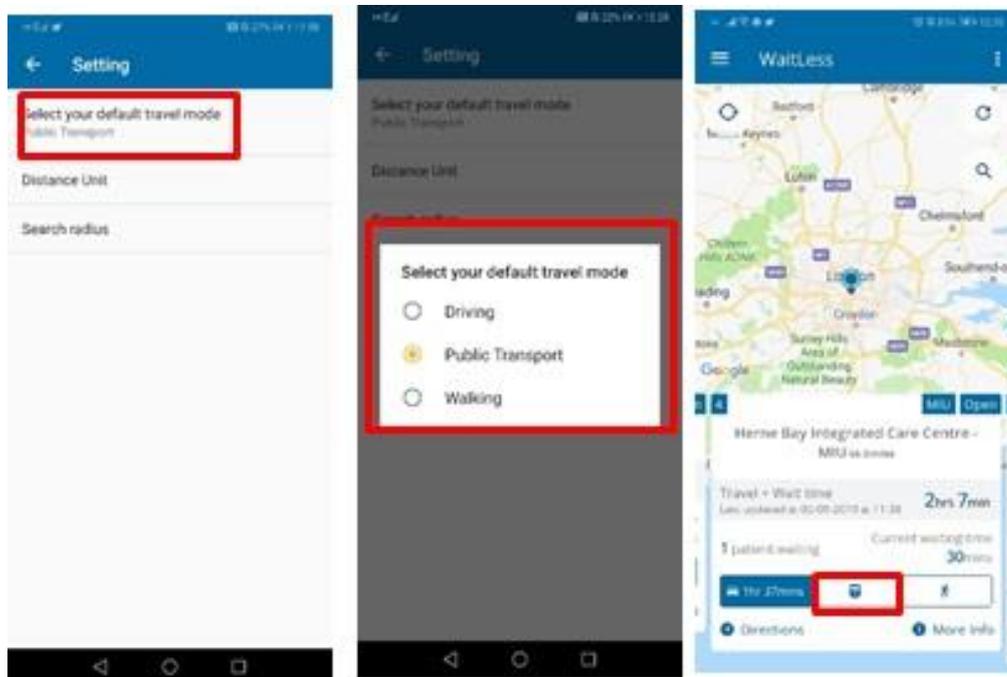


Figure 4.11 a,b) Search setting options for public transport. c) Current display mechanism

Issue 6: Lack of labels for search settings input fields



The search settings input fields don't specify the units of measurement.

Recommendations

- Labels should be included for all input fields to guide the user as to what the corresponding input field means. In this example, the input field for the radius should display whether the measurement for the radius is in km or miles
- The selected values for each input field should be displayed to confirm that a value has been selected successfully. For example, if the user has selected the distance unit to be 'km' this should appear in Figure 6.5b.



Figure 4.12 Search radius input field does not contain a label

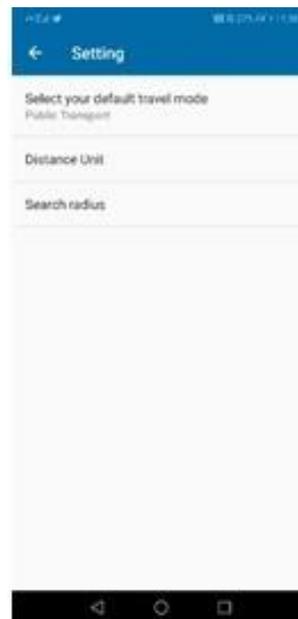


Figure 4.13 Selected values for the input fields for distance and search radius are not displayed

Issue 7: Visual presentation of search results



Time estimates for urgent care services are calculated by travel time + wait time. In certain search results, this time estimate is presented in one line (Figure 6.6a) and in some others this is broken down to two lines (Figure 6.6b).

When the time estimate is broken down to two lines, this appears to be a breakdown of the travel estimate (one line) and the wait estimate (second line). This might confuse users as it is not clear how long the waiting time is.

Recommendation

- Be consistent in the visual presentation of time estimates, preferably in one line (Figure 6.6a) by perhaps reconsidering the placement of the 'last update' information.

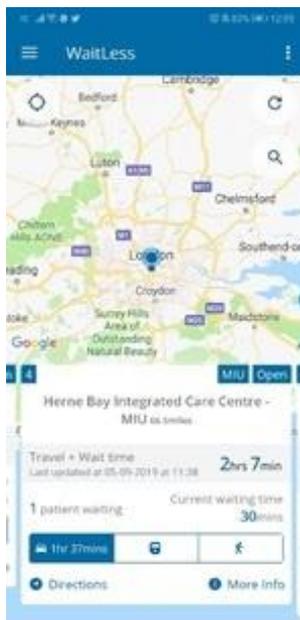


Figure 4.14 Time estimates for travel and wait time are presented in one line



Figure 4.15 Time estimates for travel and wait time are broken down to two lines

4.3.5 Conclusion

The focus of this investigation was to evaluate the usability of the user interface of the WaitLess app, as part of the CASI.

This review found that there are a number of issues with the app that could negatively impact the user experience. During the review we encountered a number of barriers to usability, especially during the search process, which is an integral part of the app and the CASI.

We present a summary of issues detected which mean many of the heuristics were not sufficiently adhered to:

- The search process should be better supported with additional options for search and improving the usability of the search settings.
- The basic task of searching for appropriate urgent care services could be disrupted due to lack of clear information about what services each centre provides.
- There are inconsistencies in the visual design and presentation of travel and waiting time estimates.
- The visual design of the pages sometimes presents barriers to access such as scroll stoppers and important information not being immediately visible.
- Help is provided, but it could be presented in a more comprehensive and usable format, to help first time users under distress to navigate the app.

4.4 Patients Know Best (PKB)

PKB allows patients to access their personal healthcare record at any time. Patients will be able to access their care plans and test results via an online web app, and the application will be integrated with DrDoctor, Medopad and WaitLess to provide support with appointment scheduling, symptom monitoring and signposting. The evaluation was conducted in November 2019.

4.4.1 Summary

During the review we found a number of issues with the PKB web app which would likely negatively impact the overall user experience of the CASI.

The most serious issues with the website included:

- Confusing and potentially disorientating navigation system
- Unclear navigation within the 'Events and messages' page
- Various links opening in new browser windows, which can cause confusion
- Content within a section is not well structured/prioritised

In addition, there were a number of issues relating to the navigation and visual presentation which, if resolved, would allow users to better orientate themselves on a page and find the most relevant information.

Although some of the reported issues may appear relatively minor, as with the other evaluations, encountering a number of minor issues creates a cumulative effect which can negatively impact the user's experience when using the app.

4.4.2 Positive aspects

While the main focus of this report is to highlight issues with the PKB website which may negatively impact the experience of users, a number of aspects and features which positively support the user experience were detected.

- We were able to complete two out of the four tasks as described in the methodology section (access settings and change password and invite healthcare professionals to access health record).
- The content and tone of language is appropriate for a health-related website.
- The visual design is aesthetically pleasing, and the use of appropriate colours make the website appear credible and trustworthy.

4.4.3 Methodology

The focus of this investigation was to evaluate the usability of the user interface of the PKB, assessing common tasks which would be completed, the focus being on logging in, accessing and sharing a care plan and messaging healthcare professionals. The overall user experience was evaluated by the extent to which the interface and tasks met established principles of usability, or heuristics as outlined in the DrDoctor evaluation (above). The issues described in this report can usually be related to these principles, although we highlight other issues where appropriate. We also adopted the same mixed-method approach that was used to evaluate the other DrDoctor app.

The evaluation was carried out by three human factors experts that were given the following tasks and were asked to complete them while using the website.

The testing was carried out on a laptop in Chrome.

Tasks completed

The following tasks were completed as part of this investigation:

- Log in to the system
- Access settings and change password
- Send a message to a healthcare professional
- Invite a healthcare professional to access patients' data
- Review treatment plan and medications

Severity of issues

For the purposes of this investigation, we categorised the severity of usability issues based on the following scale:

 **High priority:** Likely to **severely restrict** users from effectively and efficiently completing tasks.

 **Medium priority:** Likely to **limit** what target users can achieve.

 **Low priority:** Likely to cause **some inconvenience** to target users.

4.4.4 Issues

Issue 1: Navigation

The navigation of the website is very confusing, and it does not adhere to conventional navigation models. Although the content is well categorised in clearly named sections (Share, Health, Treatments, Diary etc.) the hierarchy associated with the navigation is not clear and is not clearly represented through the interface. For example, the main menu and user actions associated with it can be found at the bottom of the page, when they should be at the top.

Recommendations

- The core navigation items (Figure 7.1a) should be repositioned at the top of the page, to ensure they are seen by users and to follow conventional navigation models.
- Reconsider the three secondary navigation items on the right-hand corner of the page. If the user actions associated with them are important or frequently carried out, consider adding them to the first level core navigation menu.

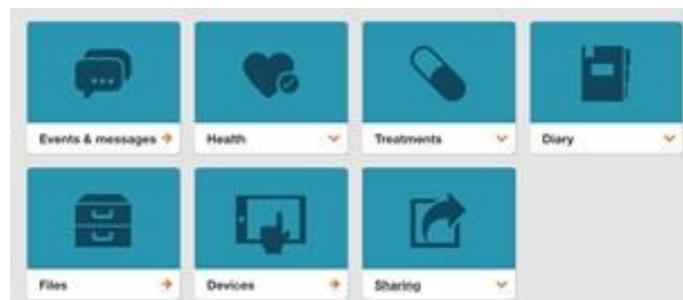


Figure 4.16 Main menu

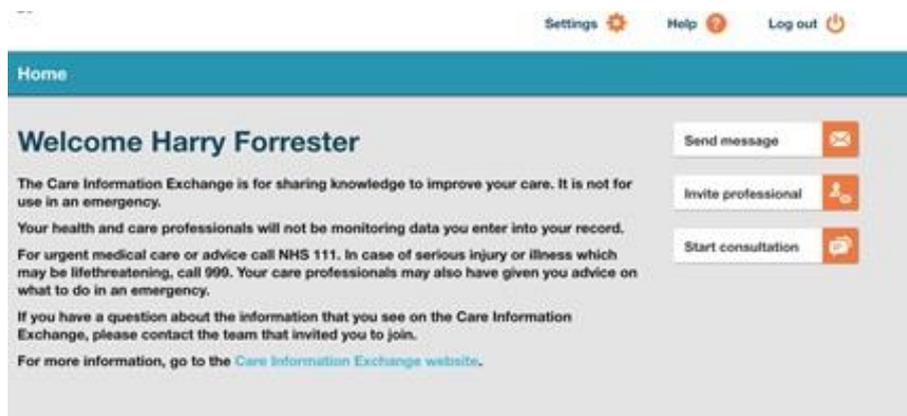


Figure 4.17 Secondary menu

Issue 2: Opening legend links in new window



Across the website there are a few incidences of legend icons that open up in new browser windows, such as 'Latest symptoms', 'Events & messages' etc. Opening a new browser window is disorientating for the user, especially when it happens without warning. Once the user visits the new browser window, they will not be able to navigate back to the main page by pressing 'back', which is the most used navigation function.

Recommendations

- Make the question mark legend icon give minimal information to the user when they hover over it and if you need to give them more information then warn them that this will mean that the link will open in a new window.

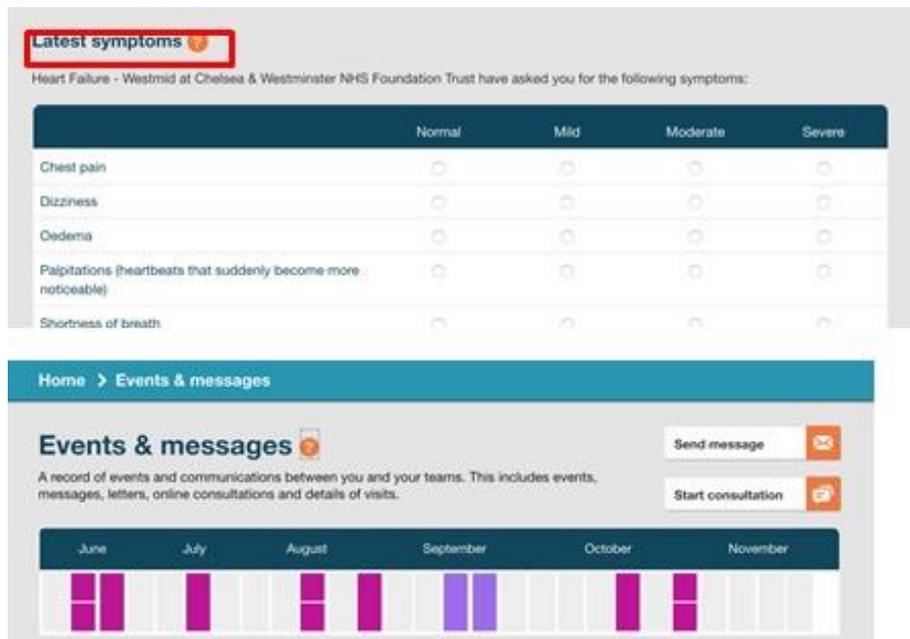


Figure 4.18 Icon legends open in new window

Issue 3: Forgotten password user flow



When the user selects the 'forgotten password' link on the sign-in page, they are presented with the 'Reset password' page with some explanatory text and a map (that dominated most of the screen space). The instructions on how the user should proceed are not very clear.

Recommendations

- If the user will be receiving an email to reset their password, then refer to this as an 'email' and NOT as a 'message', as this might confuse users.
- In terms of privacy and confidentiality, do not show the participant's email address when explaining that is the email address registered. Instead change the text to: 'If your email address is registered with us....'
- Re-phrase the third sentence and make it clear what the user should do to manage their expectations. Do they need to refresh their browser? How long do they need to wait until they request another email?



Figure 4.19 Forgotten password/reset password user flow

Issue 4: Search map in forgotten password



In the event where a user does not remember the email address they registered with, a map is presented so they can get help from the team who registered them (e.g. their hospital). The predictive address finder function is not working when the user types in the hospital name (e.g. Chelsea and Westminster Hospital or West Middlesex University Hospital) and instead the map is displaying results across the UK.

Recommendations

- Either make the predictive address feature work (for hospital names) or clarify that the user can only search by postcode.
- The information about the hospital displayed in the results includes an email address but no telephone number. If the user has forgotten their email address, how could they email for help? Consider including a phone number users could call or alternative means for getting help.

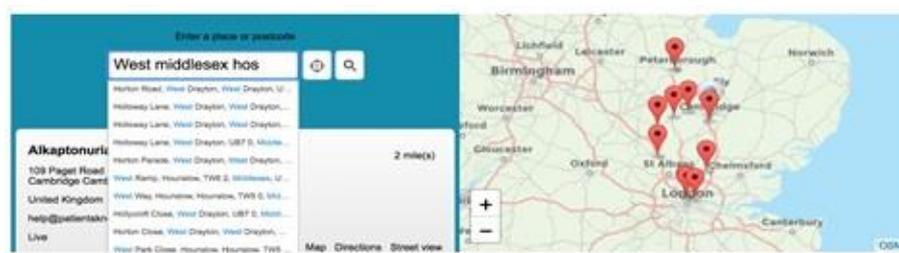


Figure 4.20 Map for forgotten password help

Issue 5: Security question



When the user tries to change their password, the system requests they enter a security question from a drop-down menu and a security answer, but the reason for this is not clear. The red asterisks indicate that this field is mandatory and needs to be completed prior to the user changing their password, but no other explanation is communicated to the user.

Recommendation

- Make it clear to the user why they need to set up a security question/answer. Is this something they would need to remember if they try to change their password?

A screenshot of a web application interface for changing a password. The page has a teal header with 'Home > Password' and a dark blue navigation bar with 'Settings' and 'Password' buttons. The main content area is light gray and titled 'Change your password'. Under the heading 'Choose a security question', there are two fields: 'New security question *' with a dropdown menu containing 'Choose a security question', and 'New security answer *' with a text input field. Below these is the heading 'Choose a good password' and a list of 'Password requirements:' including '10 or more characters'. The red asterisks on the security question and answer fields indicate they are mandatory.

Figure 4.21 Change your password security question

Issue 6: Notifications description



On the homepage, the first table that is presented to the user is the notifications. A list of notifications is presented alongside an icon and short description of the nature of the notification.

Recommendations

- Consider using a general primary title for each notification to describe the nature of the notification (e.g. 'Message', 'Test result' etc.). Different icons are used for this, but every piece of information communicated to the user should be available in both visual (icon) and textual format.
- For example, the notification description could be:
Message: Brief description of content (e.g. date received)
Test results: Brief description of nature of test

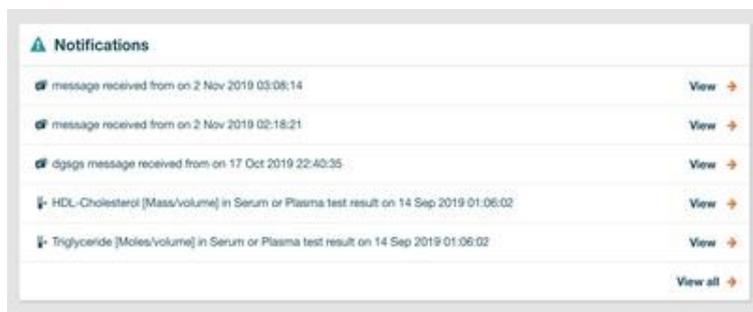


Figure 4.22 Notification description

Issue 7: Events & messages page



The 'Events & messages' page is arranged in a way that could be very confusing for users. Firstly, it is not clear why the events and messages are merged in one page. The white rectangle across the screen includes an icon that has not been presented to the user before, without text description. There is a label attached to 'general health', but it is not clear who the message is from, whether this is a message the user has sent or received, and the content of the message.

Recommendations

- Consider redesigning this page to follow an 'inbox' metaphor that the users will be familiar with (e.g. follow the same user interface design that is adopted by email clients or text message services).
- Consider separating 'events' from 'messages'.

