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# Quality Improvements in Medicines Reconciliation at transfers of care in and out of an acute hospital



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| | |

**Title:** Quality Improvements in Medicines Reconciliation at transfers of care in and out of an acute hospital

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Key words: medicines reconciliation; patient safety; hospitals; pharmacist; hospital medicine; quality improvement

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## ABSTRACT

Objectives: Reliable reconciliation of medicines at admission and discharge from hospital is key to reducing unintentional prescribing discrepancies at transitions of health care. We introduced a team approach to the reconciliation process at an acute hospital with the aim of improving the provision of information and documentation of reliable medication lists to enable clear, timely communications on discharge.

Setting: An acute secondary care NHS hospital in London UK.

Participants: The effects of change were measured in a randomised sample of ten patients a week on the Acute Admissions Unit over 18 months.

Interventions: Quality Improvement methods were used throughout. Interventions included education and training of staff involved at ward level and in the pharmacy department, introduction of medication documentation templates for electronic prescribing and for communicating information on medicines in discharge summaries co-designed with patient representatives.

Results: Statistical Process Control analysis showed an increase in reliable documentation of current medication on patients' discharge summaries from 29.8% to 49.2%. This was sustained and appears to have continued to improve (to 85.2%) according to a post-study audit the year after the project end. Variation in results occurs at junior doctor rotations showing a negative relationship between error-free prescriptions and the changeover.

Conclusion: New processes led to a sustained increase in reconciled medications and thereby an improvement in the number of patients discharged from hospital with unintentional discrepancies (errors or omissions) on their discharge prescription.
The initiatives were pharmacist-led but involved close working and shared understanding about roles and responsibilities between doctors, nurses, therapists, patients and their carers.


## Strengths and Limitations of this study

- We recognised the importance of organisation and structure in reducing unintended discrepancies at transfer of care.
- Documentation by pharmacists of medicines reconciliation at discharge in addition to that undertaken on admission was improved.
- We showed a critical relationship between discharge summary quality and junior doctor rotations. Interventions were specifically made at these key times and appear to have had a positive effect on the numbers of patients with error-free medication lists.
- QI methods ensured a clear structure to the project organisation and management, while allowing room for creativity.
- Appropriate systems changes were embedded to ensure sustainability.

- Limitations in our methodology meant we are unable to show whether the decrease in errors was directly related to introduction of pharmacist-led discharge medicines reconciliation.
- We do not know if improvements in communications had any impact on patient outcomes post discharge from hospital.

**Key words:** Medication reconciliation; patient safety; hospitals; pharmacist; quality improvement

## INTRODUCTION

Transfers between interfaces of care, especially discharge from acute hospital into the community, are recognised as high-risk transitions for the development of medicines-related problems, a leading cause of morbidity and mortality.[1] Medication 'continuity' errors are frequent, involving up to 70% of inpatients on admission to hospital [2] and contributing to avoidable re-admissions.[3] Considering between 28-40% of medicines are discontinued or altered during hospitalization,[4] and less than 10% of elderly patients are discharged on the same medications with which they were admitted,[5] reconciliation at discharge is an increasingly important contribution to patient safety and quality of care.

Increased pharmacist involvement at admission, documentation of changes and systems facilitating transfer of information from the GP to hospital all appear to reduce medication error. Pharmacy-led reconciliation is considered to be a cost-effective intervention.[6]

Previous local audit had revealed that though actively involved in the timely resolution of discrepancies between patients' medicines list from the General Practitioner (GP) and the hospital doctor, there was a lack of discharge communication from hospital pharmacists. In addition, the quantity and quality of information on medication changes made during hospitalisation was low; only 1 in 10 patients were discharged from hospital with sufficient information on their discharge summaries to enable safe ongoing prescribing. [further data available] This was poorest at junior doctor changeover (which occurs three times a year).

We recognised the need to integrate discharge reconciliation into the processes involving ward pharmacists; that is in confirming the clinical appropriateness of prescribing during the inpatient stay and checking back to the medicines history when organising take home medicines.

The overall aim of this study was to provide seamless, high quality medicines reconciliation from admission through to discharge for all patients and improve communication with community service providers.

The objectives were to:

- reduce unintentional discrepancies in transcribing medication during admission to hospital.
- improve documentation of medicines reconciliation at discharge
- improve the quality of communications regarding new and intentional changes to medication in the hospital discharge summary

### Ethical approval

Ethics approval was not required for this work as it was part of a service evaluation and improvement activity and not human subjects research. An ethics waiver was granted by Chelsea and Westminster Hospital NHS foundation trust (CWH) Research and Development lead.

## METHODS

### Setting

The main study was conducted at an acute hospital over 18 months from September 2011 to March 2013. A post-study audit to check whether any improvements have been sustained, was carried out in June to August 2014. The focus of the study was the Acute Assessment Unit (AAU) where junior doctors are responsible for documenting the patient's history on admission (including their medicines), prescribing on-going medication and preparing the discharge summary. The pharmacist on AAU verifies the medication history and checks that all current continuing medicines are correctly prescribed on the in-patient electronic prescribing system (EPR). The completion of this pharmacist-led process of reliable reconciliation at admission is also documented appropriately on the EPR. Discharge prescribing is supported by pharmacists who check (or transcribe) take-home medicines (TTO).

