Imperial College London

Safety, performance, and user perceptions of RxConnect when used to provide patient-specific, indication based prescribing support

Short title: RxConnect user testing study

Study Management Group

Principal Investigator: Professor Bryony Franklin

Co-investigators: Calandra Feather

Clinical Queries

Clinical queries should be directed to Calandra Feather who will direct the query to the appropriate person

Sponsor

Imperial College London is the main research Sponsor for this study. For further information regarding the sponsorship conditions, please contact the Head of Research Governance and Integrity.

Research Governance and Integrity Team
Imperial College London and Imperial College Healthcare NHS Trust
Room 215, Level 2, Medical School Building
Norfolk Place
London, W2 1PG
Tel: 0207 594 1862

This protocol describes the RxConnect user testing study and provides information about procedures for entering participants. Every care was taken in its drafting, but corrections or amendments may be necessary. These will be circulated to investigators in the study. Problems relating to this study should be referred, in the first instance, to the Principal Investigator.

This study will adhere to the principles outlined in the UK Policy Frame Work for Health and Social Care Research It will be conducted in compliance with the protocol, Data Protection Act 2018 and General Data Protection Regulations (Europe) and other regulatory requirements as appropriate.

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1. INTRODUCTION

Background

Medication errors are the leading cause of preventable harm in healthcare settings worldwide (1). An estimated 237 million medication errors occur in England alone every year, with 66 million considered clinically significant (2). There is an estimated cost to the NHS from definitely avoidable adverse drug reactions as a result of these errors of £98.5 million per year, consuming 181,626 bed-days and causing to 712 deaths(2).

Medication related clinical decision support systems, often integrated with electronic prescribing systems, are rapidly increasing in number over the last few decades, ranging from drug-drug interaction alerts to allergy checks and formulary support. A recent systematic review summarised that these systems are still relatively immature, with limited use of patient-specific input or human factors research used to develop them (3). There is an opportunity to improve these systems significantly for the benefit of the user and for patient safety. The World Health Organization propose that interventions to reduce medication error should include the development of technologies that are well understood and designed for the systems and practice they are applied to (1).

Human factors and usability engineering is an integral part of developing medical devices, such as clinical decision support (CDS) systems, to ensure that such devices are easy to use and can be used safely as intended (4). User testing / usability testing, which may incorporate several methods, should be conductive throughout the development process (at formative, summative assessment, and during post-market surveillance) (4). These methods are now becoming more common place in healthcare technology research and should continue to support the development of new technologies (4–7).

RxConnect

RxConnect, a newly registered UKCA marked medical device, is an on-demand clinical decision support tool that receives medication and patient inputs and uses them to filter an underlying formulary, such as the BNF, and perform dosing calculations, as needed, to return patient-specific dosing recommendations. RxConnect does not have a user interface and relies on an integration with third-party systems, such as electronic prescribing systems, to deliver CDS services to clinical end users. For this study a prototype user interface for RxConnect that emulates a typical electronic prescribing system will be used.

The study team hypothesise that use of RxConnect as a digital prescribing aid is quicker, easier, and as safe to use as currently available prescribing aids. This study aims to utilise user testing to prove or disprove the above hypothesis and to generate quantitative and

qualitative outputs to support the continued development of RxConnect prior to clinical deployment.

2. STUDY OBJECTIVES

Primary objective

To determine whether the use of RxConnect as a prescribing aid, when compared with usual practice decreases or increases the number of prescribing errors

Secondary objectives

To determine whether the use of RxConnect as a prescribing aid, when compared with usual practice-

1. Decreases or increases the magnitude of dose errors
2. Decreases or increases the time to prescribe a medication
3. Decreases or increases the mental load as perceived by the prescriber
4. Alters the prescribing workflow

To explore the opinions of the participants regarding the use of RxConnect as a prescribing aid and indication-based prescribing more generally.

3. STUDY DESIGN

Study Design

A mixed-methods cross-over observational study will be conducted to explore the safety, performance, and user perceptions of utilising RxConnect to support prescribing, in comparison to current practice.

Direct observation of participants will be conducted using multi-angle audio-visual recording, this will be set up behind the computer workstation, to capture the computer display and from above to capture the workstation. The cameras will not be angled to take footage of the participant face. A member of the research team will also be present through the study session.
Prescribing scenarios will be presented on laminated paper along with any relevant patient information, e.g. patient gender, age, weight, diagnosis, relevant medical history, relevant laboratory results.