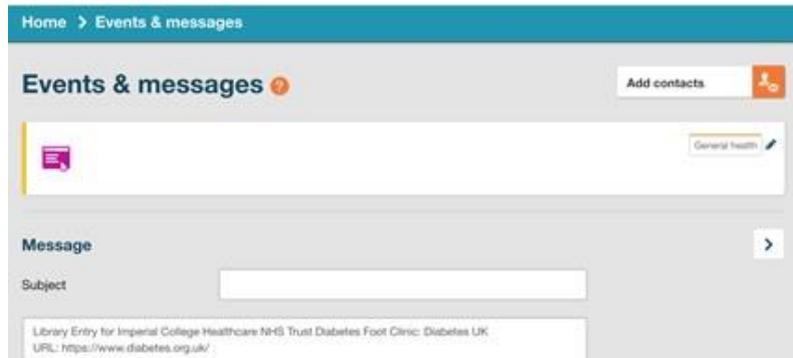


Figure 4.23 Read messages page

Issue 8: Choosing a recipient for a message

It is not clear how to choose a recipient for the message the user is trying to send. The 'Add contacts' label is in line with the 'Events & messages' heading and it does not appear in the same format as the rest of the message's information (e.g. subject, message body, attachment etc.). The label name could also be confusing.

Recommendations

- Consider renaming the label to 'To' or 'Recipient'.
- Follow known practices in regard to message interface design:
To
Subject
Message
Attachment

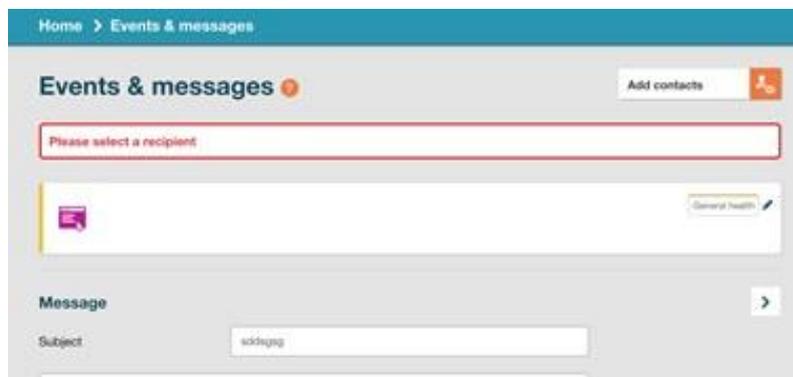


Figure 4.24 Read messages page error

Issue 9: Confirm message sending action



It is not clear whether a user is 'saving' or 'sending' a message. This could be very confusing.

Recommendation

- Change the text on the 'save' button to reflect the exact action the button is associated with.

Figure 4.25 Unclear actions associated with buttons

Issue 10: No sub-menu description



There is no sub-menu description under the 'Events & messages' heading. Figure 7.10a shows the 'read message' page while Figure 7.10b shows the 'send a message' page. This is currently not communicated to the user, and it is very disorientating and confusing.

Recommendation

- Consider adding a name to the sub-menu items by using breadcrumbs to ensure hierarchical navigation on a specific page.

Figure 4.26. a) Read message page. b) Send a message page

Issue 11: Mandatory fields in 'Share' actions



All fields in 'Invite professional' of the 'Sharing' section are mandatory and users are therefore blocked from saving or moving on to the next screen.

Recommendation

- Only make mandatory the fields that need to be mandatory to make form filling as easy as possible for users.

Home > Sharing >

Professionals Friends/Family Pending Past Access log

Invite professional ?

Title *
Enter title

First name *

Last name *

E-mail address *
We will send your message to this address

Figure 4.27 Mandatory title field in sharing record user action



There is a lot of content within a care plan, which means the user has to scroll down a few times to access it all. The actual traffic light care plan can be found at the bottom of the page – so even if the user did manage to access this, they would assume that this is not important content.

Recommendation

- Consider prioritising the content within a page to display the most important/critical to the user content at the top of the page.

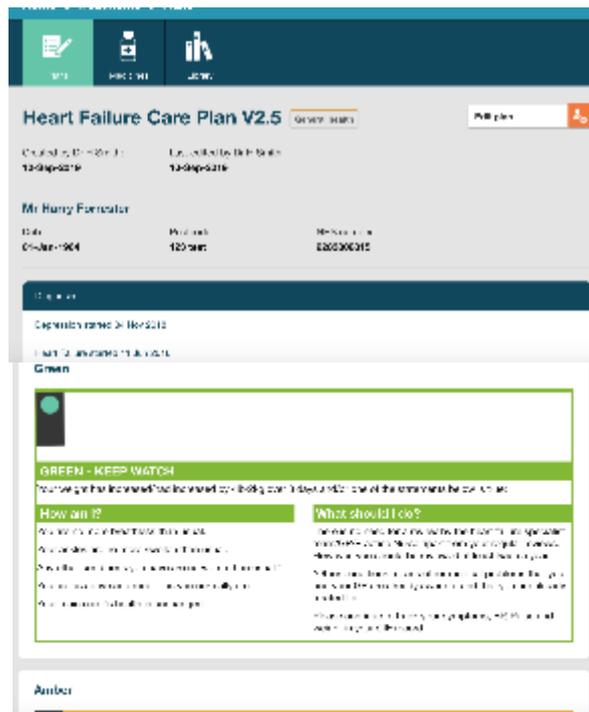


Figure 4.28 Access treatment plan page

4.4.5 Conclusion

The focus of this investigation was to evaluate the usability of the user interface of Patient Knows Best, as part of the CASI.

This review found that there are a number of high and medium priority issues with the app which could negatively impact the user experience. During the review we encountered a number of barriers to usability, especially during the messaging and accessing care plan sections, which are integral parts of the website and the CASI.

We present a summary of the most critical issues detected which mean many of the heuristics were not sufficiently adhered to:

- The overall website navigation is very confusing, and it does not adhere to conventional navigation models.
- The basic task of messaging a healthcare professional is confusing as it is not clear whether the user is sending a message or reading a message.
- Legend icons opened in new windows without any warning.

- Content within individual pages was not organised in order of importance, making it difficult for users to locate important pieces of information.

5 Process evaluation

5.1 Clinician focus group and semi-structured interviews

5.1.1 Introduction

The main aims of the clinician focus group and semi-structured interviews were to:

- Understand staff perceptions of how the CASI changed the existing service
- Understand what the barriers to adoption are and how to overcome them
- Understand the impact of COVID-19 on care service delivery
- Map out the impact of the CASI on clinical pathways

Focus groups and semi-structured interviews have been widely used in health research in recent years to explore the perspectives of patients, clinicians and other groups in the healthcare system (e.g. Carr *et al.*, 2003; Côté-Arsenault and Morrison-Beedy, 2005; Kitzinger, 2006).

Focus groups are a form of group interview that capitalises on communication between research participants to generate data. Questions relating to the research topic are designed by the researchers and are used to guide the discussion (Stewart *et al.*, 2007). The group functions as a promoter of synergy and spontaneity by encouraging the participants to comment, explain, disagree and share their views.

Semi-structured interviews are a terrific way to build rapport and gather rich information. Researchers can explore a participant's experiences, detailed perspectives, opinions and feelings in greater depth than through other methods.

Due to the COVID-19 situation, it was difficult to gather focus groups for all clinical pathways as many clinicians were not available on the same date and time. A mix of focus groups and semi-structured interviews are used in this evaluation to complement each other.

5.1.2 Methodology

A protocol was developed based on the outcome tables in the Logic Model (Appendix 2) and used for both focus groups and interviews (Appendix 4). In addition, clinicians were given a table to explain how patients are diagnosed, treated and managed before and after the introduction of the Test Beds programme to map out the changes in clinical pathways. In total, 12 clinicians from heart failure, chest pain and pre-eclampsia participated.

The heart failure clinician focus group lasted 30 minutes, and the clinician interviews lasted around 20 minutes each. The researcher began by introducing herself, describing the work of the Test Beds programme, and explaining the structure of the focus group/interview. She also reminded participants of their right to withdraw, at any time and for any reason. Participants were then asked to provide their experience of pathways and processes involved in the management of heart failure patients using the CASI.

All the interviews for which recording permission were granted were transcribed (not verbatim). Recordings were reviewed and thematically analysed in order to obtain the information required to understand the participants' experience in using the CASI, whether the CASI met their expectations, the adoption barriers and the solutions to overcome them.

Table 5.1 Clinician interview

Pathways	Date	Semi-structured interview
Chest pain	September 2019	Clinician 1
Heart failure	September 2019	Clinician 2
	June 2020	Clinician 3
Pre-eclampsia	May 2020	Clinician 4
	May 2020	Clinician 5
	May 2020	Clinician 6
	May 2020	Clinician 7
Pathways	Date	Focus group
Heart failure	July 2020	5 clinicians

5.1.3 Results

Clinicians’ perspectives of how the CASI changed the existing service were as follows:

Health system perspective

A reduction in the number of patients who attended A&E/Maternity triage. The implementation of the CASI reduces A&E attendance for heart failure and chest pain patients and also reduces pre-eclampsia patients’ attendance at the maternity assessment suite (MAS)/triage, which is one of the primary outcomes for the Test Beds programme.

Clinician 1: “[If] women do start to develop symptoms or blood pressure or something like that [it] gets picked up early because they’re doing it daily, monitoring at home rather than coming to the hospital twice a week or once a week. If you’re bringing someone into the hospital, the chance that you get a false positive is quite high ... everything takes a bit longer at the hospital; you have to wait for the blood pressure to settle ... whereas at home they are taught to do it at a scheduled time that works for them. They are more likely to get to a true earlier diagnosis if they’re doing it at home in a semi-controlled way. If they do get diagnosed earlier, they get better treatment.”

Health outcome perspective

The remote monitoring and the possibility to communicate with clinicians via the CASI function enable early diagnosis, which leads to early treatment. Patients can borrow blood pressure monitors from the hospitals, measure their blood pressure at home with instructions from clinicians, upload the results and other symptoms, and get feedback from clinicians promptly. Clinicians are able to diagnose patients rapidly and provide the right treatment, including adjusting medication.

Clinician 2: “You teach women how to self-monitor, basically check their own blood pressure and urine. So, you don’t have to deliver women too early and their pregnancy could continue to full term, if managed properly.”

Clinician 3: “We can start monitoring before problems start to happen. So, you're making this pre-eclampsia diagnosis earlier because you're getting the data that would indicate it earlier. So, you're in a position to be proactive and make plans rather than reactive. You don't want to wait until someone's already symptomatic; we try to pick them up at an earlier stage.”

Patients' benefit

Patients are able to communicate with clinicians quickly and easily via the CASI and are able to perform home monitoring correctly with instructions from a clinician. This reduces the need to come to hospital, which saves patients time and expense. In addition, patients are able to view the test results on the CASI, which gives them more control of their own health information.

Clinician 4: “With the CASI, patients now have more involvement potentially in their own care. They can see these results rather than having to phone a helpline.”

Clinician 5: “The CASI has helped us to better communicate and manage the patients, however, it didn't change the way we diagnose, treat and manage our patients. It didn't change our clinical pathway.”

Barriers

The barriers to clinicians adopting the CASI are mainly the following:

- **Usability:** Clinicians mentioned that the CASI is not particularly user friendly and is cumbersome to use. However, clinicians also appreciated that the usability has been improving. For example, the introduction of single sign-on allows them to log in with one single ID and password, which has greatly improved access to the CASI.
- **Time constraints:** Clinicians have time constraints dealing with routine work and adopting the new technologies.

Clinician 6: “It's not particularly user friendly... It's not too difficult to use, but it's cumbersome. When I do the checking of the women, it will take me between two to three hours each time. There's no dashboard screen where you can see at a glance who might not be compliant, who might have results that are out of range, and who needs actions. You have to go to each individual patient to look them up.”

- **Complementary devices:** The CASI needs to be used in combination with other devices such as a blood pressure monitor to perform the remote monitoring function. The lack of blood pressure monitors affected the efficacy of the Test Beds programme.

Clinician 7: “The reason for the delay at the beginning was the supply of blood pressure monitors.”

Impact of COVID-19

- **The CASI facilitates healthcare service delivery:** Most of the clinicians who took part in the research mentioned that implementation of the CASI facilitated healthcare service delivery, reducing face-to-face interactions and unnecessary hospital attendance.

Clinician 8: “When COVID came, we didn’t need to change the pathway. Having the Test Beds programme reinforced the fact that it is so important to have a lean and efficient AEC which is safe and effective.”

Clinician 9: “We have less people coming to the hospital [during COVID]. And when they come to the hospital, they do actually need to; they don’t just come for no reason. We are actually seeing people who truly need to be seen.”

Clinician 10: “In addition, midwives and GPs are sending patients to hospital who do need to be seen, which is actually very good.”

- **Usage of the CASI has increased:** The clinicians further confirmed that patients were using the CASI to get health-related information, perform home monitoring and communicate with them during COVID-19. They also expressed the need for more digital health applications in the future.

Clinician 11: “There’s the convenience aspect that women aren’t having to come to the hospital, which probably has some health impacts as well at the moment, because you don’t want women coming to a COVID area, which the hospital is. So that’s one health impact.”

Clinical pathway mapping

All clinicians confirmed that there had been no change in the clinical pathways in terms of how patients were diagnosed, treated and managed. In other words, the CASI facilitated service delivery in aspects such as remote monitoring, earlier diagnosis, earlier treatment, viewing test results and communicating with clinicians, but it didn’t change the clinical pathways.

5.2 Patient interviews

5.2.1 Introduction

The main aims of the patient interviews were to understand:

- Patient perceptions of the CASI (usability, usefulness in managing and improving their health)
- Barriers to, risks associated with and facilitators of the effective adoption of the CASI

Semi-structured interviews are where the interviewer has developed an interview protocol (Appendix 3) but remains free to ask different questions based on the responses given. Semi-structured interviews are more flexible; patients may bring up topics that researchers hadn’t thought of before and the researcher can delve deeper or change course slightly depending on responses.

5.2.2 Methodology

Patients were recruited with help from clinicians. Clinicians informed patients who were eligible for the Test Beds programme of the opportunity to participate in the evaluations. With the patients' permission, clinicians sent their contact details to the researcher from NIHR London IVD Co-op, who then invited the patients to telephone interviews. The interview protocol (Appendix 3) was developed by IVD and comments and feedback were received from the clinicians.

Each patient was contacted up to six times at different times and dates (if they didn't reply). Of 23 patients who agreed to participate, we managed to interview 16 patients.

Interviews for which recording permission was granted were transcribed (not verbatim). Recordings were reviewed and thematically analysed in order to obtain the information required to understand the patients' perceptions of the CASI and the barriers to adoption.

Table 5.2 Patient interviews

Pathways	Contacted	Interviewed
Chest pain	6	1
Heart failure	13	12
Pre-eclampsia	4	3
Total	23	16

5.2.3 Results

The 16 interviews were conducted between December 2019 and August 2020. At the time of the interviews, the patients had been using the CASI for between two and 18 months. The usage frequency varied from daily to monthly depending on their health condition and pathways. All the patients had been recommended by clinicians to use the CASI and showed a great degree of trust in using the digital applications recommended by healthcare professionals.

Expected gains

Patients' expected gains from using the CASI included:

- Reduced hospital attendance and associated time and cost savings

PE patient 3: "I had weekly blood and urine tests to upload in the CASI, and they were able to ring me the same day to talk about it. Very quick feedback."

- Better and quicker communication with healthcare professionals

HF patient 6: "Sometimes emails get kind of lost in the system [and] they don't get addressed quickly, whereas this seems to be much, much more efficient. And my messages are now replied [to] within 12 to 24 hours, if not before that."

- Ability to view the test results and appointments

HF patient 7: "Easy to read results. There is a menu for everything, and you can turn the test results into graphs."

- Digital health medical records kept in one easily accessible place

Areas of like and ease of use

Aspects of the CASI that patients liked included:

- It enables fast and timely communication with clinicians

HF patient 12: "I use the testbed applications mainly to keep in contact with my nurses and also my consultants, get my appointments and letters."

- It is self-explanatory to use

HF patient 5: "It [the CASI] gets me a lot of notifications such as discharge summary, notification of out-patient visits, messages, diagnosis, test results, imaging, etc. That's really helpful because it is like a one-stop shop for everything I need. I am really lucky to have it. It is a very very useful tool."

- It gives them control of their own health by enabling them to view test results and appointments online and to keep all health records in one place

HF patient 8: "The Care Information Exchange is extremely convenient. I feel like [I] have some participation in what's happening and have the clarity of it."

HF patient 10: "Blood test results and X-ray results are very helpful!"

CP patient 1: "It [the CASI] is very handy. I don't need to carry medical records, appointment letters, etc. Everything is a lot more eased [sic]."

- It enables users to share health information with healthcare professionals at different hospitals

HF patient 2: "I have diabetes at Charing Cross and heart failure at West Middlesex. Information used to be missed and I needed to explain to other consultants. Now they know straightaway my health is moving forward."

Areas of dislike and difficulty of use

Aspects of the CASI that patients did not like included:

- Test results can be slow to appear

HF patient 9: "The chest X-ray is being very slow going on the test results for whatever reason. I asked [for] a hard copy of the discharge letter and the X-ray when I was in the hospital. I always get them to give me a record just in case. But obviously it was actually brilliant because I cannot see that in the CASI."

- There is a lack of training on how to use the CASI and how to read the results

HF patient 1: "It would be nice to have some training on how to use it properly."

HF patient 3: “To have the test results and the RAG (red, amber and green) are great. However, it would be nice to have the interpretation of the results and recommendation on how to improve my health.”

- Patients need to use the web application for some functions

PE patient 2: “It’s not easy to understand how to input info. I usually use my mobile but for inputting information I need to log in to the web.”

- There are some usability issues such as errors and not all functions are fully working

HF patient 6: “It is difficult to see test results. I don’t have the Patients Know Best icon on my phone screen. Each time I need to access it, I have to click the message from the email box which directs me to the application.”

HF patient 5: “In addition to receiving emails notifying me of incoming letters (some of which I find in the system and some I still don’t), today I received a notification by text with a link to an appointment letter. This was much simpler to navigate, and I was able to find and open the letter very easily. However, I received the same message seven times this morning, and the appointment was for 24 June 2020. Today is 2 July. Fortunately, I had already attended this appointment by telephone.”

HF patient 8: “There are so many functionalities on the CASI, however, I only use it to communicate with my clinicians [and] view test results and medication functions.”

- Users are not able to share the information with consultants from certain hospitals

HF patient 4: “It is personal health information which I believe I should always have access to [to] have control of my health. So, I can be proactively act and doing things [sic]. In the old days, it was doctors’ information. Different doctors cannot see each other’s stuff. I am on 10 different medications. My consultants have to ring my GP. There doesn’t seem to be link and information exchange among them. It would be good to have joint thinking among them.”