### Planning the intervention

Quality improvement (QI) methodologies were employed throughout the project (see Appendix 1). Workshops and process mapping took place at the start of the project using a multidisciplinary team which included senior clinical leaders, senior nurses, junior doctors, consultant physicians, physiotherapists, pharmacists and a data analyst. Patient representation was part of the core team for the project. Members of the public were called upon on an *ad hoc* basis at first and subsequently patient representatives were fully recruited to the core team resulting in co-design of our interventions and systems updates.Stakeholders received feed-back through emails and personal communications when the process maps were finalised.
Interventions were assigned into one of three work streams:

1. Education
2. Documentation
3. Communication out of hospital

### Analytic plans

The study was a qualitative and quantitative improvement project using statistical process control (SPC, see Box) to monitor improvement measures. Data collation was carried out each week by the research pharmacist (SK). A sample of 10 discharge prescriptions was identified weekly using randomly generated numbers. Data for these prescriptions was obtained retrospectively from EPR and dispensing records to identify any unintentional discrepancies between inpatient prescription chart and discharge list of medicines. Confirmation of pharmacist-led verification of a patient's medication history was obtained from documentation in the electronic pharmaceutical care notes and the discharge summary for admission and discharge respectively.

**Statistical Process Control**
SPC analyses are a graphical family of techniques designed for the analysis of data over time using a number of "rule sets" to determine whether a process has unusual variation (special causes), or if fluctuations observed are simply a representative of the inherent properties of that process.[7] In this study, we use the flexible XmR analysis and consider special causes to be indicated by points falling outside the natural limits; a trend of 6 or more all increasing or decreasing values, and 7 or more points consecutively above or below the mean line. P- charts are employed for percentage data, but rely on the assumption that events are independent; it is not clear whether that assumption should hold with these data.

Process measures were designed to monitor improvements see Table 1

Table 1 Process Measures

| Measure | Percentage of |
|---|---|
| 1 | patients with pharmacist-verified reconciliation on admission |
| 2 | patients with pharmacist-verified reconciliation at discharge |
| 3 | patients with error-free TTO prescriptions |
| 4 | medications unreconciled at discharge |
| 5 | medications with an error (or omission) on TTO |

Measure 3 is directly related to measures 4 and 5. Sustaining high levels of medicines reconciliation at admission is key to facilitating improvement in discharge reconciliation (measure 2). It is not possible to reliably reconcile at discharge without the availability of a list of medication verified as being taken as prescribed prior to coming in to hospital.
Weekly analysis of these measures was facilitated through the web improvement support for healthcare (WISH) tool.[8] The tool provides reports with SPC analyses, by calculating the mean and respective upper and lower natural limits of the measures in question, tracked over time. Results were fed back to the core project team weekly.
The improvement measures supported the iterative changes during implementation process and the use of Plan-Do-Study-Act cycles. Several audits measuring standards of medicines history taking and reconciliation of discrepancies were undertaken during the study period and helped to inform and support the project. Further details of QI methodologies and outputs are given in the Appendices.
Data were collected from patients discharged between weeks commencing 30 October 2011 and17 February 2013 (70 weeks, with one missing week). A post-study audit was carried out using the same sampling method from 06 June to 31 August 2014 (nine weeks), to check whether any improvements made during the project were sustained. Small variations in selected numbers occurred in-week where there were delays in a patient's discharge. These patients were not excluded but appeared at a later date in the measures data.

## Interventions

A diagrammatic representation of all interventions carried out during the project is given in the Appendices.

Education

All pharmacists and medicines management technicians received a training update and accreditation in medicines reconciliation and were instructed in the importance of full documentation of pre-admission medication histories. Feedback was provided on a regular basis, at least twice monthly advocating 'good practice' in summarising changes made to medication during hospitalisation. Training was held collaboratively with other staff groups including nurses and therapists.

Pharmacy sessions took place on AAU during weekly lunchtime teaching for doctors and also at induction, around mid-year changeover (November/ December and March/April) and before end of year change (July/August). Two junior doctor champions were recruited to assist with the delivery of training and act as a channel for providing feedback to their peers. The project champions were well received (informal feedback from peers) and reported high levels of satisfaction with their role (informally direct to the rest of the project team and at appraisal with their clinical leads).

Documentation

EPR provides an easily accessible central documentation of patients' current medication and relevant history on the same screen as inpatient prescribing. This allows access to the original list while prescribing so that changes made by the hospital clinicians can be transcribed onto the discharge documentation with ease. However, locally the medication history list and medicines reconciliation detail required free-typing, without a set format or obligatory fields. Following consultation with IT support and the junior doctor champions, changes to the system were designed by the project team and approved by the executive lead for EPR creating tools to prompt and aid documentation of medication reconciliation. (These were brought in during the project data collection period in October 2012, as an intervention so that we are able to measure any effect on documentation and communication) and included:

- Changing screen colours to distinguish between reconciled and unreconciled medication lists
- Changing existing "Pharmacy Discharge Summary Text" box visible on GP, Patient and Pharmacy copy to "Pharmacy Screening/Dispensing Text" only visible on Pharmacy copy. GPs and Patients previously received unnecessary dispensing information on their discharge summary.
- Creating a "Pharmacy Medicines Management Text" box, to allow clear timely documentation by pharmacists of medicines reconciliation, and information about changes visible as required on all copies.
- The addition of space headed "Information for Patient" on the patient copy of the discharge summary for the pharmacist to add selected counselling points specific to their new medicines [further data available]
- Signposting to the hospital Medicines Information Helpline to aid access to further information they may need once they are home, developed in response to patient experience feedback.[9,10]