Intervention arm: Prescribing with RxConnect via a prototype user interface
Participants will be asked to complete a number of practice prescribing tasks whilst *thinking aloud* to describe their thought process and actions. To undertake the prescribing tasks, participants will be asked to use the prototype user interface emulating an electronic prescribing front end, which presents RxConnect medication guidance to the clinical end user (the participant).
Once familiarised with the software workflow, the test prescribing tasks will be given to the participant. For these tasks the participants will be asked to perform the task without the need to think aloud. If the participant wishes to continue to think aloud so long as it doesn't distract

them from completing the task. The medication order the participants have generated using RxConnect support via the user interface will then auto populate a medication order form.

Control arm: Prescribing on Cerner with existing resources
Participants will be asked to perform similarly simple and then complex tasks using their usual practice methods when prescribing. Access will be provided to the prescribers usual electronic prescribing platform, including links to the British National Formulary, Medicines complete, local antimicrobial stewardship application, local intranet, and a generic online search engine. A hard copy of the BNF and BNFc will also be readily available.
As with the intervention arm, if the participant wishes to continue to think aloud so long as it doesn't distract them from completing the task. Participants will be asked to enter their medication order for the patient within a 'test ward' on the Cerner Millennium Powerchart system.

Order of control vs intervention arm-
Each participant will be randomly assigned to begin with either the control arm or the intervention arm (Group 1 and Group 2, see Table 1). With an equal number of participants being in each group. A random team generator (https://www.randomlists.com/team-generator) will be used for randomisation (see Figure 1) and participants will be assigned their 'participant number' in the order of their participation in the study.

Table 1 - Order of study arms, Group 1 and Group 2

Group 1	**Group 2**
Practice 1 (simple) RxConnect	Practice 1 (simple) RxConnect
Practice 2 (complex) RxConnect	Practice 2 (complex) RxConnect
Test scenario 1 Control	Test scenario 1 RxConnect
Test scenario 2 Control	Test scenario 2 RxConnect
Test scenario 3 Control	Test scenario 3 RxConnect
Test scenario 4 RxConnect	Test scenario 4 Control
Test scenario 5 RxConnect	Test scenario 5 Control
Test scenario 6 RxConnect	Test scenario 6 Control

Figure 1 Example of participants randomised into two groups

Group 1					
1 Participant 5	2 Participant 43	3 Participant 19	4 Participant 3	5 Participant 34	6 Participant 23
7 Participant 30	8 Participant 27	9 Participant 21	10 Participant 22	11 Participant 7	12 Participant 1
13 Participant 10	14 Participant 36	15 Participant 32	16 Participant 26	17 Participant 46	18 Participant 14
19 Participant 33	20 Participant 31	21 Participant 29	22 Participant 15	23 Participant 47	24 Participant 11
25 Participant 6					

Group 2					
1 Participant 12	2 Participant 28	3 Participant 35	4 Participant 41	5 Participant 44	6 Participant 2
7 Participant 40	8 Participant 38	9 Participant 20	10 Participant 49	11 Participant 16	12 Participant 37
13 Participant 39	14 Participant 18	15 Participant 25	16 Participant 13	17 Participant 17	18 Participant 9
19 Participant 45	20 Participant 48	21 Participant 8	22 Participant 24	23 Participant 42	24 Participant 50
25 Participant 4					

Sample size

A target of 30-50 participants is desirable for this descriptive exploratory mixed methods study. This number has been selected pragmatically to account for approximately 5 participants per day over 10 working days.
Sample size sufficient to calculate statistical significance will not be feasible, therefore a power calculation will not be required.

Data collection and management

Data collection

Data will be collected via audio-visual recording which will take place on the SimWard, Paterson Building, St Marys Hospital. A Scotia Medical Observation Training System (smots, Scotia UK, Edinburgh, UK), with two 3- axis, ceiling- mounted video cameras, and three mobile, high-definition cameras equipped with boom microphones, will be used. The cameras will be angles at the computer screen ann onto the workstation and will not take footage of participants faces. Participants will be asked to remove or cover any name badges that may identify them prior to recording commencing.
The researcher will also keep field notes to assist with later analysis of the observations and interviews. The interviews will be transcribed verbatim by the study researcher prior to thematic analysis.
Participant demographic information will be collected via a short 'demographic questionnaire' at the beginning of the user testing session. Nasa Task Load Index questionnaires will be complete by the participant after each of the intervention arms.