Impact of COVID-19

During COVID-19 the CASI has been beneficial in:

- Avoiding unnecessary/unplanned hospital visits
- Enabling easy communication with healthcare professionals

HF patient 8: “I am able to perform the requested monitoring at home. There is no need to wait in the hospital and no need to park. Parking is always an issue and I am not going to take the bus during the COVID-19 time.”

The analysis of the interviews shows that all the expected gains from the patients had been met. Patients perceived it as an innovation in the healthcare system that is useful in managing and improving their health.

Most of the patients thought the CASI was intuitive to use and had been using it when they needed. However, this perception depended on patients' digital literacy. During the course of the evaluation, patients' feedback on the usability improved, which indicated the continuous improvement of the CASI development.

Patients who attend different hospitals of CWFT and Imperial College Trust highly appreciated the fact that their health records could be viewed and accessed by various consultants in the same trusts. Those patients who attended multiple hospitals that don't share information complained about the fragmented information their consultants were able to view.

Most of the patients confirmed that they would keep using the CASI as it is useful, except the pre-eclampsia patient, who planned to stop using it after giving birth.

These results demonstrated that the key intended outcomes of the Test Beds programme – improved patients' healthcare experience, increased awareness of patients' health condition, greater patient satisfaction, increased patient activation and increased patient wellbeing – have all been achieved.

5.3 Survey

5.3.1 Introduction

The main aims were to:

- Assess patient experiences of the CASI
- Measure usability (i.e. effectiveness, ease of use, user satisfaction, usefulness, trust)

Surveys are a commonly used tool in healthcare. Surveys allow selection of a relatively large sample of people from a certain population, followed by the collection of data from those individuals. The surveys may be exploratory, descriptive, or explanatory. A bespoke questionnaire was developed to understand patients' perceptions of the CASI and its usability in a quantitative way.

5.3.2 Methodology

A survey was designed based on the protocol and the output from the patient interviews. Clinicians' feedback on the survey protocol was taken into consideration and implemented. The survey was distributed by the PKB and by clinicians to the patients who participated in the Test Beds programme.

Cross-tabulation was used to analyse the data. This method allows us to quantitatively analyse the relationship between multiple variables. Also known as contingency tables or cross tabs, cross-tabulation groups variables to understand the correlation between different variables. It also shows how correlations change from one variable grouping to another.

5.3.3 Results

Between May 2020 and September 2020, 75 survey responses were received, of which 62 were valid. 73% of the participants were female, and 27% of them were male. They were from all three cohorts and more than half were pre-eclampsia participants. Participants were all adults from all age bands. 73% of them had been using the CASI for more than three months.

Table 5.3 Question 3: Gender

Gender	%	Count
Male	26.67%	16
Female	73.33%	46
Total	100.00%	62

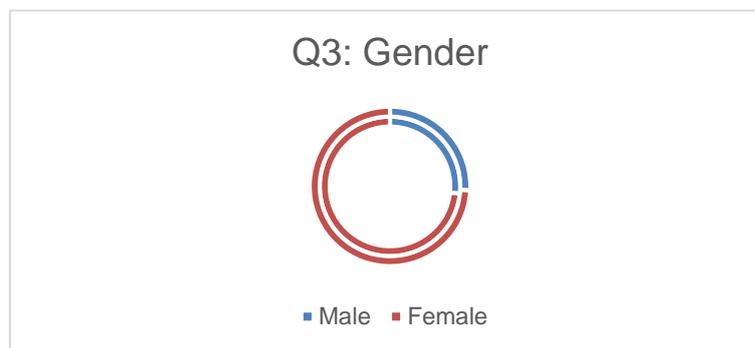


Figure 5.1 Question 3: Gender

Table 5.4 Question 4: Age

Age	%	Count
Under 18	0.00%	0
18 - 24	1.67%	1
25 - 34	30.00%	20
35 - 44	21.67%	13
45 - 54	11.67%	7
55 - 64	8.33%	5
65 - 74	16.67%	10
75 - 84	6.67%	4
85 or older	3.33%	2
Total	100%	62

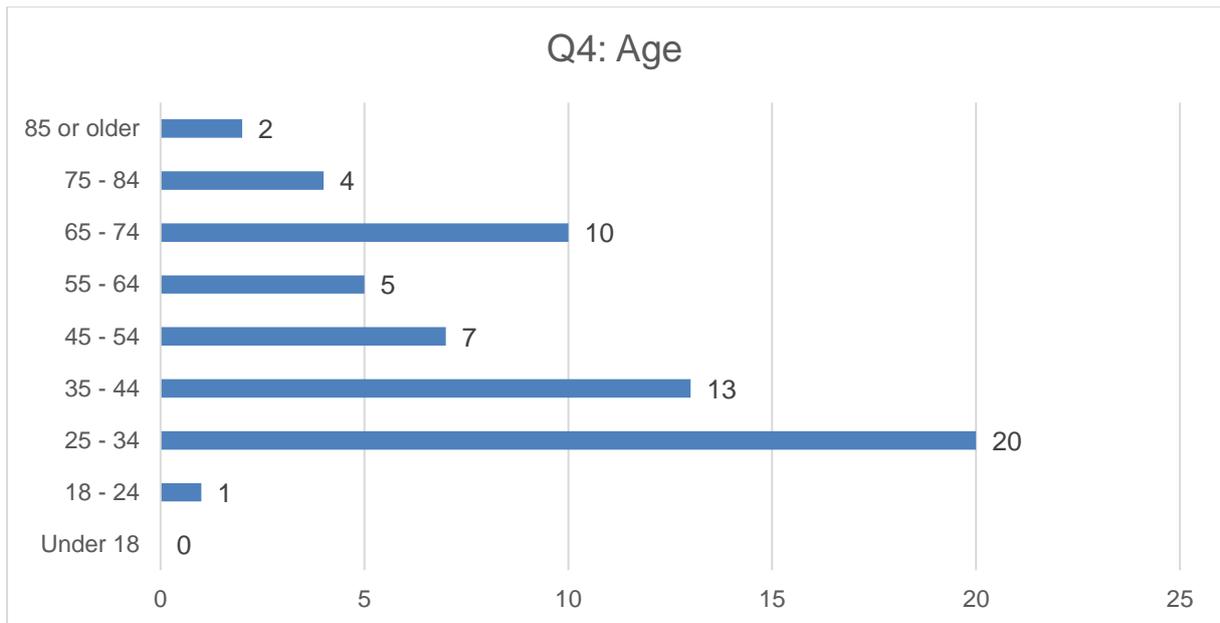


Figure 5.2 Question 4: Age

Table 5.5 Question 5: What type of patient are you? (Please select all the categories you belong to)

Answer	%	Count
Heart failure	24.19%	15
Chest pain	19.35%	12
Maternity – pre-eclampsia	56.45%	35
Total	100%	62

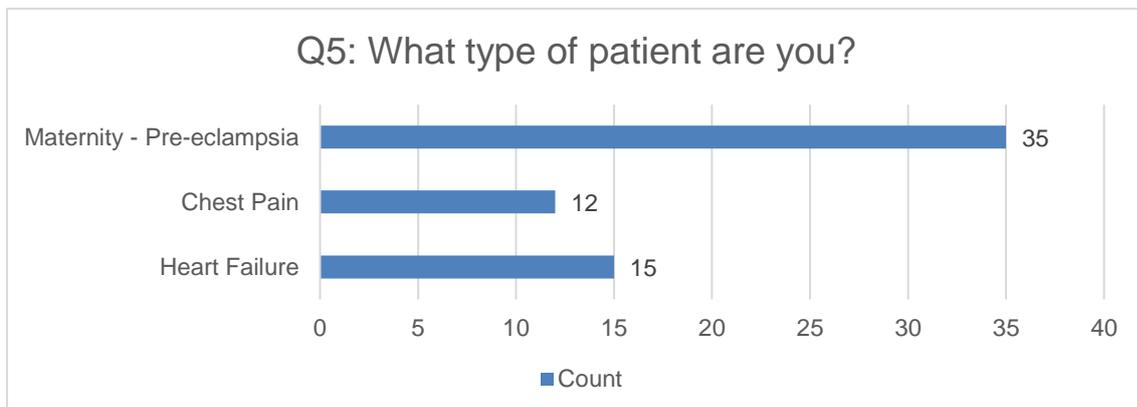


Figure 5.3 Question 5: What type of patient are you?

Table 5.6 Question 6: How long have you been using the CASI?

Answer	%	Count
Less than 3 months	26.67%	16
3-6 months	26.67%	16
6-9 months	21.67%	15
More than 9 months	25.00%	15
Total	100%	62

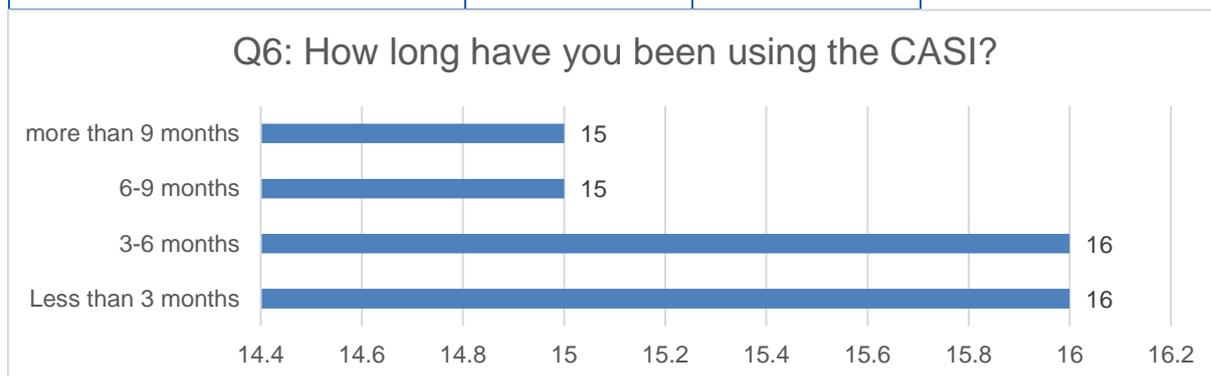


Figure 5.4 Question 6: How long have you been using the CASI?

The main themes that emerged from the key questions

- The top three expectations of using the CASI were: better communication with clinicians; ability to view test results; ability to keep digital medical records in one place.
- 87% of the participants turn to CASI when they need health-related information.
- Aspects that participants liked most about the CASI were: ability to access health data; feeling of receiving continuity of care; and increased awareness of their health condition/s.
- Participants believe using the CASI saves them time and money. However, they also mentioned a number of other benefits such as being less stressed about not being able to get the test results and appreciating the comfort of being able to be monitored at home, especially during COVID-19.
- Participants most dislike the user interface, which is not easy to use and navigate. Participants also mentioned: not being able to share the data with private clinics, GPs or consultants from other hospitals; reports and tests not being easy to understand; and receiving too many messages which are not relevant.
- The main functions of the CASI, including viewing test results, in-app communication and viewing a care plan, are found to be easy to use. Participants like the email notifications, which can take them directly to the updates.

The themes that emerged from the survey supported and validated the results from the patient interviews and clinician interviews/focus group.

Table 5.7 Question 7: What do you expect from using the CASI ? (you can choose more than one option)

Answer	%	Count
Better communication with healthcare professionals	27.27%	39
Able to view/book/reschedule appointments online	17.48%	25
Able to have medical records in one place	21.68%	31
Able to view test results using the app	26.57%	38
Able to see nearby A&E waiting times	4.20%	6
No expectations	1.40%	2
None of the above-mentioned options (please specify)	1.40%	2

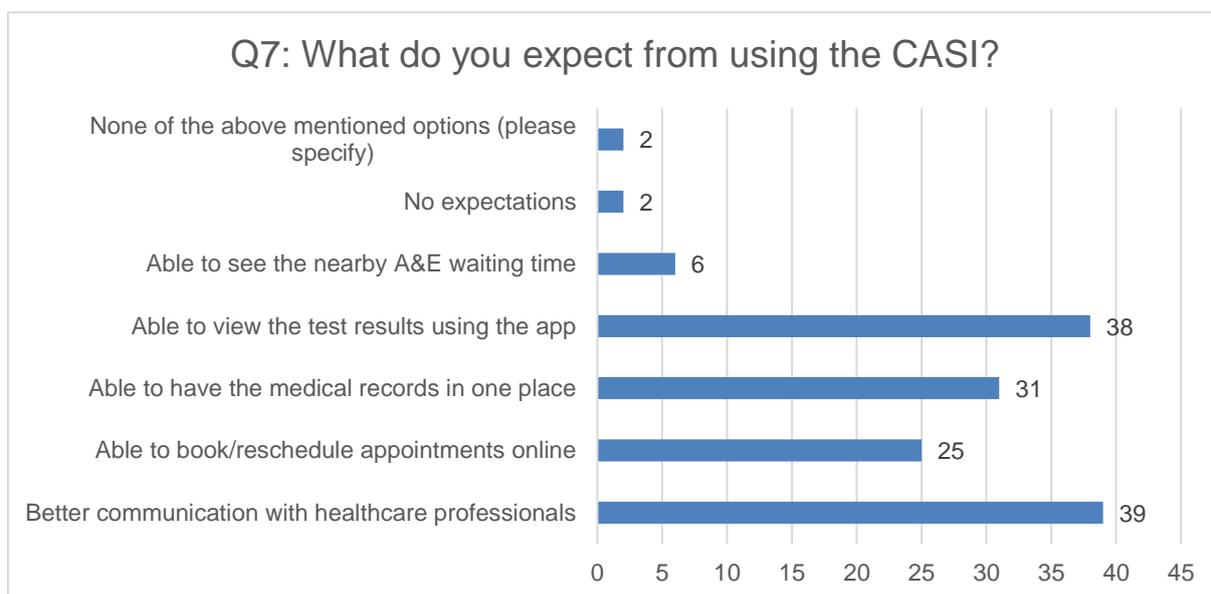


Figure 5.5 Question 7: What do you expect from using the CASI?

Table 5.8 Question 8: How often do you turn to the CASI when you need health-related information?

Answer	%
Almost always	9.43%
Often	16.98%
Sometimes	37.74%
Seldom	22.64%
Never	13.21%
Total	100%

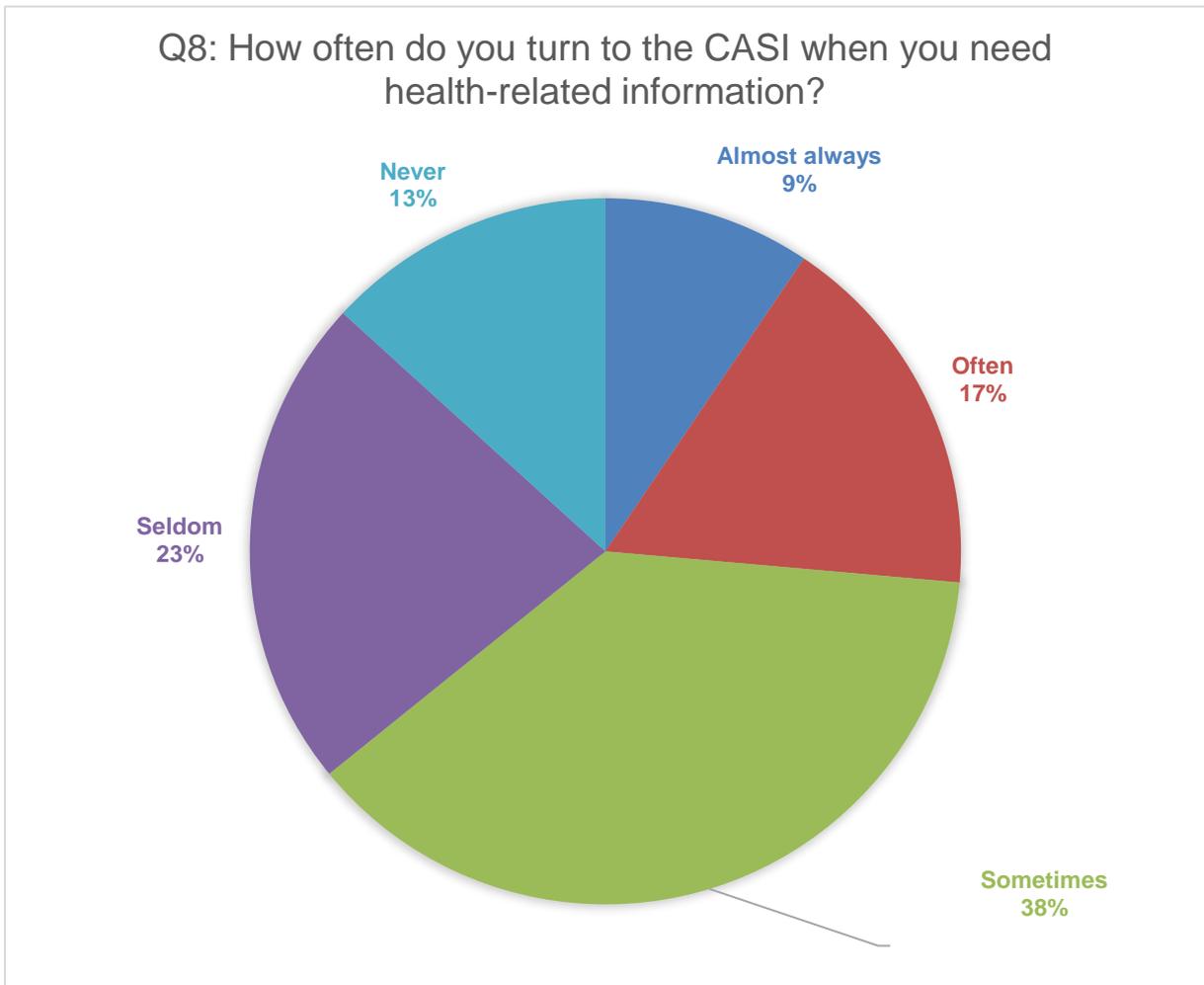


Figure 5.6 Question 8: How often do you turn to the CASI when you need health-related information?