Communication with the GP

At first presentation at hospital an individual patient's complete list of current medication is required either via the patient or their carer (e.g. a repeat prescribing document or detail on a referral letter from the GP) or if this is not with the patient, the GP surgery is usually contacted at the earliest opportunity. There is as yet no direct e-communication locally between the hospital EPR and GP practices. Communication out to the GP about any changes made to medication in hospital requires free-typing into the discharge summary; local audit found this was missing in over 40% of cases.[further data available] The approved changes to the EPR documentation as above were designed to improve medication reconciliation communication including with the GP.

## RESULTS

A step-wise improvement is seen across measures relating to discharge medicines reconciliation throughout the project (Figures 1 to 4). For the post-study audit all measures indicate sustained improvement, summarised in Table 2.

During the study period a decline is seen in measure one from a starting average of 66.5% to 62.2% of patients having pharmacist- verified medicines reconciliation on admission (see Figure 1a). However, the average (mean) remained consistently above 60% for medicines reconciliation on admission throughout the project and also showed some short-term improvement to 82.7% coinciding with when initiatives were put in place to engage staff in pharmacist-led processes. This mid project improvement appears to be sustained as it was found in a nine-week period of measures during summer 2014, an average of 88.1% of patients had pharmacist-led medicines reconciliation documented on admission.

Table 2 Audit data to examine for sustainability of changes

| *For audit period: weeks commencing 06-Jul-2014 to 31-08-2014* | | | | |
|---|---|---|---|---|
| *Number of patients in audit = 88, number of medications = 1148, mean number per patient = 13* | | | | |
| % Patients with Pharmacist verified reconciliation on admission | % Patients with Pharmacist verified reconciliation at discharge | % Patients with error-free medication | % medications unreconciled at discharge | % medications in error |
| 87.5% | 64.8% | 85.2% | 3.7% | 2.3% |

Pharmacist documentation of medicines reconciliation at discharge improved from an average of 4.2% of patients to 30.7% and then to 57.5% (Figure 1b). This improvement appears to be sustained and improved upon as it was found during summer 2014, that an average of 64.8% of discharged patients had their medicines reconciled and documented on the discharge summary. A sustained increase in average from 29.8% of patients with no medication errors or omissions on discharge to 49.2% is seen but with marked variation

in late 2012 after changes were made to the EPR discharge text boxes (Figure 2). In the period of measures during summer 2014, sustained improvement was seen with 85.2% patients having error-free medication using the same criteria for reconciliation as during the project 18 months previously.

Key events mapped onto the process control chart for error-free medications from admission and through to discharge during one calendar year of the project, show the relationship between junior doctor rotations and the weeks when the hospital was under bed pressures (Figure 2). A fall the percentage of error-free medications is seen during September 2012 though this is not sustained and improvements are apparent when teaching sessions had been completed.

The percentage of medications unreconciled reduced from an average of 13.2% to 10.2% (Figure 3). In the summer of 2014, further improvement was seen with 3.7% of medicines recorded as unreconciled at discharge.

The percentage of medications with an error (or omission) reduced from an average of 15.8% to 12.4% (Figure 4). During summer 2014, continued improvement was seen with an average of 2.3% of medicines (prescribed or omitted) in error using the same criteria as during the project.

## DISCUSSION

Hospital based, pharmacist-led medicines reconciliation processes frequently identify and resolve unintended prescribing discrepancies between healthcare providers.[11] We have made improvements to these local processes particularly in provision of documentation and communication of medication changes at discharge from hospital.

The effect of this quality improvement is demonstrated in the decrease in numbers of patients leaving hospital with unintentional discrepancies (errors or omissions) on their discharge prescription. Though there was marked variation in this figure during the study, it appears to be sustained overall with an expectation that it remains consistently below 20% (as shown in 2014). There is clearly a need for further improvement; regular teaching and support particularly for junior doctors has been put in place and remains a key aspect of current practice and the subject of further medicines optimisation research locally.

A median of 45% of hospital patients in USA and Canada have at least one clinically significant discrepancy in their medications at transfer of care according to a systematic review of reconciliation in 2013.[11] Garfield and colleagues in the UK found unintentional discrepancies in 70% of medication prescribed on admission for around 60% of patients. [12] Unintentional discrepancies in discharge medication received by patients occurred up to 27% of items and these translated to discrepancies in repeat medication subsequently received from the GP in 57% patients. [12] In our study we looked at documentation on the discharge summary, exactly as it would be received by the GP. An ‘error’ was recorded if a medicine was missing from this communication or details of a change in medication not noted. The number of medicines unreconciled at discharge fell to 10% and then to 4% (2014 figures). Ascertaining whether any changes to medication reported are actually received and acted upon by the recipient was outside the scope of this project.