Data management

Physical copies of the consent forms and participant list with pseudonymised participant study numbers will be kept within a locked room with swipe card access to the floor of the department.

Audio-visual recordings of the observations and semi-structured interview (See Appendix 1 for a sample interview guide), psuedoanonymised data capture forms and interview transcripts will be stored on an encrypted hard drive and kept in a locked room with swipe card access to the floor of the department. Interview transcripts will use the participant's psuedoanonymous study code in place of their name.

Publication of study findings will not contain identifiable data, participants will be given a study code name and only referred to by their profession and speciality.
Data and all appropriate documentation will be stored for a minimum of 10 years after the completion of the study.

Duration of study

The duration of the study will be six months from the date of the first participant recruited.

Study outcome measures

The following outcomes will be measured-
Primary outcome measure-

Number of prescribing errors per scenario

- Subcategorised as - Incorrect drug, dose, route, frequency or patient.

Secondary outcome measures-

- The magnitude of any dose errors (deviation from recommended dosing range)
- Time taken to prescribe each medication
- Prescribers perceived mental load per prescribing scenario
- Hierarchical task analysis
- Qualitative feedback from participants

Number and magnitude of prescribing errors

We define a prescribing error as any of the following errors:

- Incorrect prescribed dose: *prescribed doses that deviate from the recommended dose in the BNF/ BNFc or local guideline by more than 10%.*
  - If the recommended dose is a range, deviations will be calculated from the max/min of the range, whichever is closest to the user calculated dose. If there are multiple recommended dose options e.g., from the BNF and from local guidelines, the researcher will calculate deviations based on the most appropriate source for the indication. When all sources are deemed equally valid, the researcher will record the smallest deviation allowed.
  - Magnitude of dosing error will be calculated as a percentage deviation from the recommended dose.
- Incorrect prescribed route: *a medication prescribed via a route that deviates from the recommended route for the medication and dose as per the BNF/BNFc or local guidelines.*
- Incorrect prescribed frequency: *a medication prescribed for a frequency that deviates from the recommended frequency or that accumulated to a total daily dose for the medication and dose as per the BNF/BNFc or local guidelines.*
- Incorrect patient: *a medication order issued to incorrect patient's electronic medication chart.*

Time

The length of time for each prescribing scenario will be calculated from the time the participant begins to read the first scenario, and for subsequent scenarios from the time they complete one scenario and move onto the next.

Task load index

At the end of each scenario the user will be provided with an online NASA TLX (task load index) form to complete (8).

Hierarchical task analysis

Hierarchical task analysis (HTA) will be conducted for each of scenario, a framework will be created apriori based on the anticipated task steps and previous research (9,10), however any additional steps will be added if observed during video analysis. HTA results for participants using RxConnect will be compared to their usual practise.

Qualitative interviews

Following completion of the user testing scenarios, the participant will be invited to take part in a short semi-structured interview regarding their experience of using RxConnect and other more generic questions regarding the use of digital dosing support and indication-based prescribing. (See Appendix 1 for a sample interview guide).

Statistics and data analysis

Sample size

A sample size of 30-50 participants is desirable for this descriptive exploratory mixed methods study. A sample size calculation is therefore not relevant for this study.

Statistical analysis

Categorical data (error counts) from the control arm and intervention arm will be compared using the chi-square test.

Continuous data (magnitude of error, time, task load) will be measured using Mann-Whitney test for non-parametric data.

Sub analysis will explore the effect of possible confounders will be measured using multivariate logistic regression, subject to effect size and sample size limitations.

Variables which may be accounted for include - group number, scenario number, prescribing scenario complexity, prescriber grade, prescriber speciality, control arm or intervention arm.

Hierarchical task analysis

Hierarchical task analysis will be conducted to provide an overview of the prescribing workflow for the control arm and intervention. Vulnerable process steps can be highlighted if they are associated with increased error or time taken when prescribing the scenarios, along with any feedback from participants during practice, observation or in the qualitative interview.

Thematic analysis

Thematic analysis will be conducted using data from throughout the observations and the qualitative interviews (11).