Table 5.9 Question 9: What do you LIKE about the CASI ? (You can choose more than one option)

Answer	%
Increase the awareness of my health condition	15.50%
Support me to play an active role in my own health (for example, able to book and reschedule my appointments, choose which A&E to attend, communicate better with clinicians)	11.63%
Other (please specify)	2.33%
Feel I am receiving good continuity of care	18.60%
Get access to my health data (able to keep my medical records, tests, etc. in one place)	32.56%
Help me make decisions about my health	10.85%
Reduce duplication (appointments and tests)	8.53%

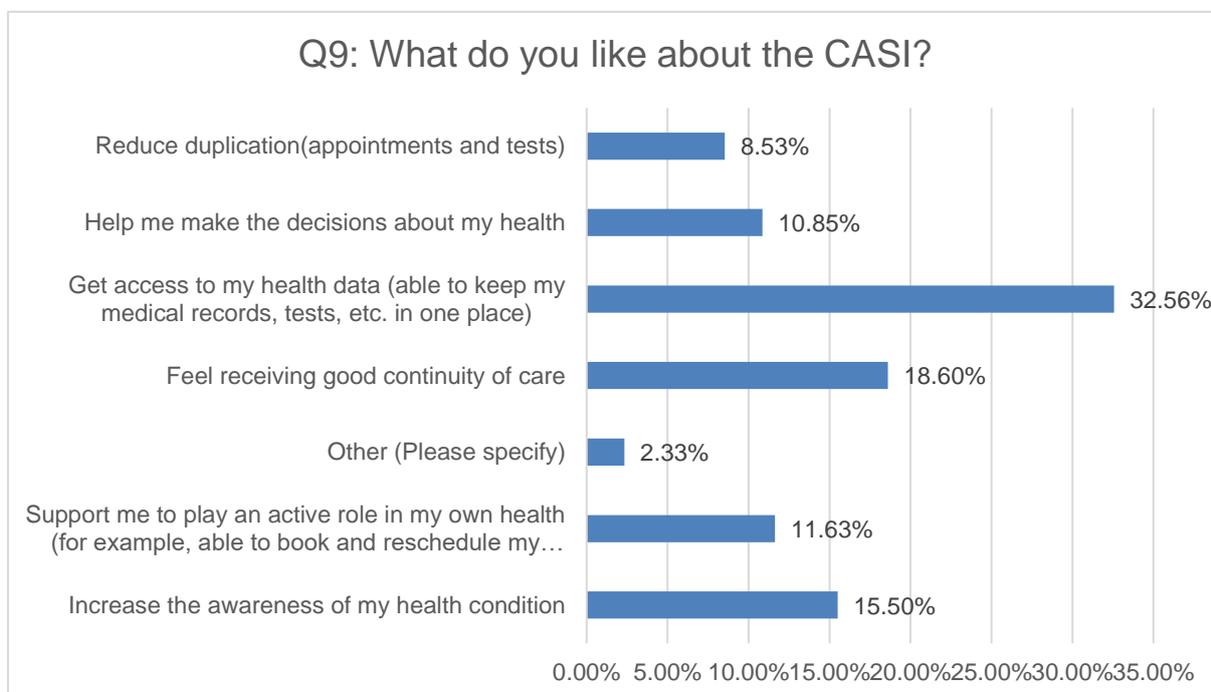


Figure 5.7 Question 9: What do you LIKE about the CASI?

Table 5.10 Question 10: What BENEFITS do you get from using the CASI ? (You can choose more than one option)

Answer	%
Time saving: easier appointment booking and rescheduling	28.57%
Time saving: less A&E waiting time	7.14%
Expense saving: saving on transportation from and to hospitals/GPs	17.86%
Expense saving: reducing potential work and life disruption	14.29%
Other (please specify)	32.14%
Total	100%

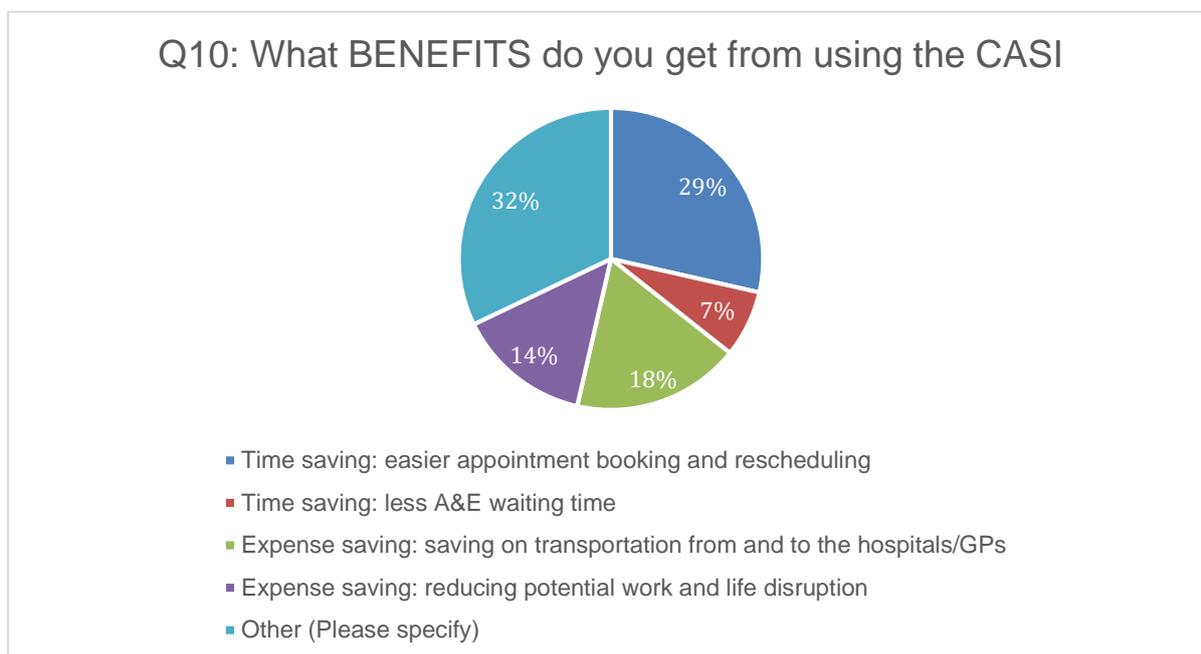


Figure 5.8: Question 10: What BENEFITS do you get from using the CASI ?

Table 5.11 Question 11: What do you DISLIKE about the CASI ? (You can choose more than one option)

Answer	%	Q11
The user interface is not intuitive (not easy to use)	33.82%	23
Some functions I want are not there	11.76%	8
It does not work well (errors while using it)	11.76%	8
None	25.00%	17
Other (please specify)	17.65%	12

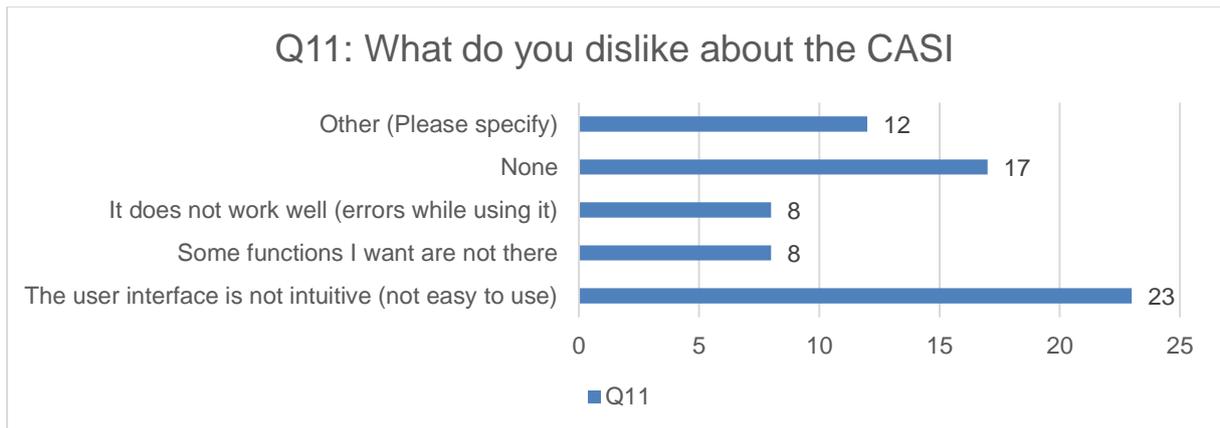


Figure 5.9 What do you *DISLIKE* about the CASI ?

Table 5.12 Question 12: Which functions of the CASI do you think are *EASY* to use? (You can choose more than one option)

Answer	%	Q12
Email notification	28.30%	30
In-app communication with clinicians	11.32%	12
Viewing my care plan	18.87%	20
Appointment booking	6.60%	7
Viewing the A&E waiting time of nearby hospitals	0.00%	0
Other (please specify)	5.66%	6
Viewing my test results	29.25%	31

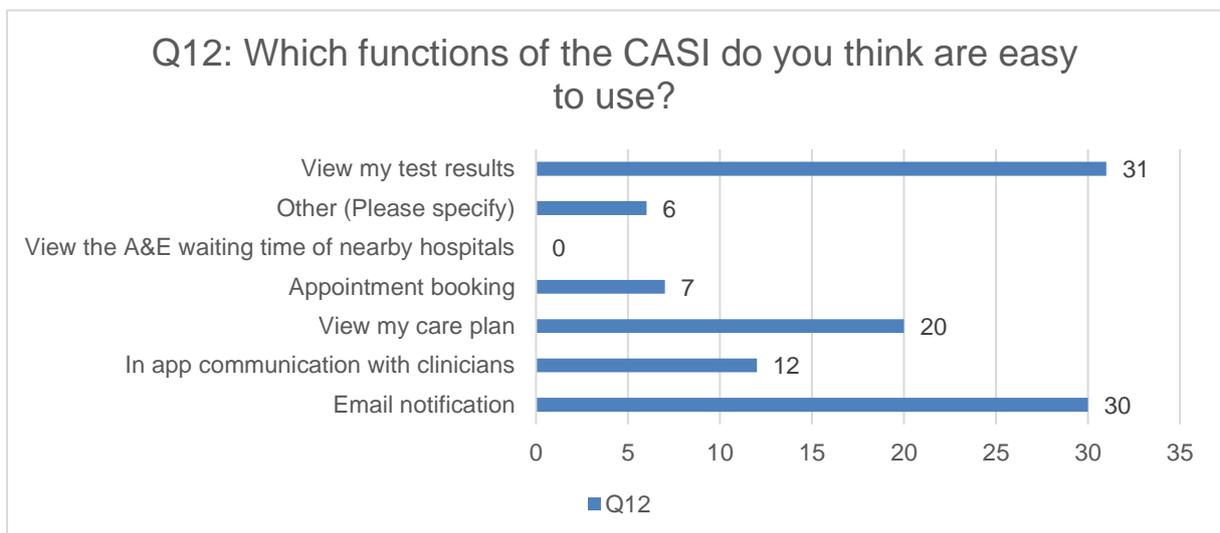


Figure 5.10 Question 12: Which functions of the CASI do you think are *EASY* to use?

Table 5.13 Question 13: Which functions of the CASI do you think are DIFFICULT to use? (You can choose more than one option)

Answer	%	Q13
Navigation	21.88%	21
Communication with clinicians	17.71%	17
Viewing the care plan	9.38%	9
Viewing test results	11.46%	11
Booking an appointment	17.71%	17
Viewing the A&E waiting time of nearby hospitals	12.50%	12
Other (please specify)	9.38%	9

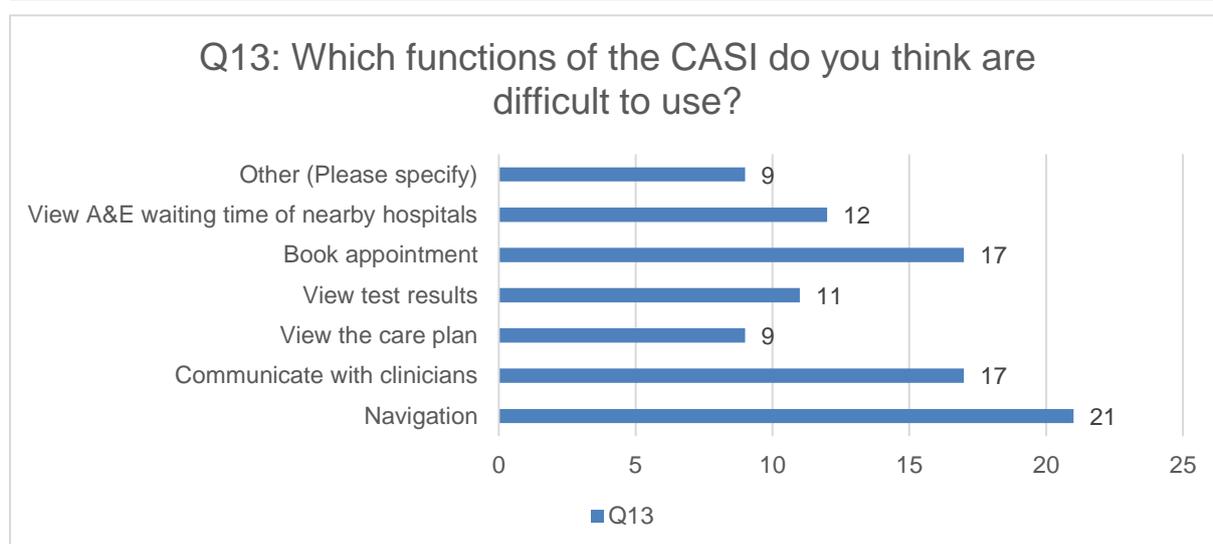


Figure 5.11 Question 13: Which functions of the CASI do you think are DIFFICULT to use?

The overall evaluation of the CASI

92% of participants believe that the CASI is useful in helping them manage their health, and 86% of patients believe that the CASI is useful in helping them improve their wellbeing. More than half of the patients agree that it has been particularly useful during COVID-19, especially in getting access to health data and receiving good continuity of care (for example, scheduling a telephone consultation rather than a hospital visit). 78% of participants are satisfied with the services provided by the CASI and 86% will keep using it.

Table 5.14 Question 14: Overall, how useful do you think the CASI is in helping you MANAGE your health?

Answer	%
Extremely useful	16.00%
Very useful	32.00%
Moderately useful	30.00%
Slightly useful	14.00%
Not at all useful	8.00%

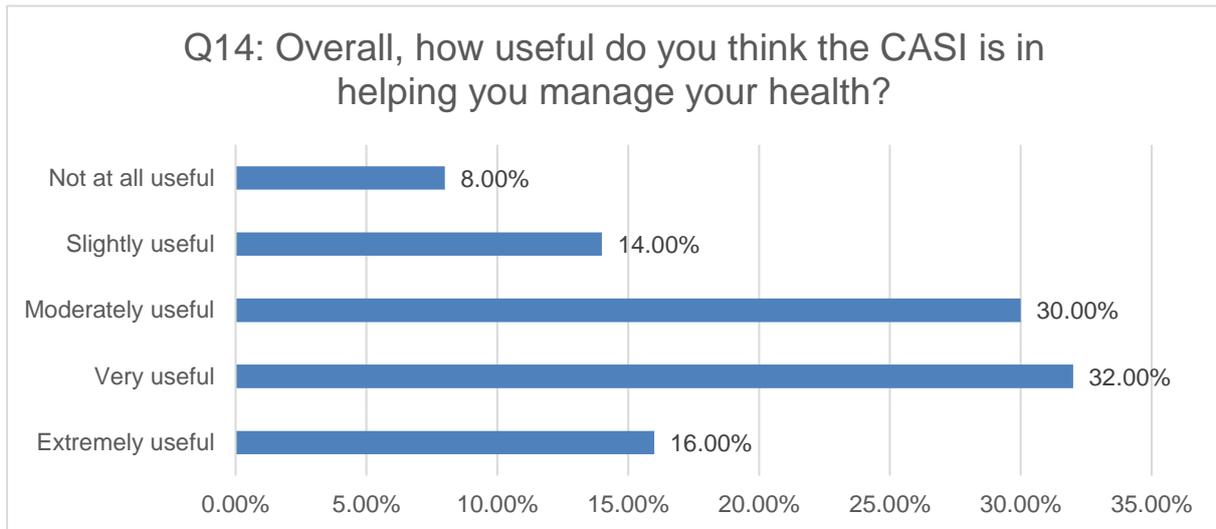


Figure 5.12 Question 14: Overall, how useful do you think the CASI is in helping you MANAGE your health?

Table 5.15 Question 15: Overall, how useful do you think the CASI is in helping you IMPROVE your wellbeing?

Answer	%
Extremely useful	9.80%
Very useful	35.29%
Moderately useful	29.41%
Slightly useful	11.76%
Not useful at all	13.73%

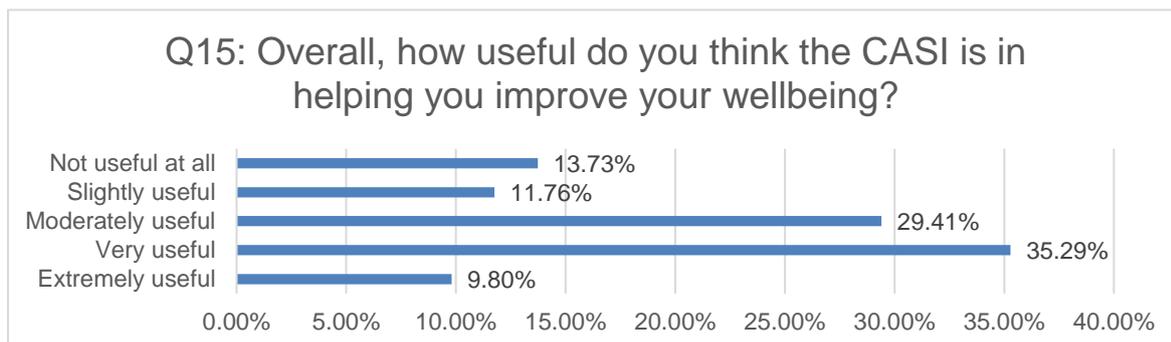


Figure 5.13 Question 15: Overall, how useful do you think the CASI is in helping you IMPROVE your wellbeing?

Table 5.16 Question 16: Do you find the CASI particularly useful in the COVID-19 situation?