Follow-up of patients at another UK hospital where medicines reconciliation was found incomplete, revealed that the majority of failures occur when the standard admission documentation is not used. This was more likely to occur where specialist admission pathways were in place and paper proformas were not updated or if they had to be used in parallel with several other documents.[13] A small telephone survey of patients attending an Emergency Department in Ireland, suggested development of national standards of practice may help to eliminate the variation found between hospitals and would support improvement.[14] During our study we embedded new EPR tools to prompt and aid documentation of medication reconciliation particularly on the discharge summary but also at admission where we sought to standardise the pharmaceutical care entries made by pharmacy staff regarding medication histories. An audit undertaken in 45 English hospitals (including this study site) suggests that pharmacist-led medicines reconciliation at admission prevents adverse events occurring during an inpatient stay.[15] Our EPR updates appear to have had a positive effect on the quality of discharge summaries as error-free TTOs rates are seen to rise in the period from its inception in October 2012 to February 2013 when measurement stopped, and again when measured in 2014.

In the 2013 systematic review the authors note that the actual benefits of resolving unintended discrepancies are not seen; medicines reconciliation does not seem to reduce emergency department visits or readmission within 30 days. The review covered USA and Canada where many of the medication discrepancies appeared to have no clinical significance and given limited resources in hospitals, it is suggested it may be prudent to target patients at high risk rather than all admissions.[11] Our study did not include patient follow-up so does not add to this but follow-on projects are planned with examination of the clinical significance of intervening on unintentional discrepancies and readmission rates. In part to inform this research we recently compared medicines reconciliation by doctors on first contact with patients to pharmacy-verified medication lists. Full and accurate documentation was found for only 27% of patients prior pharmacy check. [further data available] The value of the pharmacist in medicines reconciliation was also shown in a Swedish Medical ward though the researchers suggested more work is needed.[16]

Documentation by pharmacists of medicines reconciliation at discharge in addition to that undertaken on admission was a new concept locally; prior to this project any changes made to patients' medicines had to be communicated by the prescriber as part of the free-type letter to the GP on the discharge summary.

We showed a critical relationship between discharge summary quality and junior doctor rotations and during periods when the hospital was under pressure for beds. Interventions were specifically made at these key times to improve discharge summary documentation and appear to have had a positive effect on the numbers of patients with error-free TTOs.

We recognised the importance of organisation and structure in reducing unintended discrepancies at transfer of care. A 'whole system' approach in this discharge process involved members of staff from a range of disciplines, all of whom were involved in appropriate prescribing, ensuring the assessment of a patient's ability to take their medication, or education of a

patient about their discharge medications. While other studies have underlined the importance of the interactions between medical and pharmacy staff, the success of this project partly lay in its ability to engage with nursing and allied health staff in addition.
The project team made ongoing sustainability a priority from the start, which is judged as important in embedding change,[17] and where appropriate, systems change was sought (e.g. improved electronic prescribing software functionality). Building improvements into the processes helps to minimise human error and reduce variability of outcomes. Better use of existing resources and embedding new tools for daily practice therein, ensures a sustainable change for the organisation which might be expected to be cost-neutral.
Integration of best practice project management using QI methods ensured a clear structure to the project organisation and management, while allowing room for creativity.

## LESSONS LEARNT

The project team was successful in engaging and influencing staff from all levels in changing practice. Communication barriers with doctors where they existed were removed with the recruitment of junior doctor champions to deliver training and providing feedback to peers. Culture within the pharmacy department was changed by seeking out early adopters to act as catalysts for change. Engaging the right people at the right time for the right tasks that complement their skills and interests, was a key to success (e.g. AAU sister in mapping discharge process; junior doctors in preparing posters).
This included effective engagement with the hospital's GP Relationships Manager who supported the project's initiatives where possible; this proved important as engaging directly with GPs was difficult.
Other aspects of the project, such as junior doctor and patient education, which are labour intensive, were successful but may prove less sustainable.

## RECOMMENDATIONS

Regular feedback of the quality of doctor's medication reconciliation at discharge is an important aspect of training that has resulted in an improvement in the number of patients discharged without errors on the discharge summary. However, maintaining weekly measures to allow such feedback is very time consuming. An option could be through incorporating the weekly measures into Trust clinical audit agenda.
The data in the current form are unable to distinguish whether the improvement in number of unreconciled medicines or number of errors is because of the introduction of pharmacist discharge medicines reconciliation and documentation. We do not know if they resulted in improved patient outcomes nor if communications in the discharge summaries are actioned by the recipient. We therefore recommend that a subset analysis and follow-up is carried out to compare outcomes for patients who have had pharmacist involvement in the preparation of the discharge summary.

## CONCLUSION

During the period of our medicines reconciliation project we put in place new processes that led to a sustained reduction in un-reconciled medications and thereby an improvement in the number of patients whose discharge medications were documented and communicated out from the hospital without error or omission. The initiatives were pharmacist-led but involved close working and shared understanding about roles and responsibilities between doctors, nurses and patients or their carers.

Care has been taken to embed the processes involved into standard working practices and computerised systems, ensuring that reliable reconciliation and documentation is sustainable.