4. PARTICIPANT RECRUITMENT

A convenience sample of study participants will be recruited from across Imperial College NHS Healthcare Trust. Study participants will be doctors and non-medical prescribers whose usual course of work involves the prescribing of medication.
Targeted sampling may be conducted to gain participants from a wide range of specialities/ levels of seniority including but not limited to-

- Seniority-
  - Foundation Year 1 and 2, Senior House Officers, Registrars, Consultants, Non-medical prescribers (nurses and pharmacists)
- Specialities,
  - Medical, Surgical, Paediatrics, Neonatal, Emergency medicine

Department leads and managers will be approached to gain permission prior to any approach of relevant medical staff and will be asked to disseminate invitations to participate in this study. Staff will be sent an email via their trust email address via the departments 'email group'. In addition, an advert will be placed on the trust intranet and further advertisement of the study through word of mouth via established working relationships within ICHT and ICL.
Participants will be provided with a participant information sheet at least a week prior to commencing any recruitment/data collection.
On the day of participating, participants will have the option to ask any further questions before deciding to take part and a copy of the participant information sheet will be available as either paper copy or via email as a PDF.

As participants will be NHS staff, there will be an expectation that participants will have adequate English language skills (reading, written and verbal) to be able to provide informed consent and participate. However, if adaptations are required for a member of staff to participate, (such as information sheets printed in larger font/different colours) this will be accommodated as per any normal adaptations required for working.

Participation in the study should take approximately 90 minutes and will not detract from clinical duties, where possible participation should be during non-clinical hours and/or when appropriate clinical cover is available.

Inclusion Criteria

- Willingness to consent and participate
- Medical doctor – Foundation year 1 and above OR registered non-medical prescriber (e.g. nurses or pharmacists)
- Regular (at least weekly) experience in prescribing medications as part of working role

Exclusion Criteria

- Infrequent prescribing practice (less than once a week)
- Not willing to participate

Withdrawal Criteria

Participants are free to withdraw consent at any point. For any data collected up to that point consent will be sought to use this data, if consent declined then data will be digitally deleted, and any paper documentation disposed of as confidential waste. If a participant wishes to withdraw their consent at a later date, this can only be accommodated if analysis of the study results has not yet begun.

Follow up

Participants will not require any further follow up after completing their session. Should participants wish to be informed when the results are published, they may leave a contact email address on their consent form, as per the participant information sheet and consent form. In the case of any incidental findings during the observations, such as repeated erroneous prescribing which may indicate educational needs for one or more participants, the participants will be informed in a discrete and sensitive manner and the participants line manager and practice educator will be informed.

The end of the study is defined as when the data is collected from the last participant.

5. Adverse events

Definitions

Adverse Event (AE): any untoward medical occurrence in a patient or clinical study subject.

Serious Adverse Event (SAE): any untoward medical occurrence or effect that:

- **Results in death**
- **Is life-threatening** – *refers to an event in which the subject was at risk of death at the time of the event; it does not refer to an event which hypothetically might have caused death if it were more severe*

- **Requires hospitalisation, or prolongation of existing inpatients' hospitalisation**
- **Results in persistent or significant disability or incapacity**
- **Is a congenital anomaly or birth defect**

Medical judgement should be exercised in deciding whether an AE is serious in other situations. Important AEs that are not immediately life-threatening or do not result in death or hospitalisation but may jeopardise the subject or may require intervention to prevent one of the other outcomes listed in the definition above, should also be considered serious.

Reporting procedures

All adverse events should be reported. Depending on the nature of the event the reporting procedures below should be followed. Any questions concerning adverse event reporting should be directed to the Chief Investigator in the first instance.

Non serious AEs

All such events, whether expected or not, should be recorded- it should be specified if only some non-serious AEs will be recorded, any reporting should be consistent with the purpose of the trial end points.

Serious AEs
An SAE form should be completed and emailed to the Chief Investigator within 24 hours. However, relapse and death due to a pre-existing condition, and hospitalisations for elective treatment of a pre-existing condition do not need reporting as SAEs.

All SAEs should be reported to the <name of REC> where in the opinion of the Chief Investigator, the event was:

- 'related', ie resulted from the administration of any of the research procedures; and
- 'unexpected', ie an event that is not listed in the protocol as an expected occurrence

Reports of related and unexpected SAEs should be submitted within 15 days of the Chief Investigator becoming aware of the event, using the NRES SAE form for non-IMP studies. The Chief Investigator must also notify the Sponsor of all related and unexpected SAEs.

Local investigators should report any SAEs as required by their Local Research Ethics Committee, Sponsor and/or Research & Development Office.