Answer	%
Yes	58.82%
No	41.18%
Total	100%

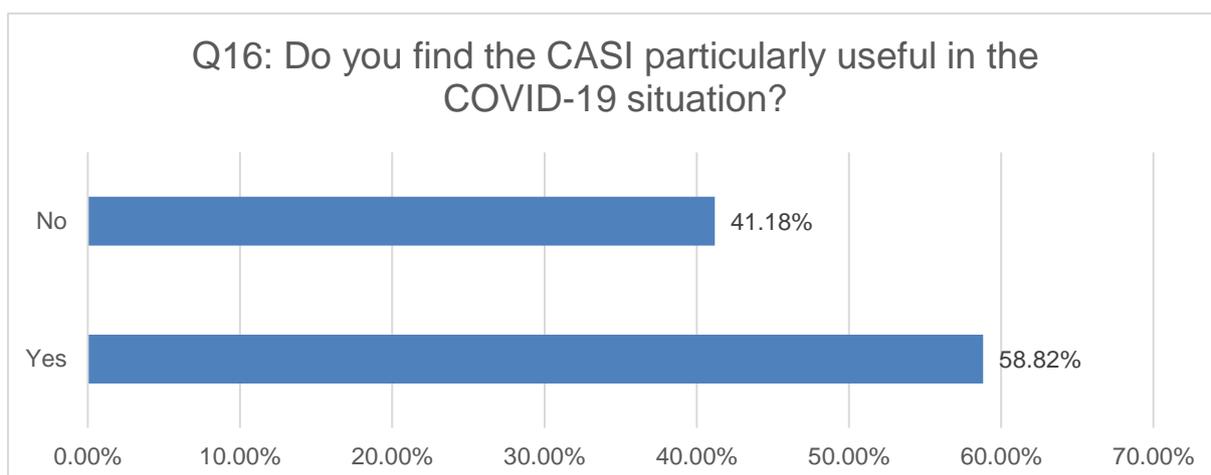


Figure 5.14 Question 16: Do you find the CASI particularly useful in the COVID-19 situation?

Table 5.17 Question 16.1: Which of the following functions do you think are the most useful in the COVID-19 situation? (You can choose more than one option)

Answer	%
COVID-19 care plan for those who have symptoms	6.25%
Get access to my health data (able to keep my medical records, tests, etc. in one place)	27.50%
Increase the awareness of my health condition	15.00%
Feel that I am receiving good continuity of care (for example, scheduling a telephone consultation rather than a hospital visit)	18.75%
Support me to play an active role in my own health (for example, able to book and reschedule my appointments, choose which A&E to attend, communicate better with clinicians)	12.50%
Help me make decisions about my health	10.00%
Reduce duplication (appointments and tests)	8.75%
Other (please specify)	1.25%

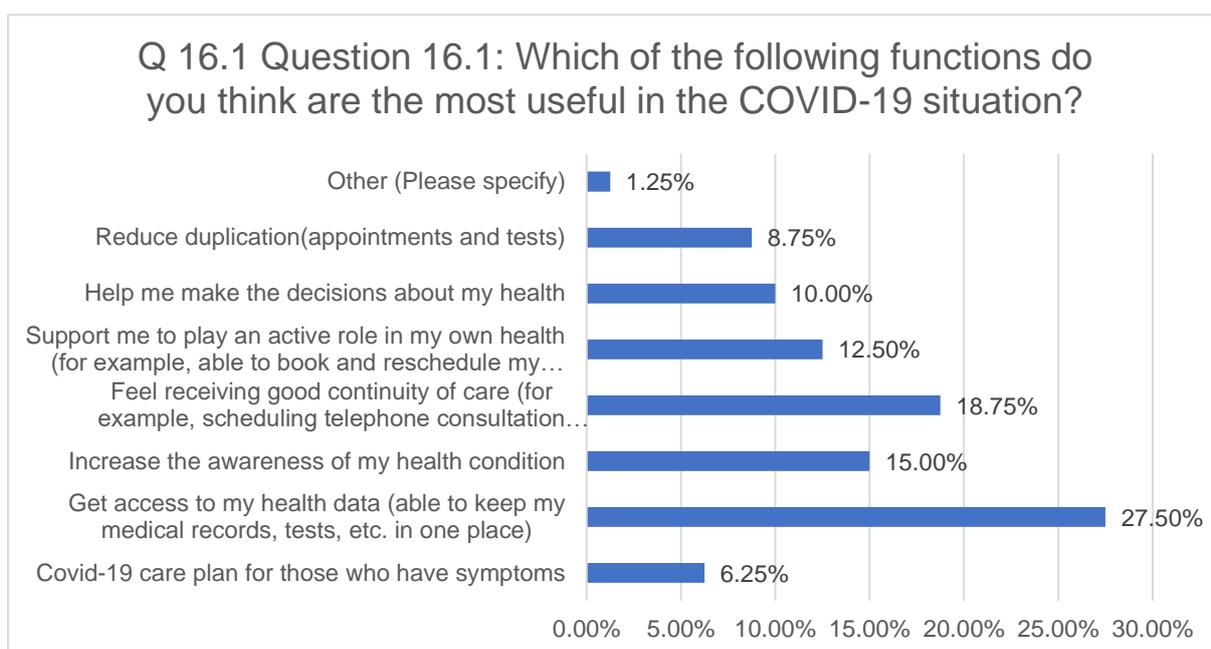


Figure 5.15 Question 16.1: Which of the following functions do you think are the most useful in the COVID-19 situation?

Table 5.18 Question 17: Overall, are you satisfied with the healthcare experience that the CASI provides?

Answer	%
Yes	78.00%
No	22.00%
Total	100%

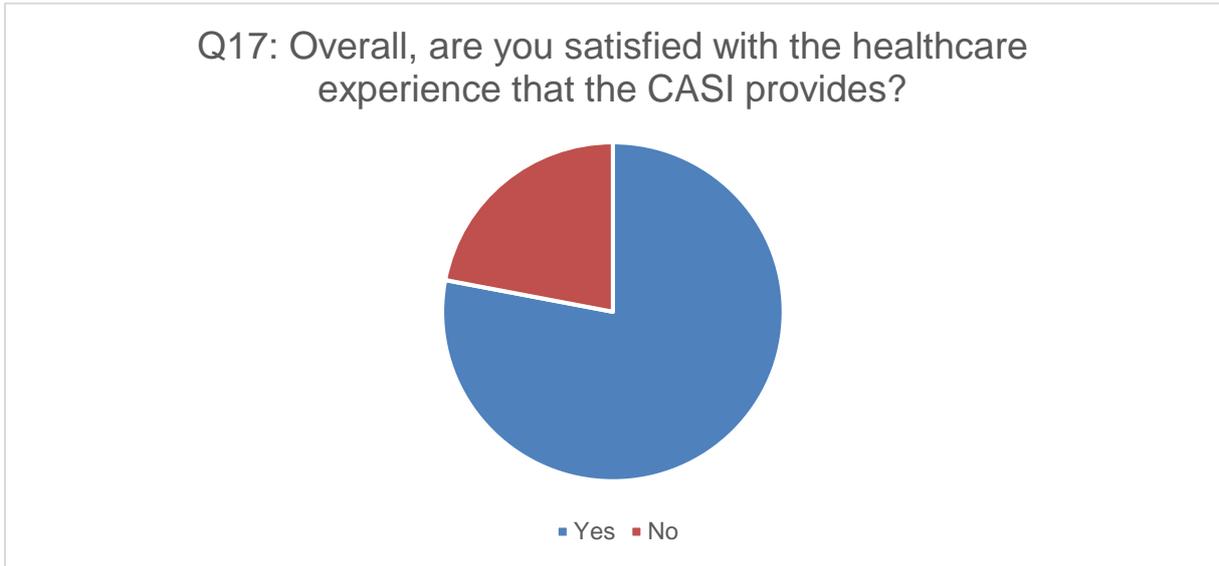


Figure 5.16 Question 17: Overall, are you satisfied with the healthcare experience that the CASI provides?

Table 5.19 Question 18: Will you keep using the CASI?

Answer	%
Yes	86.27%
No	13.73%

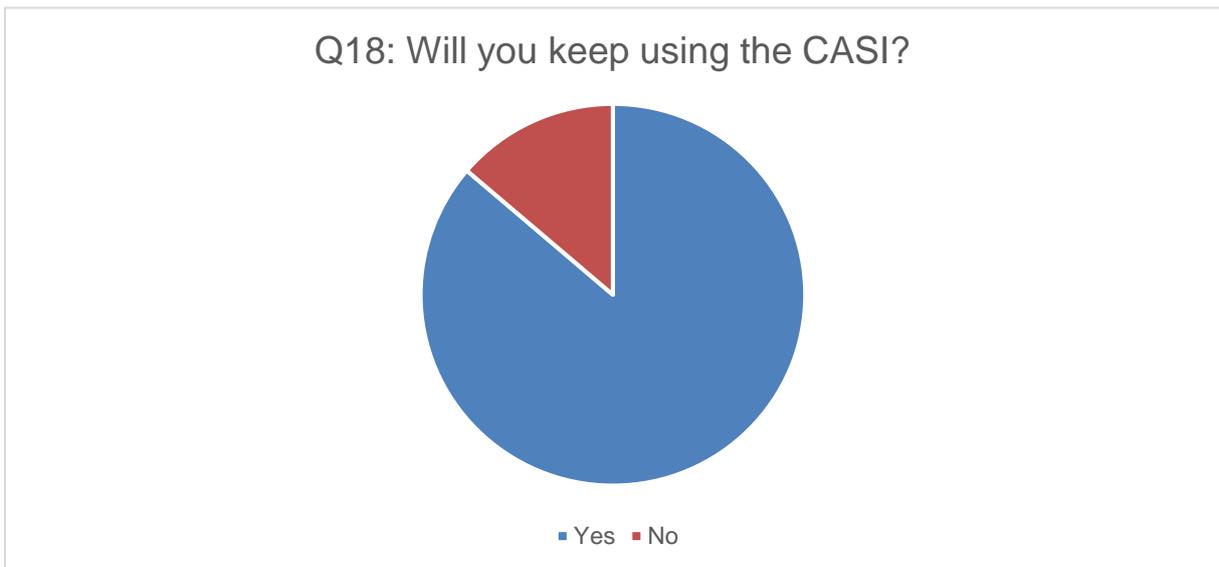


Figure 5.17 Question 18: Will you keep using the CASI ?

5.4 Summary

Key outcomes

The main benefit that the CASI has brought to the healthcare system is reduction of unnecessary/unplanned hospital attendances, which was one of the primary aims of the Test Beds programme. Clinicians also believe that using the CASI improves health outcomes thanks to the remote monitoring function and in-app communication. These were further confirmed by the patient interviews and patient experience survey. In addition, the clinicians confirmed that adopting the CASI facilitated health service delivery, but it didn't change the clinical pathways in terms of the way they diagnose, treat and manage patients.

Patients agree that reducing unnecessary/unplanned hospital attendances saves them both time and expense. Being able to view their test results and communicate with clinicians in-app allow them to be more proactive in managing their health. They can now access their health information promptly and get feedback from clinicians quickly, which greatly improve their awareness of their health condition/s, their autonomy and their healthcare experience, all of which address the main health outcomes that the Test Beds programme aims to achieve.

Both clinicians and patients believe that the CASI played a positive role in the COVID-19 pandemic. It facilitated the continuity of care service delivery, reducing unnecessary/unplanned hospital attendance, and helped to keep both clinicians and patients safe.

Main barriers

The main barriers to clinicians and patients adopting the CASI are usability, time constraints and the complementary devices needed to perform the functionalities. However, both clinicians and patients believe that the CASI is a valuable innovation for the healthcare system and are looking forward to its improvement or to similar digital health technologies being implemented.

Limitations

Due to COVID-19, all the patient interviews and the majority of the clinician interviews were conducted online or via telephone. Two main limitations presented in the process evaluations are selection bias and sample size. The interviewed patients were selected by clinicians, and so might not represent the general population. Additionally, the number of chest pain patients interviewed is low as many of the selected patients did not answer the calls when they were contacted by IVD researchers.

Table 5.20: Test Beds outcome table – Appendix 2 Logic Model

Key Test Beds outcomes achieved	
Reduced unnecessary/unplanned visits	✓
Increased patient wellbeing	✓
Improved patient experience	✓
Patients having greater awareness of their condition	✓
Improved health outcomes	✓
Increased patient satisfaction	✓
Greater awareness of heart failure in the community	✓
Improved diagnostics (earlier, more accurate)	✓
Increased patient activation/autonomy	✓
Improved patient access	✓
Improved health-related quality of life	✓

6 Impact evaluation

6.1 Data source

The main data source was the administrative data from WSIC, which holds linked primary, acute, mental health, community, and adult social care data for over 2.5 million NW London residents. We used the hospital administrative data to establish pre-existing trends in ED presentation, hospital non-elective admissions, bed days, readmissions, and wider performance measures such as referral to treatment times for whole departments.

The NIHR London IVD Co-op utilised the WSIC dataset as a source of baseline patient data to inform the comparator groups for the impact evaluation. We identified a comparable target population with common trends (i.e. similar target patients whose historical trends for each of our outcomes matched those in the new app package area). The comparator groups were selected from the patients who were eligible for the CASI but did not register for it for each pathway.

The final data extraction from WSIC took place in July 2020. The data used in the statistical analysis included 2,079 patients in the chest pain cohort, 1,605 patients in the heart failure cohort, and 85 patients in the pre-eclampsia group.

Table 6.1 Testbed number of medical visits to primary and secondary care.

	GP appointments	GP DNA	A&E	OP DNA	Referrals	Emergency hospital admissions
Chest Pain	57,587	2,482	3,705	1,537	199	1,768
Heart Failure	76,353	2,413	3,623	1,852	291	2,630
Pre-eclampsia	1,488	122	120	93	5	58

6.2 Methodology

6.2.1 Data collection

Patients were identified by clinicians to enrol in the Test Beds Programme. The data was routinely collected by the data controllers: CWFT and PKB. Patient identifiers (NHS numbers) were then transferred from CWFT to WSIC. WSIC created pseudonymised patient keys for the patient records identified in the WSIC dataset. The pseudonymised patient keys were used by an ICHP analyst to extract data for the London IVD analyst to conduct data analysis. Patients who were eligible for the Test Beds programme but did not register for the CASI were used as the control group.

6.2.2 Assumptions

The data was organised in months. March and April 2020 were removed from the analysis in order to discount for the effect of COVID-19, which massively reduced the number of emergency and primary care visits. Observations with missing dates for a particular outcome were removed from the analysis.

6.2.3 Analysis

Interrupted time series models (ITS) (Lopez et al., 2017) were used to assess the impact of releasing the application. All patients were in the control group until they registered. The registry date for the patients who registered within the study period was available and used to determine the number of registered and un-registered patients in each month. The outcome variable was a count (for example, number of A&E visits per 1000 patients), the applied ITS

models were Poisson regression models. The Poisson regression models contained polynomial terms to model the time, a variable to look at the seasonality in quarters and a binary variable that took the value 1 to indicate the group of registered patients at that time point and 0 for the un-registered patient at that time. Seasonality was not significant in any of the models, probably because the study period was not long enough. P-values <0.05 were considered significant.

The available primary care outcome variables were the number of GP visits and the number of GP DNA (did not attend) visits. The secondary outcomes were the number of A&E visits, the number of referrals, the number of outpatient DNA visits and emergency hospital admissions. The outcome variables were standardised to 1,000 patients to augment the number of events and to enable comparison between registered and non-registered cohorts as the non-registered cohort was larger.

Costs for A&E visits, referrals and unplanned hospital admissions were modelled similarly, but in this case the outcomes follow a normal distribution, and they were standardised as costs per visit/appointment.

Models could not be applied for the pre-eclampsia patients because of the small sample size. We selected the data where at least 10 patients were in the registered group. In consequence, the chest pain cohort data started at month 10 and the heart failure data at month 8.

Adjustments for seasonality were factored into the analysis. The residuals were checked to see whether they fulfilled the assumption of constant variability and were centred in zero. The studentised residuals vs predicted values were used to detect outliers. When an outlier was detected, its impact was assessed removing it from the data. Autocorrelation and partial autocorrelation plots for the residuals were used to determine whether the time series were stationary with the time terms introduced in the model.

Time series graphs for all outcomes were plotted to visually evaluate the effect of the Test Beds programme and the progression of the control group.

6.3 Results

6.3.1 Descriptive analysis

The monthly registration rate was very poor (Figures 6.1 and 6.2). The percentages of registered patients in February 2020 for the chest pain and heart failure cohorts were 24% and 23,5% respectively. There were only 1.6% of chest pain patients registered in September 2019 and 1.3% of heart failure patients registered in January 2019. The sample size of pre-eclampsia patients was already small but only 8/85 patients registered in November 2019 with only three months to finish the study period (Figures 6.1 and 6.2).

The late registration of patients considerably reduced the number of months were the intervention could be evaluated.

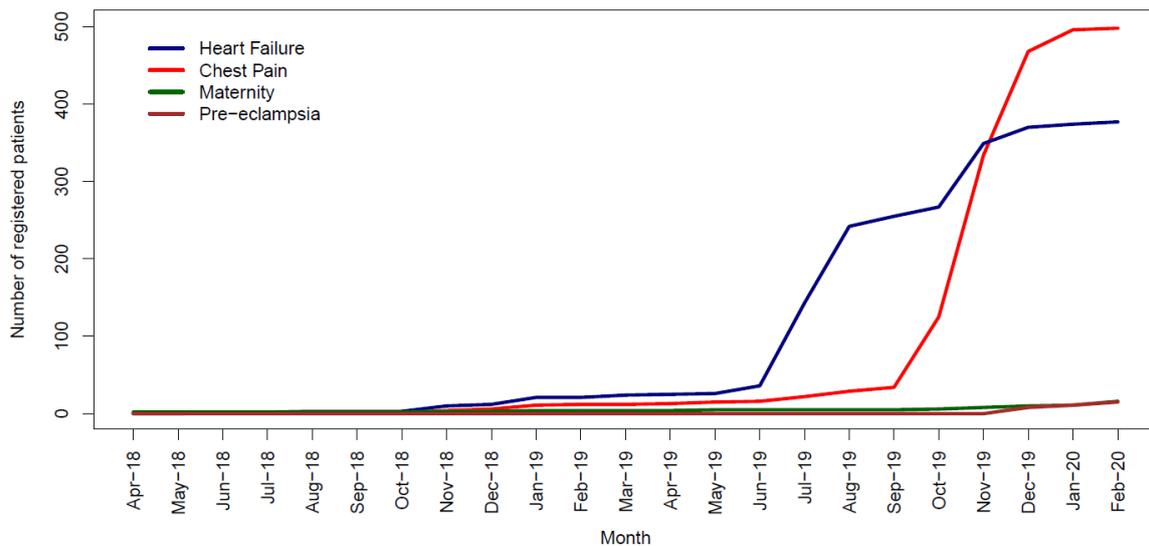


Figure 6.1 Cumulative number of registered patients in the study period for all cohorts.