**Contributorship statement**
VM project pharmacy lead; prepared the manuscript from original study reports written by SK
SK project manager
AJP analysed data and assisted in preparing the manuscript for publication
TW data manager; reported on SPC for the project
LV project clinical lead; assisted in the analysis and original report write-up
DB Director NIHR CLAHRC NWL; oversaw original project, set objective and reported on progress

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**Competing Interests**: none

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**Data sharing statement:** Unpublished data is available by email from VM as indicated in the manuscript '[further data available]' and as posters and abstracts as cited in the letter to the editor.

**Study Approval**

According to the policy activities that constitute research at Chelsea and Westminster Hospital NHS Foundation Trust this work met criteria for operational improvement activities exempt from ethics review.
Ethical approval was not required for this work as it was part of a service evaluation and improvement activity and not human subjects research. An ethics waiver was granted by Chelsea and Westminster Hospital NHS foundation trust (CWH) Research and Development lead

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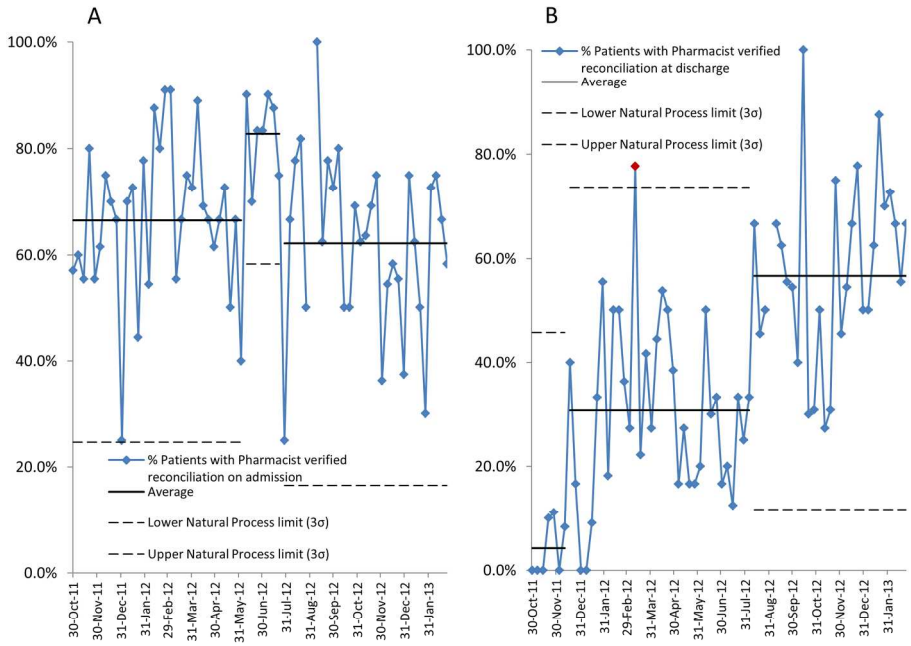


Figure 1 (Measures 1 and 2: higher percentage preferred): A. Percentage of patients with pharmacist-verified reconciliation on admission B. Percentage of patients with pharmacist-verified reconciliation at discharge
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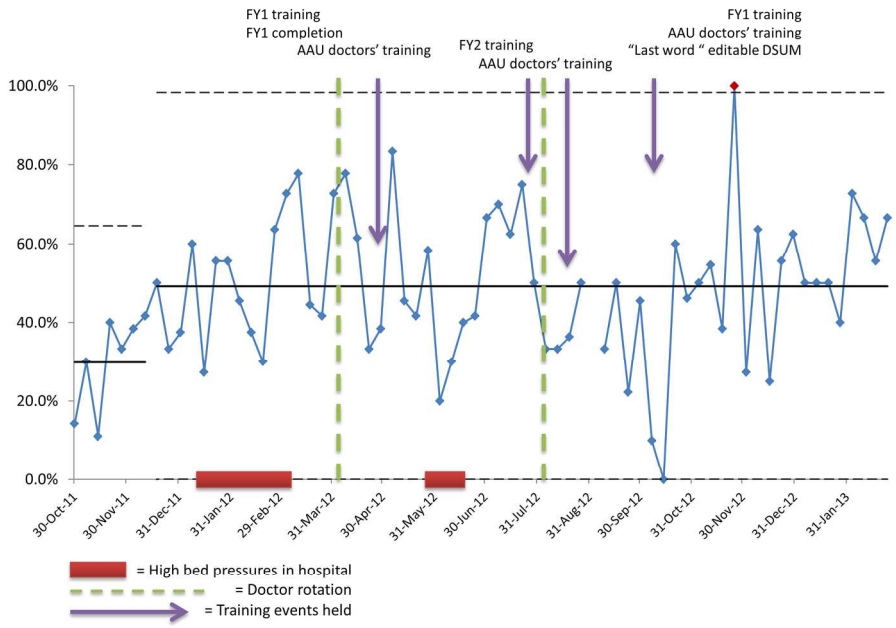



Figure 2 (Measure 3: higher percent preferred): Percentage of patients with error-free (and no omitted) medications on TTO prescriptions
Key AAU: Acute Admissions Unit, DSUM: Discharge Summary, FY: foundation year junior doctors, "Lastword": the local EPR system

190x142mm (300 x 300 DPI)