Contact details for reporting SAEs
RGIT@imperial.ac.uk
CI email (and contact details below)
Please send SAE forms to: bryony.franklin@nhs.net

6. REGULATORY ISSUES

Ethics approval

The Study Coordination Centre has obtained approval from the Health Research Authority (HRA). The study has received confirmation of capacity and capability from each participating NHS Trust before accepting participants into the study or any research activity is carried out. The study will be conducted in accordance with the recommendations for physicians involved in research on human subjects adopted by the 18th World Medical Assembly, Helsinki 1964 and later revisions.

Consent

Consent to enter the study must be sought from each participant only after a full explanation has been given, an information leaflet offered and time allowed for consideration. Signed participant consent should be obtained. The right of the participant to refuse to participate without giving reasons must be respected. After the participant has entered the study the clinician remains free to give alternative treatment to that specified in the protocol at any stage if he/she feels it is in the participant's best interest, but the reasons for doing so should be

recorded. In these cases the participants remain within the study for the purposes of follow-up and data analysis. All participants are free to withdraw at any time from the protocol treatment without giving reasons and without prejudicing further treatment.

Confidentiality

The Chief Investigator will preserve the confidentiality of participants taking part in the study and is registered under the Data Protection Act.

Data will be pseudonymised.

Indemnity

Imperial College London holds negligent harm and non-negligent harm insurance policies which apply to this study.

Sponsor

Imperial College London will act as the main Sponsor for this study. Delegated responsibilities will be assigned to the NHS trusts taking part in this study.

Funding

The National Institute for Health and Care Research are funding this study. Infrastructure support for this research was provided by the NIHR Imperial Biomedical Research Centre (BRC) and the NIHR Imperial Patient Safety Translational Research Centre (PSTRC).

Participants and individual researchers will not receive any payments, reimbursement of expenses or any other benefits or incentives for taking part in this research.

Audits

The study may be subject to audit by Imperial College London under their remit as sponsor and other regulatory bodies to ensure adherence to GCP and the UK Policy Frame Work for Health and Social Care Research.

7. PUBLICATION POLICY

The results of this study will be disseminated through open peer reviewed journals and presentation at relevant local meetings and national/international conferences.

8. REFERENCES

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9. Appendix 1: Draft semi-structured interview topic guide

RxConnect user testing questions-

- Please tell me how you found today's user testing session.
    - Could you describe how you found using RxConnect to complete the prescribing tasks.
    - How did this compare with your current prescribing practice?
- What effect do you think a system such as RxConnect could have on your prescribing practice?

- If positive, in what way?
- If negative, in what way?
- Is there anything that you think would benefit from changing/improving?

Indication-based prescribing workflow questions –

- Did you utilise the option to search by indication as opposed to by medication first?
- How does this align with your current prescribing workflow, both your mental workflow and decision making as well as the physical act of prescribing, for example entering the information onto the prescription?
- Would you consider an indication-*first* prescribing workflow to be better/worse/the same as current prescribing workflows. For example, searching for an indication and then selecting a medication, rather than searching for the medication.

Probes –

- Can you expand on that
- Do you have any examples –
  - where this would have been useful...?
  - where this may have hindered...?
  - specific patient groups
  - specific medication types – antimicrobial stewardship

10. Appendix 2: Draft Study session standard operating procedure

1. Participant will have already received an invitation to participate and agreed a time to take part in the study.
2. Participant arrives at pre-specified time, confirms they have received the PIS and has had any questions answered.

3. Participant to complete the consent form and an online copy to be sent to the participant to retain for their own records. Participants will be asked to remove or cover any name badges that may identify themselves.
4. Audio-visual recording to begin.
5. Participant training and briefing-

   Participant RxConnect training-
   A brief introductory video to be played to the participant showing how to use RxConnect.

   Participant study briefing-
   Participants to be briefed as to the purpose of the user testing and that scenarios will be presented that may cover a number of conditions, complexities and potentially error prone prescribing tasks, e.g. patients with contraindicated conditions, considerations and less frequently prescribed medications.

6. Participant encouraged to 'think aloud' when completing the following tasks. Participants are provided with two prescribing practice scenarios to complete using RxConnect and document the medication order on the paper form provided.
7. Confirm that the user is happy with how to use RxConnect and have any questions answered, a third prescribing practice scenario can be used if required.
8. Depending on allocation of control first or intervention first the participant is to complete 4 prescribing scenarios independently, they may 'think aloud' if the desire but this should not distract from the task.
9. Following each individual scenario, the participant is to complete a NASA TLX form.
10. Qualitative interview-
    Confirm that the participant consents to continue with a short semi-structured interview. Conduct the interview using the topic guide
11. Discontinue audio-visual recording.