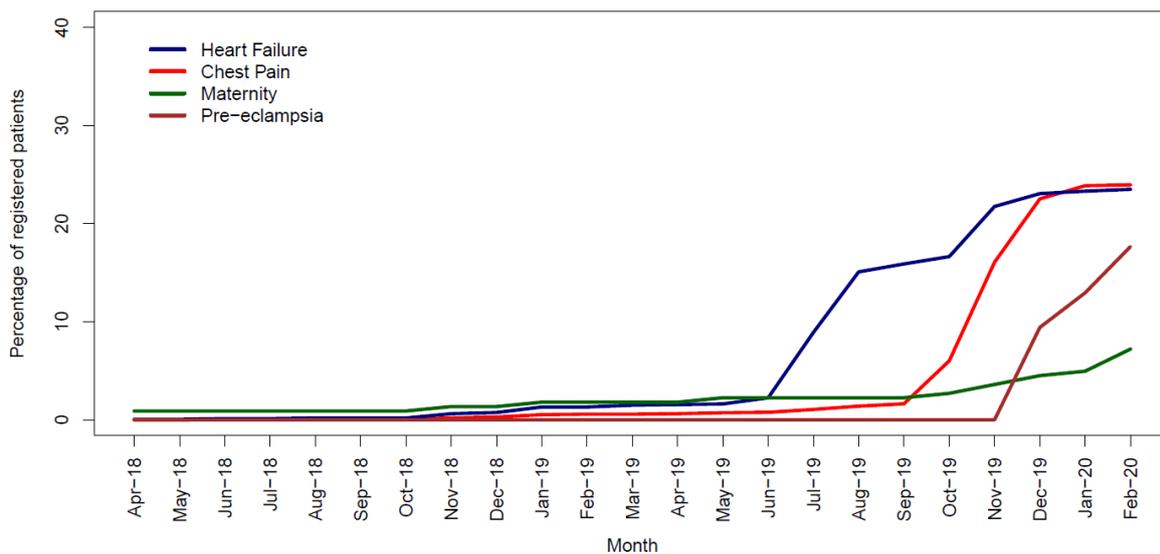


Figure 6.2 Percentage of registered patients out of the total number of patients for each cohort.

6.3.2 Impact of the Test Beds programme in the NHS

Chest pain

Primary care

The release of the application did not have any statistically significant effect on the number of unattended GP appointments (Figure 6.4 and Table 6.2). There were significant differences between the registered and unregistered group for the GP appointments. The interactions between the group and month and month² were significant. Figure 6.3 shows a greater number of GP appointments in the registered group in September and October 2019 that influence the

results, and it could be a data artifact caused by the small number of registered patients at that time.

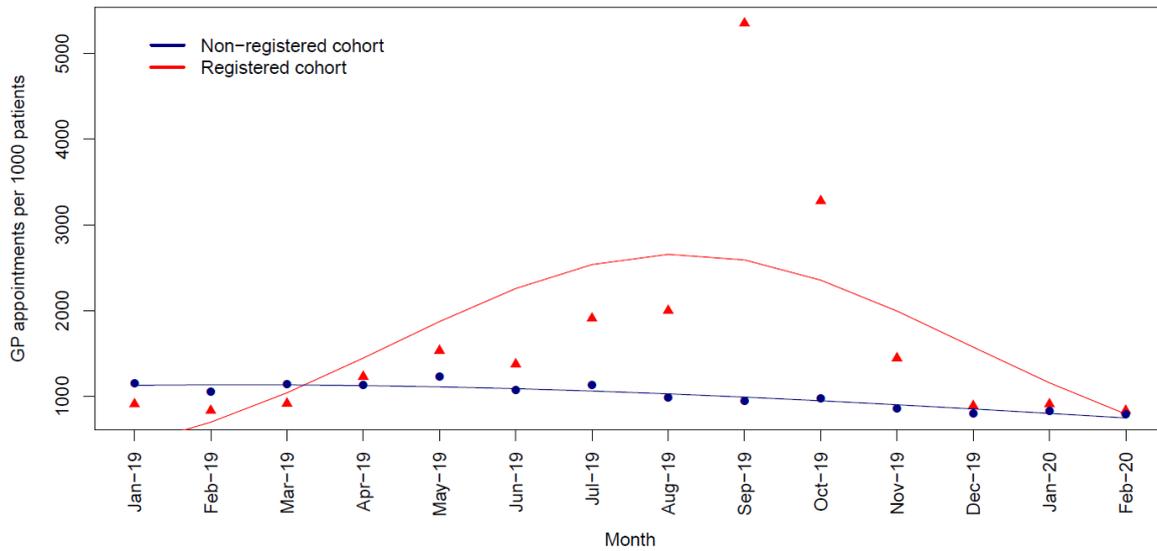


Figure 6.3 Chest pain cohort. Time series for standardised GP appointments per 1,000 patients. Lines represent the Poisson regression model fit for the registered (blue) and non-registered cohorts (red). Points are the number of GP appointments per month and group.

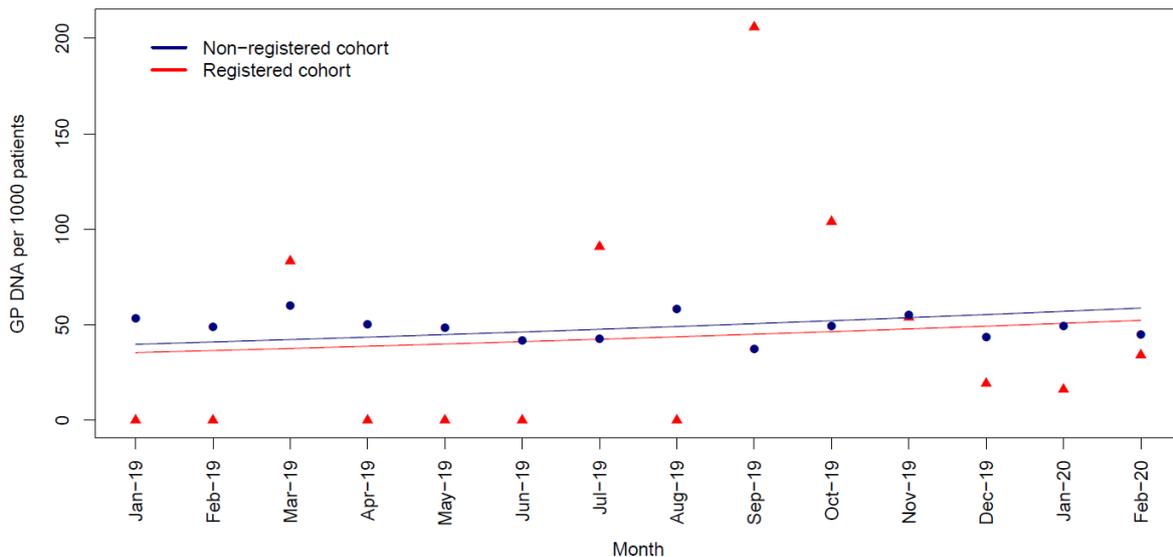


Figure 6.4 Chest pain cohort. Time series for standardised GP DNAs per 1,000 patients. Lines represent the Poisson regression model fit for the registered (blue) and non-registered cohorts (red). Points are the number of GP DNAs per month and group.

Secondary care

There were no significant differences between both groups in the number of referrals and outpatient DNAs. There was significant difference in the number of A&E visits (p-value=0.0299). The registered group presented a larger number of A&E visits in the study period. The differences seemed very large caused by the effect of the standardisation in the closed to zero number of visits per patient in each group, but the p-value showed a borderline difference (Table 6.2 and Figure 6.5).

The group variable in the analysis of the emergency hospital admissions presented significant interactions with month and month² as we observed previously in the study of GP appointments. The model tries to fit different shapes for each group. The non-registered group showed a constant trend compared to the registered group that showed a large variability across the months. This variability was probably caused by the small number of registered patients until October 2019. The last four months both groups seemed to have similar standardise rate (Figure 6.8)

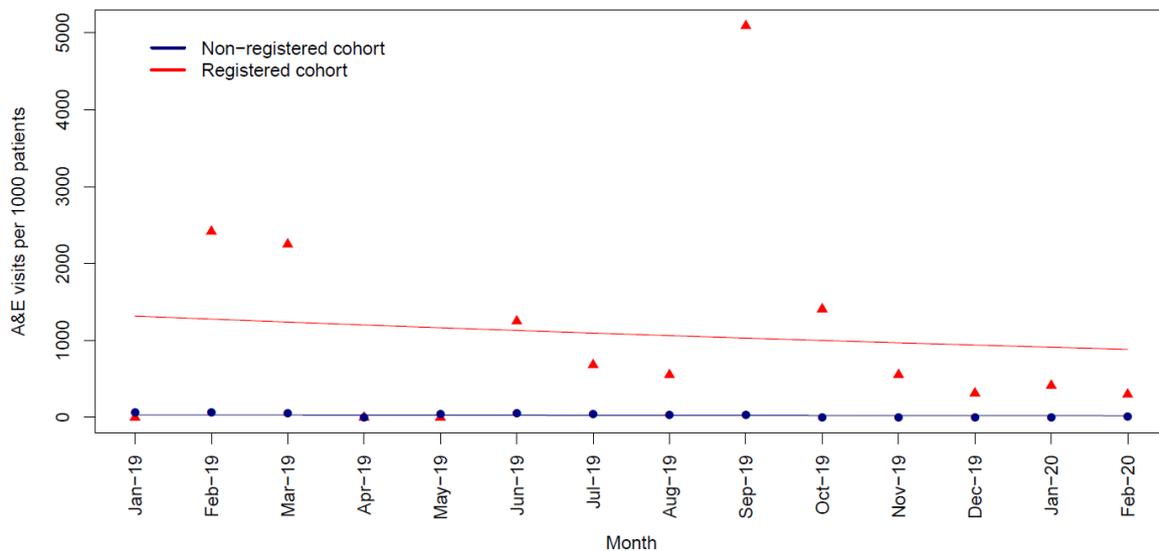


Figure 6.5 Chest pain cohort. Time series for standardised A&E visits per 1,000 patients. Lines represent the Poisson regression model fit for the registered (blue) and non-registered cohorts (red). Points are the number of A&E visits per month and group.

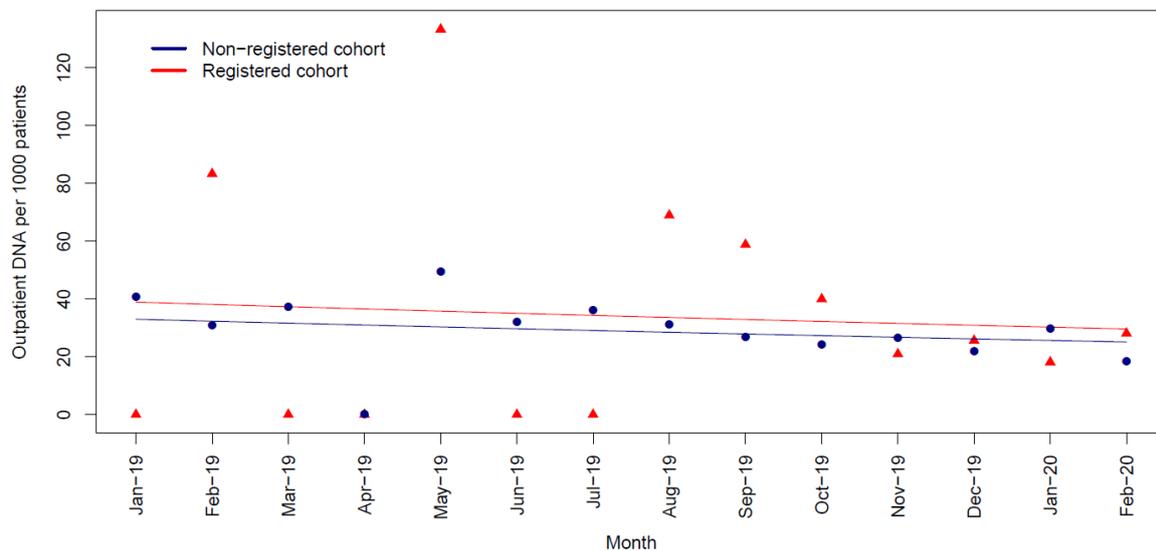


Figure 6.6 Chest pain cohort. Time series for standardised unattended outpatient appointments per 1,000 patients. Lines represent the Poisson regression model fit for the registered (blue) and non-registered cohorts (red). Points are the number of outpatient DNAs per month and group.

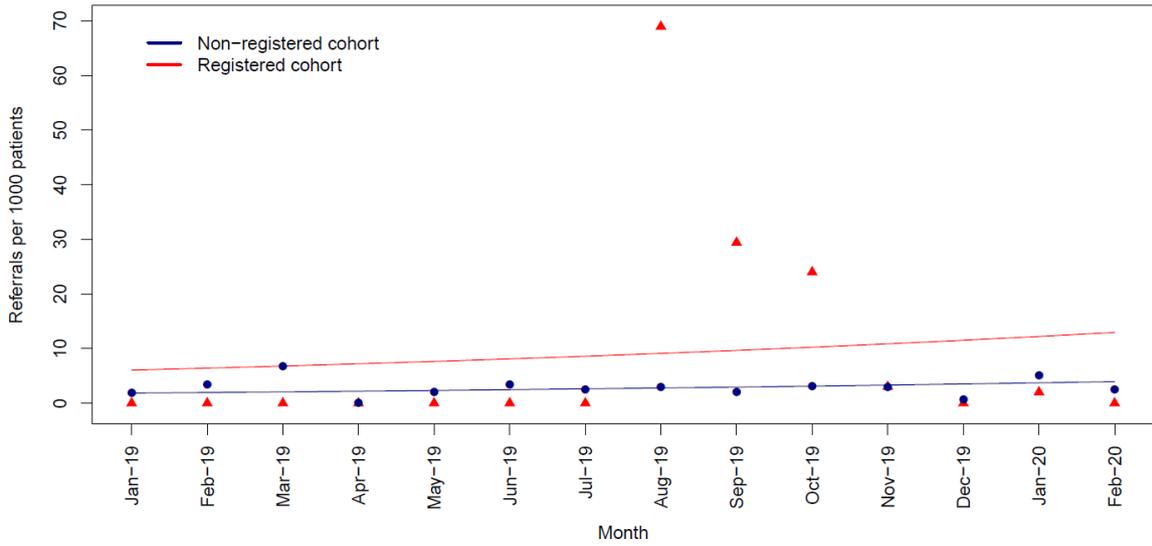


Figure 6.7 Chest pain cohort. Time series for standardised referrals per 1,000 patients. Lines represent the Poisson regression model fit for the registered (blue) and non-registered cohorts (red). Points are the number of referrals per month and group.

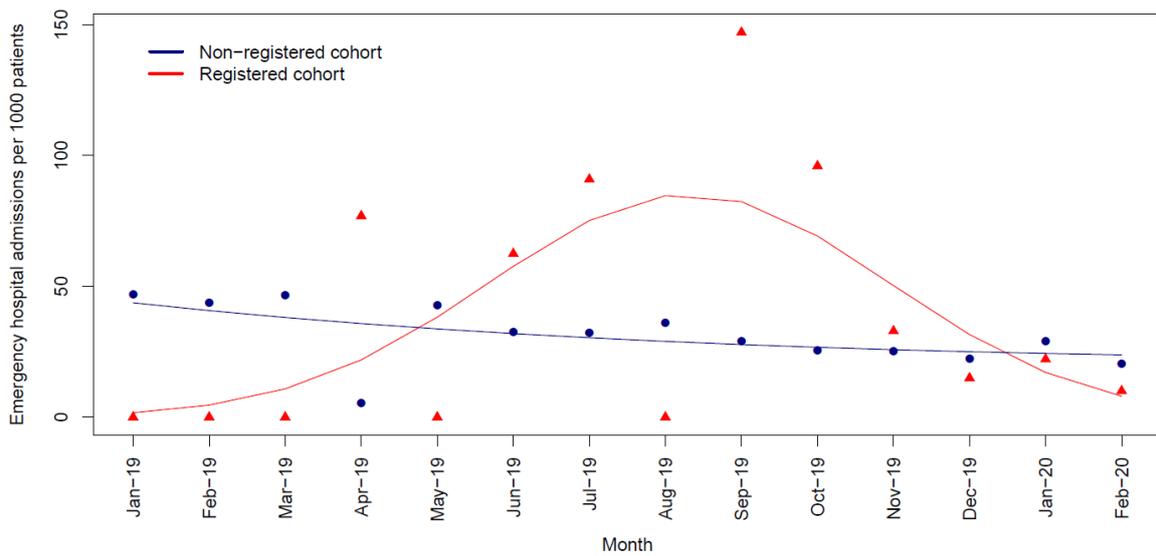


Figure 6.8 Chest pain cohort. Time series for standardised emergency hospital admissions per 1,000 patients. Lines represent the Poisson regression model fit for the registered (blue) and non-registered cohorts (red). Points are the number of emergency hospital admissions per month and group.

Heart failure cohort

Primary care

There were no significant changes in the primary care measures after the intervention in both groups (Table 6.2 and Figures 6.9, 6.10).