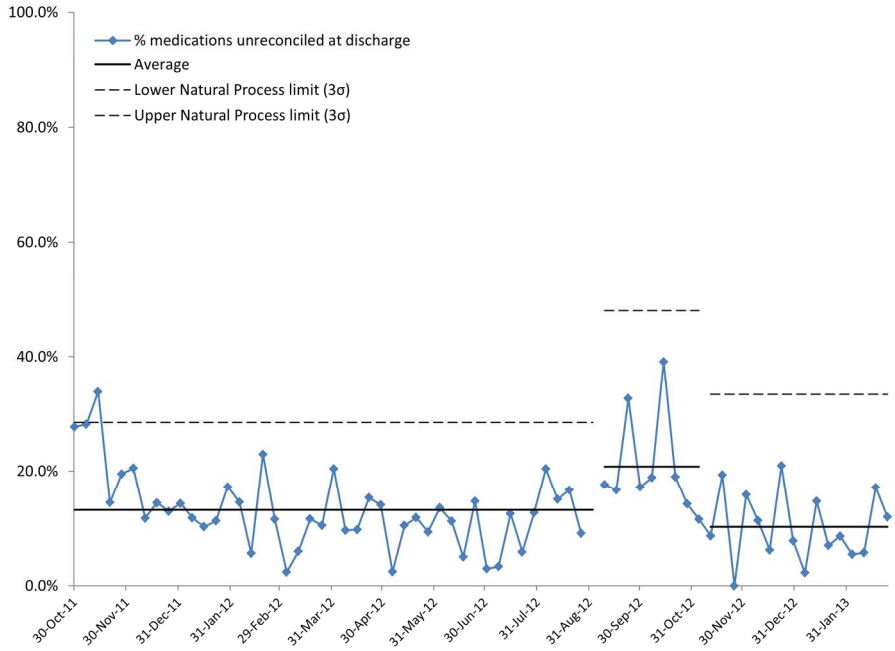



Figure 3 (Measure 4: lower percent preferred): The percentage of medications unreconciled at discharge

190x142mm (300 x 300 DPI)

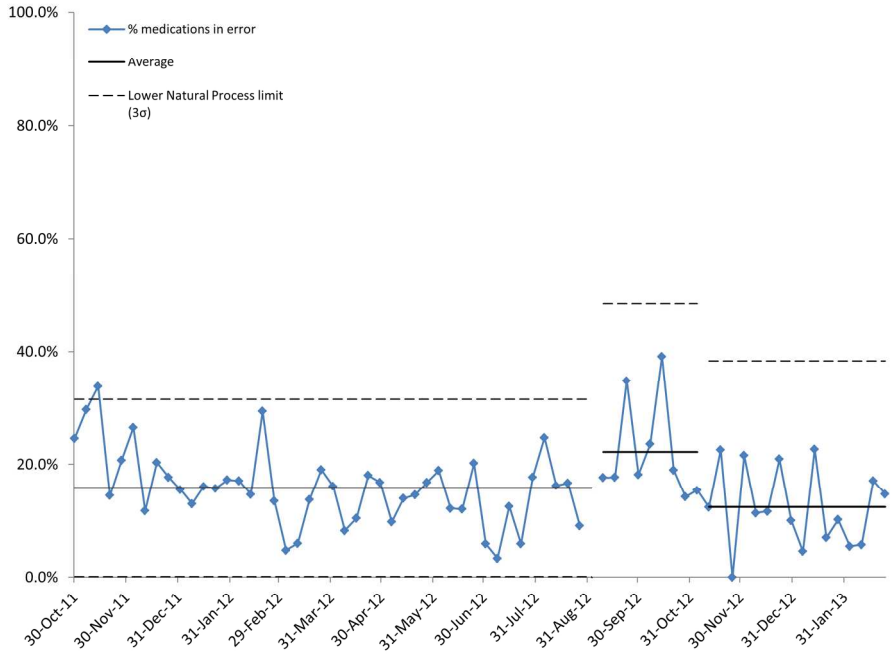
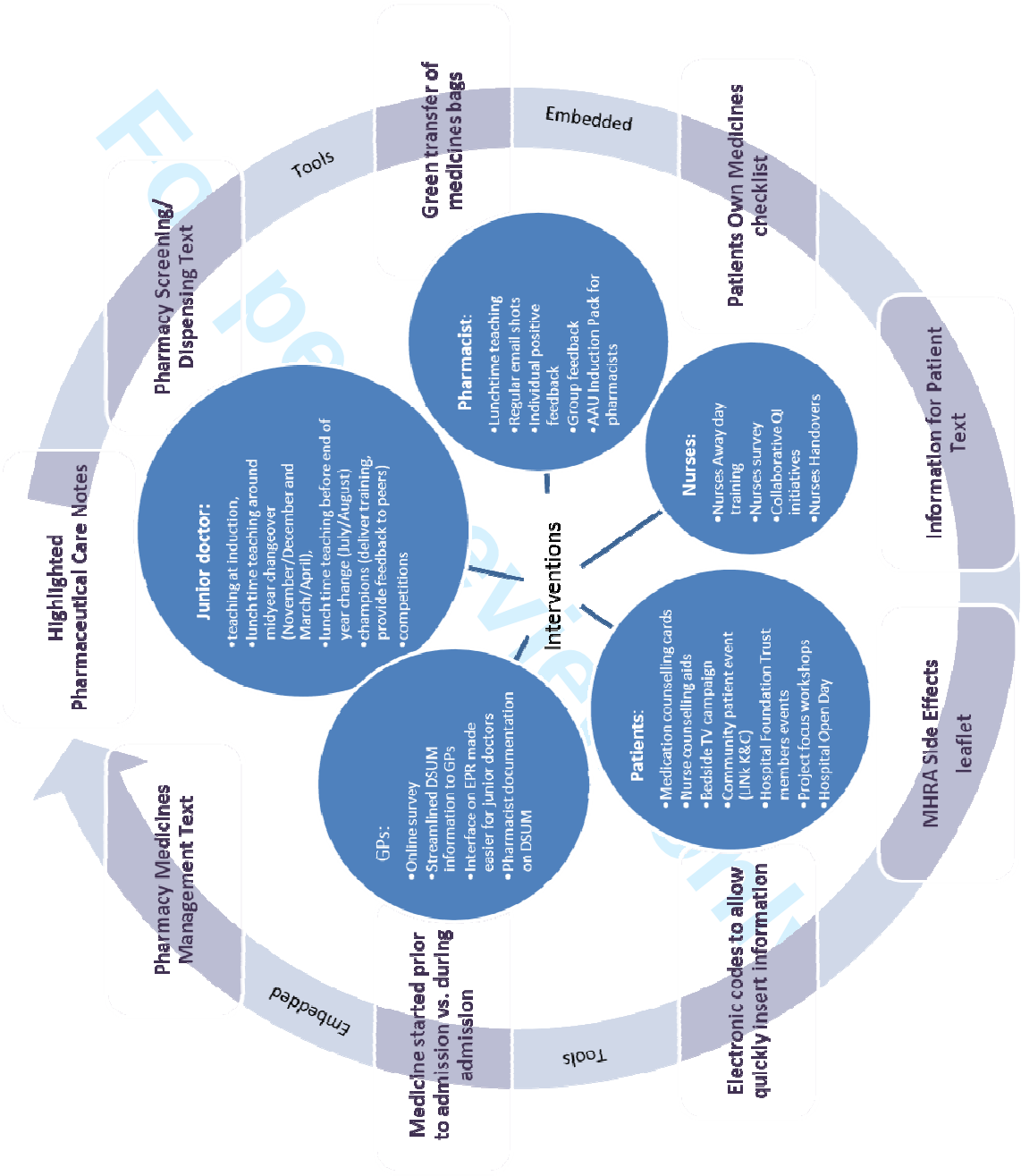