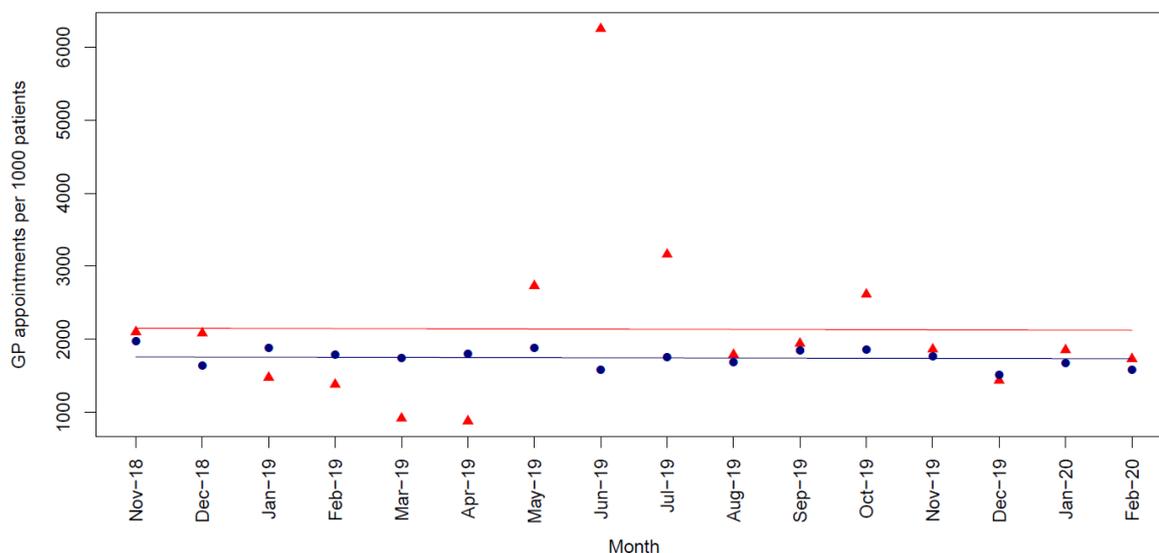


Figure 6.9 Heart failure cohort. Time series for standardised GP appointments per 1,000 patients. Lines represent the Poisson regression model fit for the registered (blue) and non-registered cohorts (red). Points are the number of GP appointments per month and group.

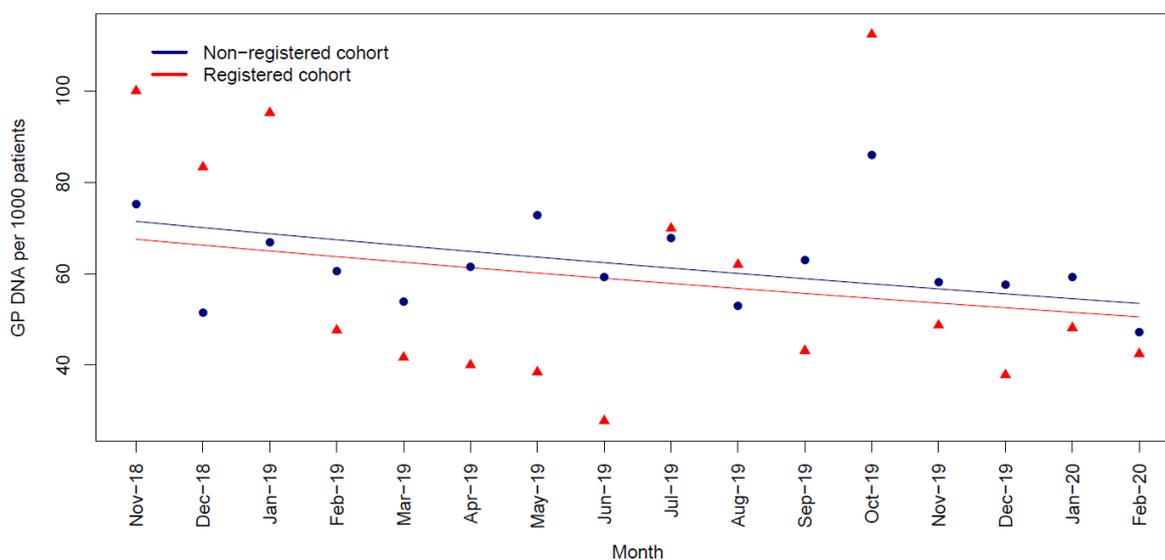


Figure 6.10 Heart failure cohort. Time series for standardised unattended GP appointments per 1,000 patients. Lines represent the Poisson regression model fit for the registered (blue) and non-registered cohorts (red). Points are the number of GP DNAs per month and group.

Secondary care

There were no significant differences in the number of referrals (p-value= 0.541), outpatient DNAs (p-value= 0.331) and emergency hospital admissions (p-value= 0.818). Although the number of A&E visits was significantly larger for the registered group, we observed the same

problem as in the chest pain cohort, the number of registered patients was very low in May and June 2019.

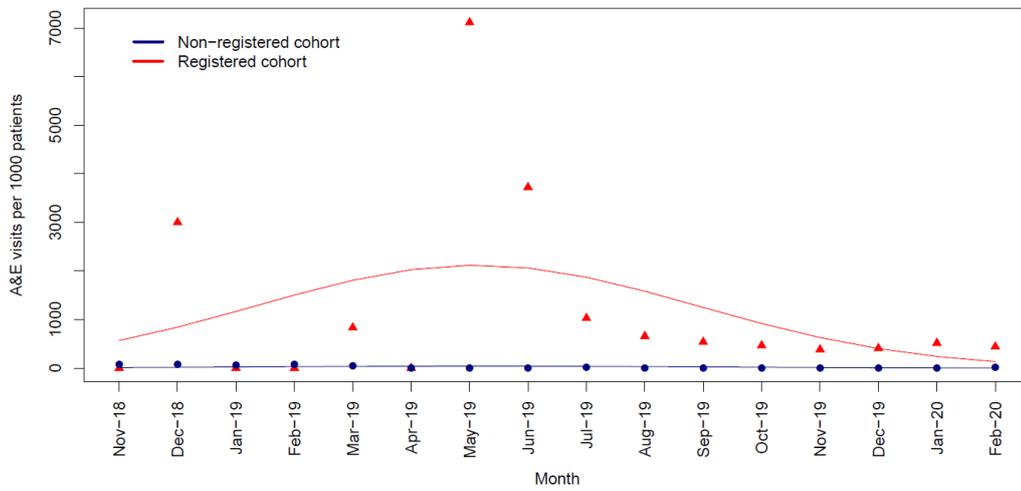


Figure 6.11 Heart failure cohort. Time series for standardised A&E visits per 1,000 patients. Lines represent the Poisson regression model fit for the registered (blue) and non-registered cohorts (red). Points are the number of A&E visits per month and group.

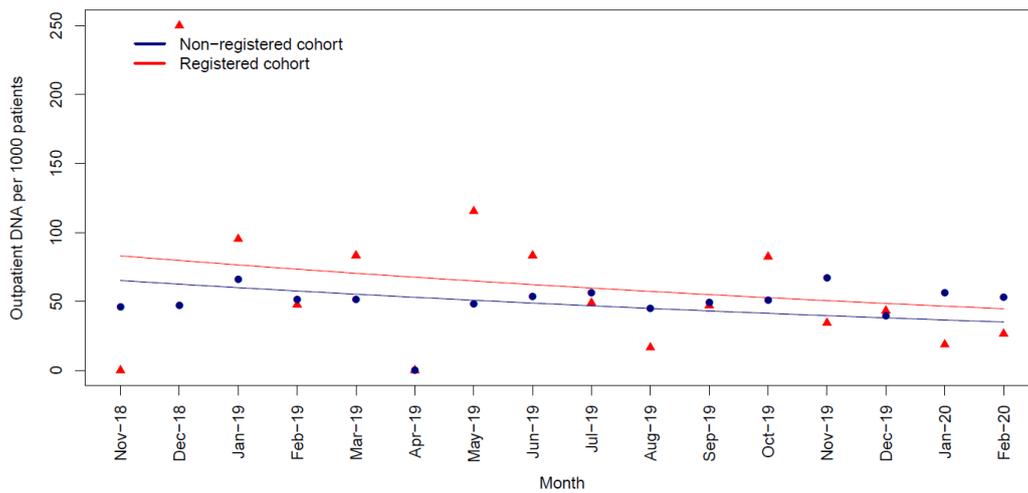


Figure 6.12 Heart failure cohort. Time series for standardised unattended outpatient appointments per 1,000 people. Lines represent the Poisson regression model fit for the registered (blue) and non-registered cohorts (red). Points are the number of outpatient DNAs per month and group.

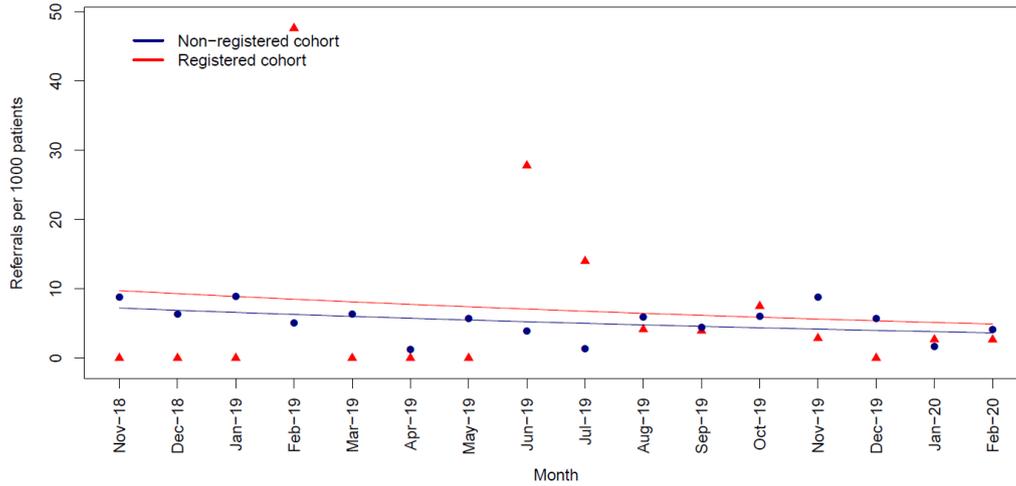


Figure 6.13 Heart failure cohort. Time series for standardised referrals per 1,000 people. Lines represent the Poisson regression model fit for the registered (blue) and non-registered cohorts (red). Points are the number of referrals per month and group.

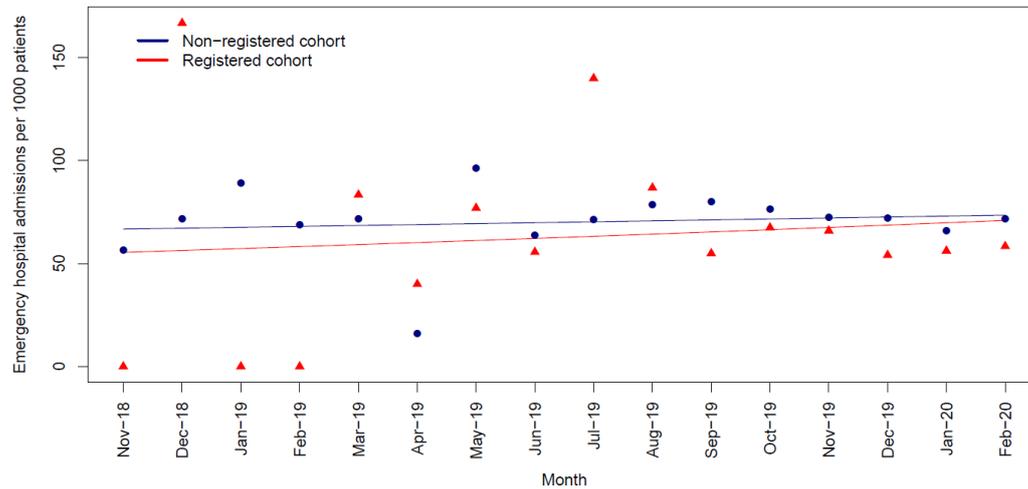


Figure 6.14 Heart failure cohort. Time series for standardised emergency hospital admissions per 1,000 people. Lines represent the Poisson regression model fit for the registered (blue) and non-registered cohorts (red). Points are the number of emergency hospital admissions per month and group.

Table 6.2 Interrupted time series summary results for the chest pain and heart failure cohort

Primary care				
GP attendance				
Covariates	Chest Pain Coefficient (95% CI)	P-value	Heart Failure Coefficient (95% CI)	P-value
Intercept	-2.511 (-7.277,2.256)	0.313	7.682 (7.123,8.24)	<0.0001
Month	1.212 (0.635,1.789)	0.0005	-0.001 (-0.034,0.033)	0.959
Month ²	-0.035 (-0.052,-0.018)	0.0005	-0.203 (-0.513,0.107)	0.21
Non-Registered	9.148 (2.531,15.766)	0.013		
Non-Registered*month	-1.142 (-1.965,-0.32)	0.012		
Non-registered*month ²	0.032 (0.008,0.057)	0.018		
GP unattended appointments				
Intercept	3.268 (1.671,4.865)	0.0005	4.367 (3.973,4.761)	<0.0001
Month	0.03 (-0.059,0.119)	0.514	-0.019 (-0.043,0.005)	0.125
Non-registered	0.116 (-0.599,0.831)	0.753	0.056 (-0.164,0.277)	0.619
Secondary care				
A&E visits				
Intercept	7.49 (5.507,9.472)	<0.0001	0.645 (-6.395,7.684)	0.8589
Month	-0.031 (-0.151,0.09)	0.6215	0.993 (0.014,1.973)	0.0567
Month ²			-0.035 (-0.068,-0.002)	0.0459
Non-registered	-3.713 (-6.874,-0.553)	0.0299	-3.977 (-7.29,-0.664)	0.0259
Referrals				
Intercept	1.214 (-2.054,4.483)	4.73E-01	2.641 (1.02,4.262)	0.0034
Month	0.059 (-0.123,0.24)	0.533	-0.046 (-0.149,0.057)	0.393
Non-registered	-1.187 (-2.886,0.512)	0.183	-0.3 (-1.247,0.648)	0.541
Outpatient unattended appointments				
Intercept	3.872 (2.476,5.268)	<0.0001	4.75 (3.92,5.581)	<0.0001
Month	-0.021 (-0.103,0.061)	0.619	-0.041 (-0.094,0.011)	0.133
Non-registered	-0.166 (-0.826,0.495)	0.628	-0.243 (-0.724,0.238)	0.331
Emergency hospital admissions				
Intercept	-17.475 (-29.986,-4.964)	0.012	3.883 (2.872,4.894)	<0.0001
Month	2.532 (1.063,4.002)	0.0027	0.016 (-0.045,0.078)	0.602
Month ²	-0.073 (-0.116,-0.03)	0.003	0.266 (-1.118,1.649)	0.709
Non-Registered	22.181 (7.862,36.5)	0.006	-0.01 (-0.094,0.074)	0.818
Non-Registered*month	-2.645 (-4.367,-0.923)	0.006		
Non-Registered*month ²	0.075 (0.024,0.126)	0.008		

Cost analysis

Both cohorts showed similar results. There were no significant differences between registered and non-registered patients in the average cost per A&E visit (Chest pain p-value=0.955; Heart failure p-value=0.111) or emergency hospital admission (Chest pain p-value=0.1232; Heart failure p-value=0.473).

The chest pain cohort showed the non-registered group presented higher costs per referral than the registered group (931.082 (451.064, 1411.1); p-value= 0.0009) (Table 6.3 and Figure 6.16). This significant result could be caused by the months where small numbers of chest pain patients registered. Thus, we ran the statistical model from August 2019 where 34 patients were in the registered group and the result was borderline significant (706.33 (116.59,1296,07); p-value=0.044).

Similarly, the cost per referral in the non-registered group in the heart failure cohort was significantly higher than the registered group (0.772 (0.29,1.253); p-value=0.004) (Table 6.3 and Figure 6.19). The difference is less than one pound. We also fitted the model from July 2019 and the difference became non-significant (p-value=0.073). The monthly incidence of referrals in both cohorts was very small, for most months less than 10 referrals were recorded for a non-registered population over 1,200 patients. A maximum of two referrals in a month were observed in the registered populations of both cohorts.

Table 6.3 Interrupted time series summary results for the costs in the chest pain and heart failure cohorts

Covariates	Chest pain	P-value	Heart failure	P-value
	Coefficient (95% CI)		Coefficient (95% CI)	
A&E				
Intercept	124.883 (0.284,249.482)	0.0607	4.678 (4.014,5.342)	<0.0001
Month	0.968 (-6.17,8.105)	0.7926	0.008 (-0.031,0.046)	0.698
Non-registered	1.673 (-55.871,59.217)	0.955	0.302 (-0.058,0.662)	0.111
Referrals				
Intercept	-5612.342 (-9997.556, -1227.128)	0.019	5.976 (5.102,6.85)	<0.0001
Month	727.063 (174.67,1279.456)	0.0164	0.024 (-0.103,0.073)	0.338
Month²	-20.814 (-37.456, -4.172)	0.022		
Non-registered	931.082 (451.064, 1411.1)	0.0009	0.772 (0.29,1.253)	0.004
Emergency hospital admissions				
Intercept	-9739.31 (-19166.596, -312.024)	0.0542	7.631 (6.954,8.307)	<0.0001
Month	1425.84 (238.315,2613.365)	0.0271	0.033 (-0.005,0.072)	0.103
Month²	-41.73 (-77.5, -5.96)	0.0314		
Non-registered	841.25 (-190.69,1873.19)	0.1232	0.132 (-0.223,0.486)	0.473

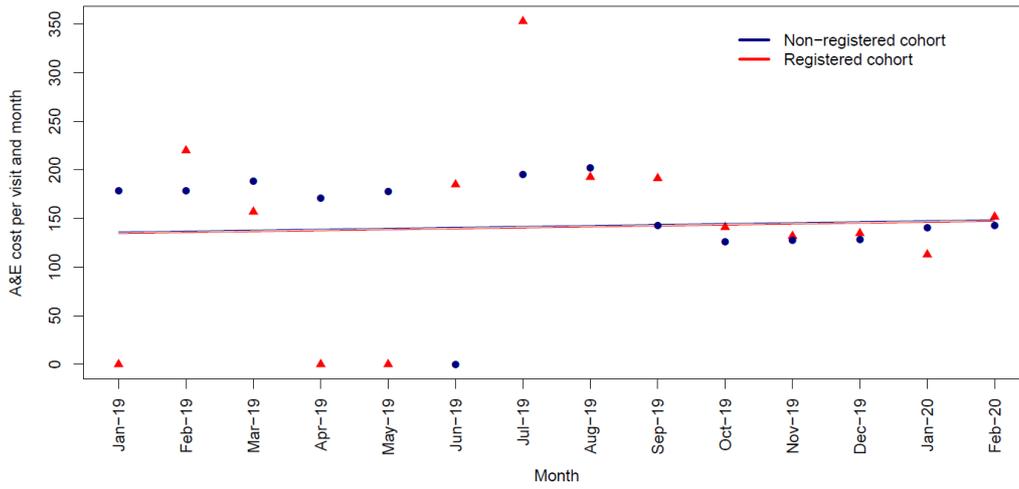


Figure 6.15 Chest pain cohort. Time series for the average monthly cost per A&E visit. Lines represent the Gaussian regression model fit for the registered (red) and non-registered (blue) cohorts

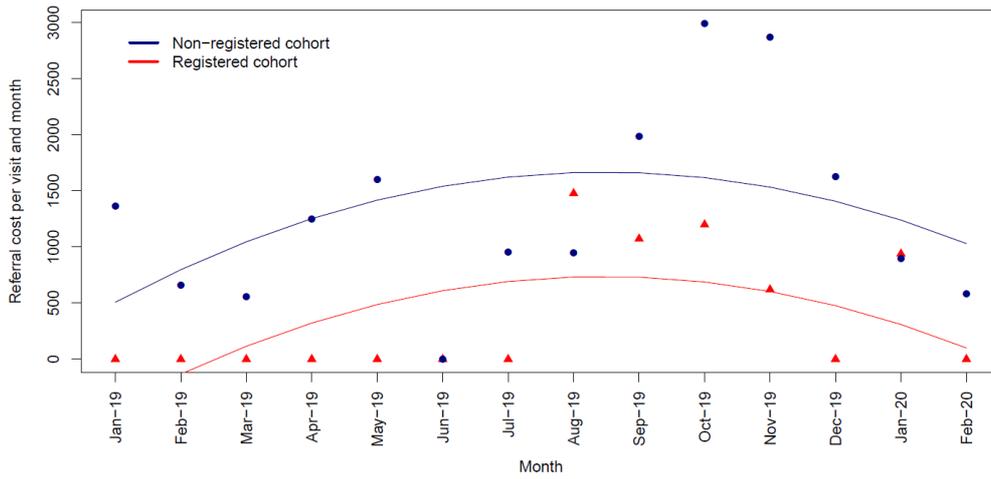


Figure 6.16 Chest pain cohort. Time series for the average monthly cost per referral. Lines represent the Gaussian regression model fit for the registered (red) and non-registered (blue) cohorts.

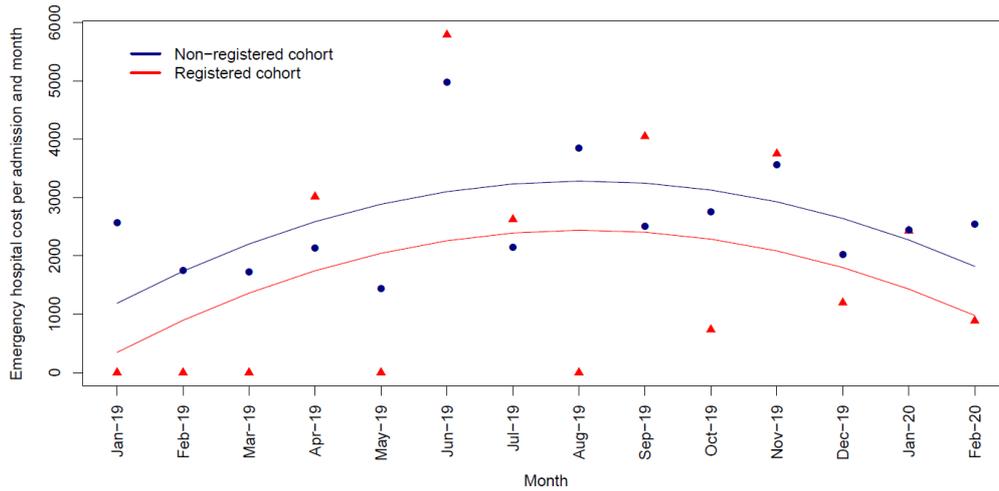


Figure 6.17 Chest pain cohort. Time series for the average monthly cost per emergency hospital admission. Lines represent the Gaussian regression model fit for the registered (red) and non-registered (blue) cohorts.

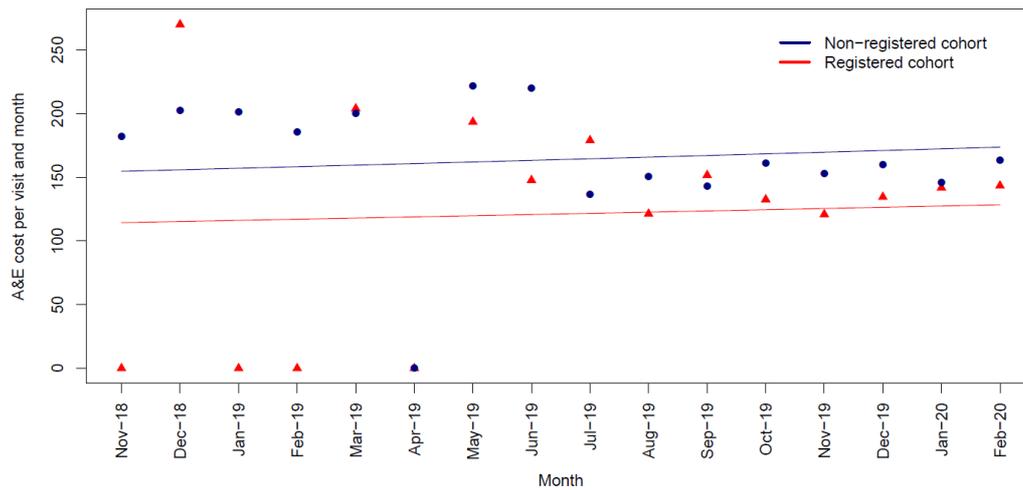


Figure 6.18 Heart failure cohort. Time series for the average monthly cost per A&E visit. Lines represent the Gaussian regression model fit for the registered (red) and non-registered (blue) cohorts.

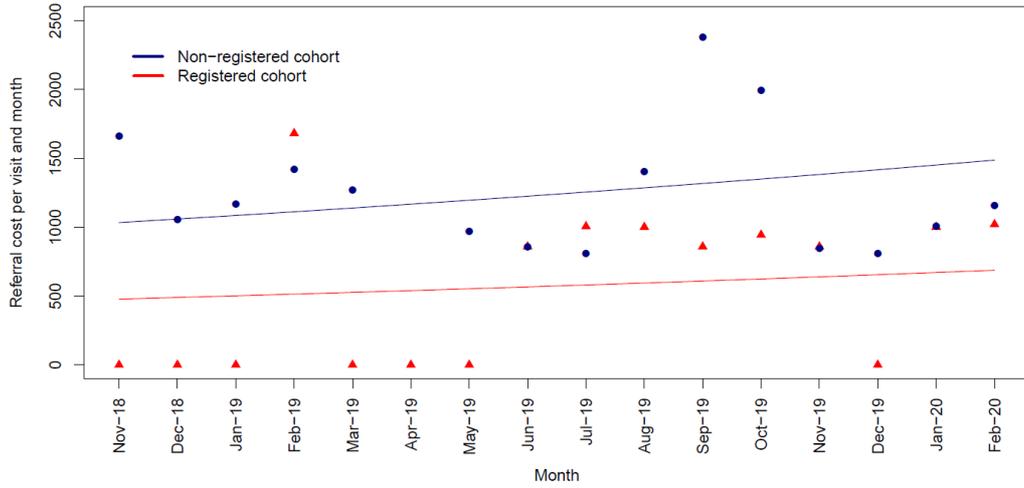


Figure 6.19 Heart failure cohort. Time series for the average monthly cost per referral. Lines represent the Gaussian regression model fit for the registered (red) and non-registered (blue) cohorts.

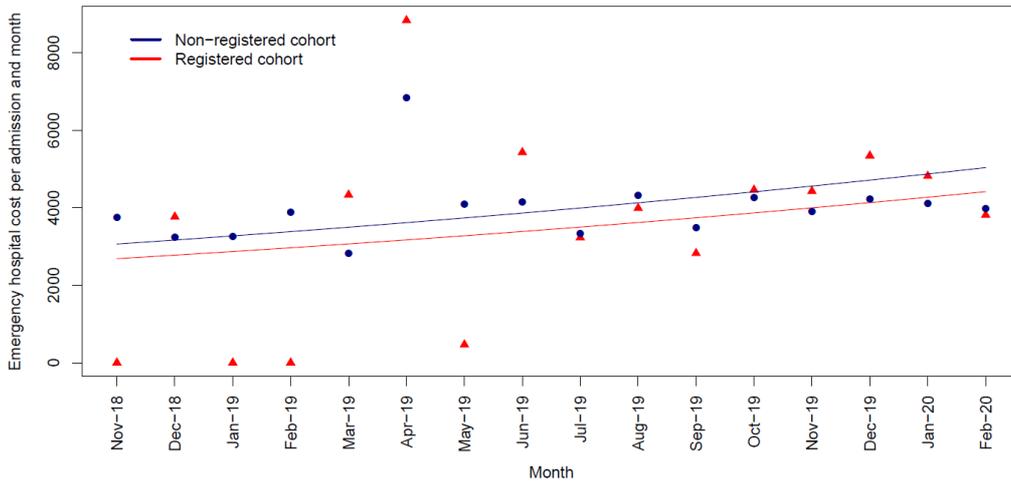


Figure 6.20 Heart failure cohort. Time series for the average monthly cost per emergency hospital admission. Lines represent the Gaussian regression model fit for the registered (red) and non-registered (blue) cohorts.

6.4 Limitations

The descriptive analysis showed that patients did not register until the last months of the study, so we observed some artifacts in the results caused by the small number of registered people. Less than 25% of patients with chest pain or heart failure condition were registered at the end of the study. A longer study period could have provided better results although it would not have been possible because of the start of the COVID-19 pandemic.

It was not possible to study the clinical impact of the intervention. We could have investigated the number of deaths or events related to the medical conditions of the study to see whether the use of CASI would lead to worse or better clinical outcomes.

The sample size of the pre-eclampsia data was not large enough to analyse the impact of CASI in this medical condition.

6.5 Statistical analysis conclusions and recommendations

There was insufficient evidence to prove any statistically significant reduction in the use of primary or secondary care. A cost reduction was found in the referrals, but we believe is an artifact of the data caused by the small referral incidence in both cohorts.

A design where patients are randomised a-priori and assigned to using or not using the system could have worked better. The problem of late registration could have been solved offering incentives or contracting a person to monitor patients' registration and use of the CASI system, and to encourage them to continue utilising CASI during the study period.

CASI is currently active. A further and more detailed evaluation of the impact of the system could be done in the future after the pandemic. The study could also target patients with more conditions. Patients' NHS numbers could be extracted from CASI and to obtain all information of those patients in the CPRD Gold and Aurum, HES A&E, HES in-patient and HES outpatient databases. These databases are national, so the number of patients would be greater and spatio-temporal statistical methods could be applied. HES databases contain all individuals going into A&E, admitted into hospital, or booking a referral appointment. Therefore, we could see the whole picture. CPRD is a GP database, it is a sample that probably represents more than 25% of the country including Gold and Aurum versions.

7 Conclusion and best practice recommendations

This evaluation concludes:

- The process evaluation confirms that the main benefit of the Test Beds programme was to reduce unnecessary/unplanned hospital attendances.
- Clinicians believe that the Test Beds programme facilitated health service delivery.
- Patients agreed that the reduction of unnecessary/unplanned hospital attendances saves them both time and expenses.
- Both patients and clinicians confirm that the Test Beds programme improved health outcomes thanks to functions such as remote monitoring and in-app communication.
- Both clinicians and patients believe that the Test Beds programme played a positive role in the COVID-19 pandemic in facilitating healthcare service delivery and keeping them safe.
- The impact evaluation concludes that the Test Beds programme's impact is not statistically significant due to the short period of time the project had been running and the short evaluation time.

PE clinician 2: "The test bed has been successfully imbedded at the Chelsea site and had really freed up ambulatory appointments and reduced admissions."

7.1 Recommendations for future work

Following the evaluation, the following recommendations have been made for future work:

- Continue to improve the usability, in particular the user interface, which could facilitate the adoption of digital health technology for both clinicians and patients.
- Provide more training to patients on how to use digital health technologies.
- Find solutions for clinicians to cope with time constraints, e.g. dealing with routine work and adopting new technologies.
- Explore the potential of digital health technology in healthcare service delivery during crises such as the COVID-19 pandemic.
- If resource allows, keep evaluating the impact once the CASI has been used for a longer period by more patients.

HF clinician 1: "Others studies have shown that the health service impact is often delayed by a year or two after an intervention like this."

8 References

1. Brazier, J., Ratcliffe, J., Salomon, J. and Tsuchiya, A. (2007). *Measuring and Valuing Health Benefits for Economic Evaluation*. Oxford, Oxford University Press.
2. Carey M. A. (1994). The group effect in focus groups: Planning, implementing, and interpreting focus group research. In Morse J. M., editor. (Ed.), *Critical issues in qualitative research methods* (pp. 225–241). Thousand Oaks, CA: Sage. [Google Scholar]
3. Carr A., Hewlett S., Hughes R., Mitchell H., Ryan S., Carr M., Kirwan J. (2003). Rheumatology outcomes: The patient's perspective. *The Journal of Rheumatology*, 30, 880–883. [PubMed] [Google Scholar]
4. Creswell J. W., Plano Clark V. L. (2007). *Designing and conducting mixed methods research*. Thousand Oaks, CA: Sage. [Google Scholar]
5. Côté-Arsenault D., Morrison-Beedy D. (2005). Maintaining your focus in focus groups: Avoiding common mistakes. *Research in Nursing & Health*, 28, 172–179. [PubMed] [Google Scholar]
6. Drummond, M., Sculpher, M., Torrance, G., O'Brien, B. and Stoddart, G. (2005). *Methods for the Economic Evaluation of Health Care Programmes*. Oxford, Oxford University Press.
7. Ericsson, K. A. and Simon, H. A. (1993). *Protocol analysis: Verbal reports as data*. Cambridge, MA, MIT Press.
8. Kitzinger J. (1995). Qualitative research: Introducing focus groups. *British Medical Journal*, 311, 299–302. [PMC free article] [PubMed] [Google Scholar]
9. Kroll T., Neri M. T., Miller K. (2005). Using mixed methods in disability and rehabilitation research. *Rehabilitation Nursing*, 30, 106–113. [PubMed] [Google Scholar]
10. Lopez Bernal J., Cummins S, Gasparrini, A (2017). Interrupted time series regression for the evaluation of public health interventions: a tutorial. *International Journal of Epidemiology*, 2017,348-355.doi:10.1093/ije/dyw098
11. National Institute For Health And Care Excellence. Evidence Standards Framework for Digital Health Technologies. March 2019
12. National Institute For Health And Care Excellence. Medical technologies evaluation programme methods guide: Process and methods. 21 August 2017
13. Stewart D. W., Shamdasani P. N., Rook D. W. (2007). *Focus groups: Theory and practice* (2nd ed.). Thousand Oaks, CA: Sage. [Google Scholar]
14. World Health Organization (2005). *Health service planning and policy-making: a toolkit for nurses and midwives. Module 2: Stakeholder analysis and networks*. Manila: WHO Regional Office for the Western Pacific.

9 Appendices

Appendix 1: Evaluation plan



Testbed Evaluation
plan_V1.0.pdf

Appendix 2: Logic models

Heart failure pain logic model



Heart failure logic
model diagram.pdf

Chest pain logic model



Chest pain logic
model diagram.pdf

Pre-eclampsia logic model



Pre-eclampsia logic
model diagram.pdf

Appendix 3: Patient interview protocol (updated with COVID-19 questions)

The semi-structured phone/face-to-face interview lasts for circa. 20 minutes. Patients are selected by the heart failure, chest pain and pre-eclampsia clinical teams at West Middlesex Hospital and Chelsea and Westminster Hospital.

Introduction: to find out about the health condition, why the patients agreed to be involved, and a bit of background about the patients such as their job.

1. Digital literacy and attitude

- 1.1 How many digital devices do you have? (For example, computer, mobile phones, tablets, etc.)
 - 1.1.1 How often do you use them?
 - 1.1.2 Do you like to use them?
- 1.2 How often do you use mobile apps? (For example, Google Maps, WhatsApp, etc.)
- 1.3 Do you use mobile apps to manage your health? If yes, how many? (For example, sports, diet, etc.)
- 1.4 Do you trust using apps to manage your health?

2. The CASI

- 2.1 Have you tried using the CASI?
- 2.2 Who recommended it to you?
- 2.3 Why do you want to use it? What's your expected gain from using this app?
- 2.4 How often do you use it?

3. The CASI user experience

- 3.1 Can you please tell me about your last experience of using the CASI?
- 3.2 What do you like about the CASI? (Time optimisation, patient activation, better awareness of your health condition)
- 3.3 What do you dislike about the CASI? (which experience frustrated you?)
- 3.4 Which functions do you think are easy to use?
- 3.5 Which functions do you think are difficult to use?

4. COVID-19 impact

- 4.1 Do you find the CASI particularly useful in the COVID-19 situation?
- 4.2 If yes, how does it help you?
- 4.3 If yes, which functions do you think are the most useful in the COVID-19 situation?

5. Overall evaluation

- 5.1 Do you think the CASI is useful for you in the sense that it is helping you to manage/improve your health?
- 5.2 Do you think the CASI adds value to the service/NHS?
- 5.3 Will you keep using the CASI?

Appendix 4: Clinician interview protocol (updated with COVID-19 questions)

1. Test Beds programme

- 1.1 How is the Test Beds programme doing? (what is your perception of the Test Beds programme)?
 - 1.1.1 How is patient uptake?
 - 1.1.2 How is clinician uptake?
- 1.2 What are the barriers/impressions?

2. Clinical pathways (if possible, ask clinicians to draw the pathways in the table below)

- 2.1 What was the clinical pathway before introducing the Test Beds programme?
- 2.2 What is the current clinical pathway with the Test Beds intervention?
- 2.3 What is the current clinical pathway with **COVID-19 impact**?

	How are patients diagnosed?	How are patients treated?	How are patients managed?
Before Test Beds			
Test Beds			
COVID-19			
Who are the stakeholders?			
Any equipment/device?			

3. Closing

- 3.1 Would you be happy to be contacted again for interviews/updates?