Figure 4 (Measure 5: lower percent preferred): Percentage of medications with an error (or omission) on TTO

190x142mm (300 x 300 DPI)

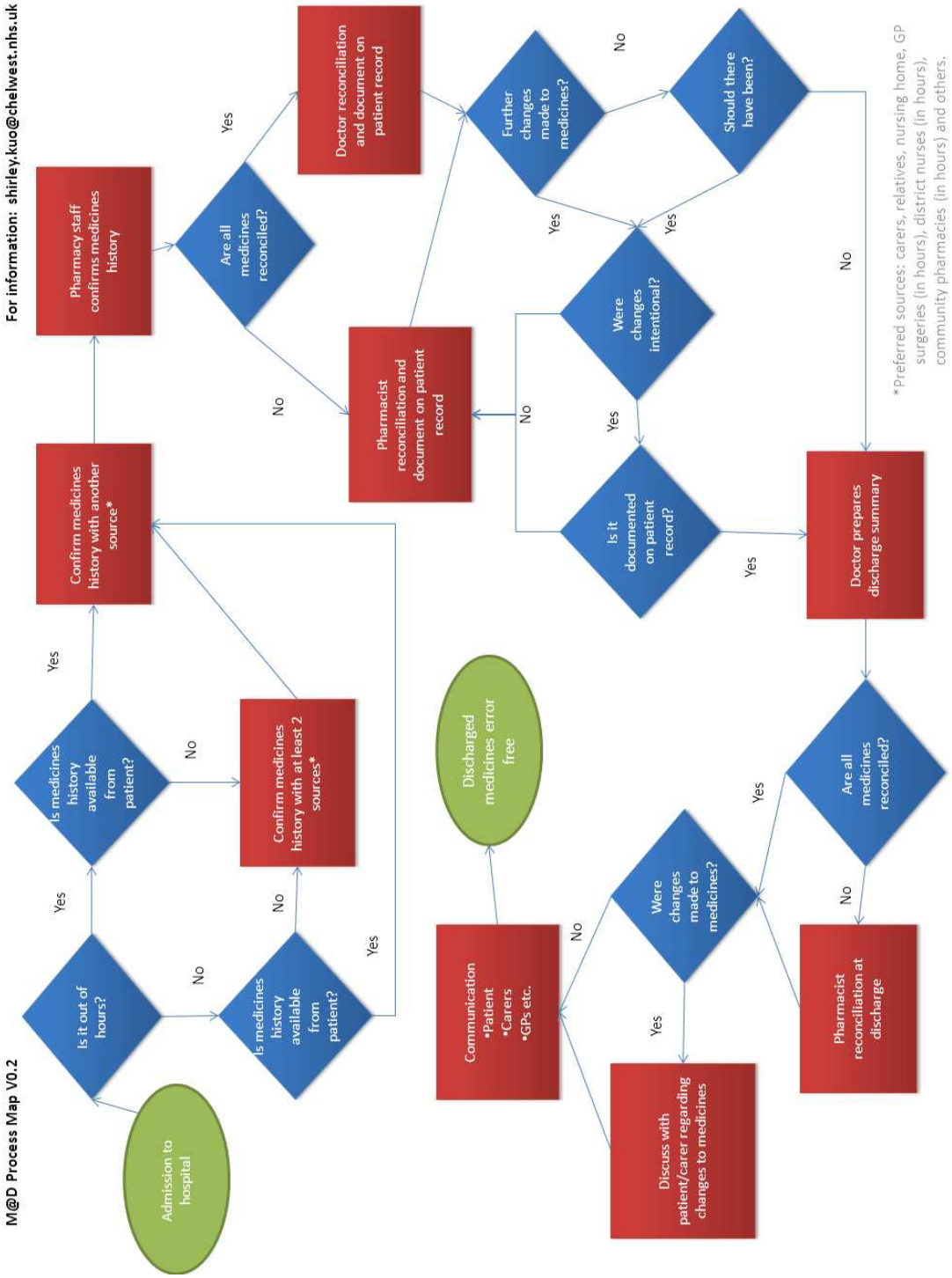
## Appendices:

### 1. Embedded interventions and stakeholder groups

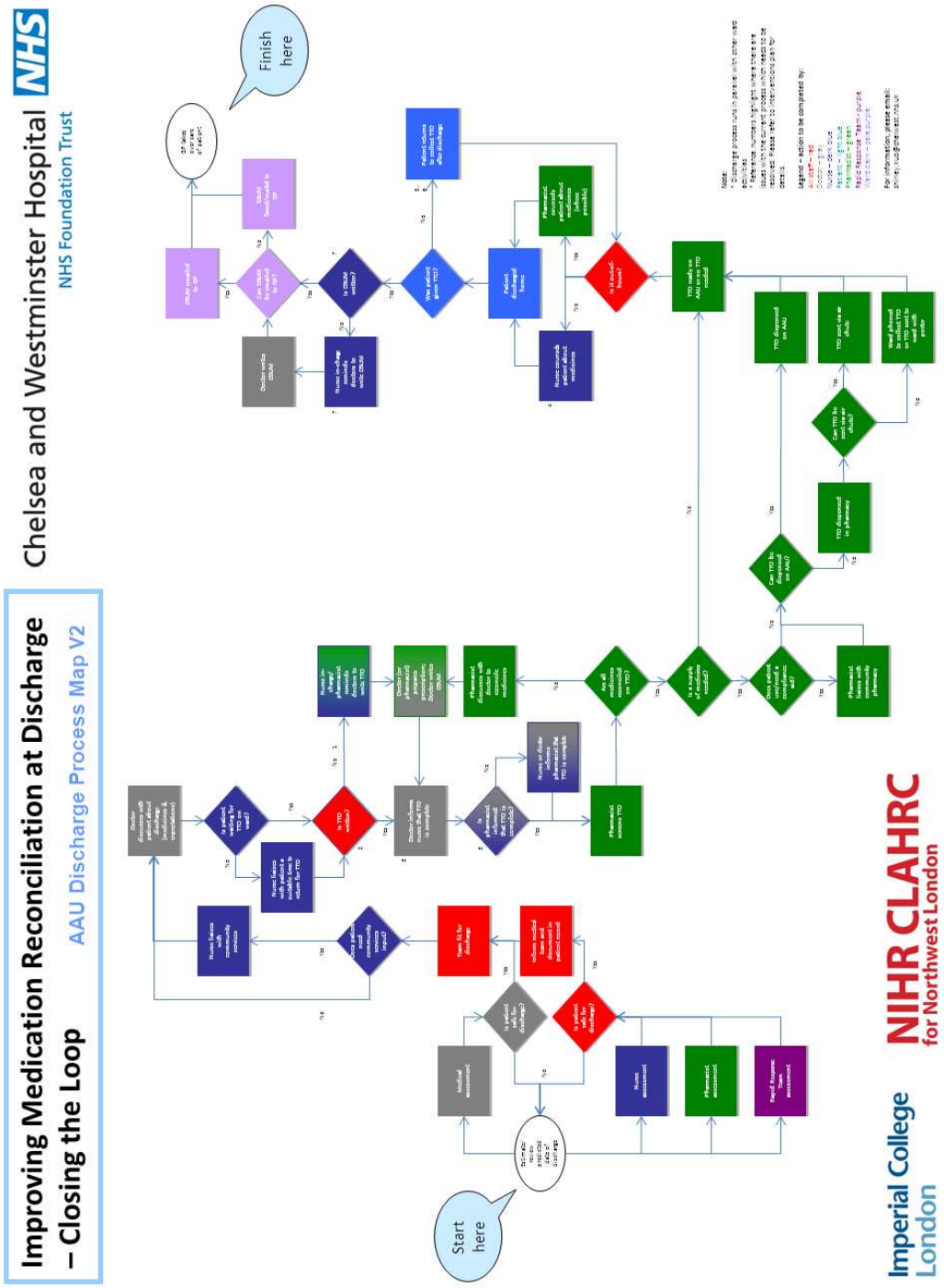


## Quality Improvement Methodologies and Outputs

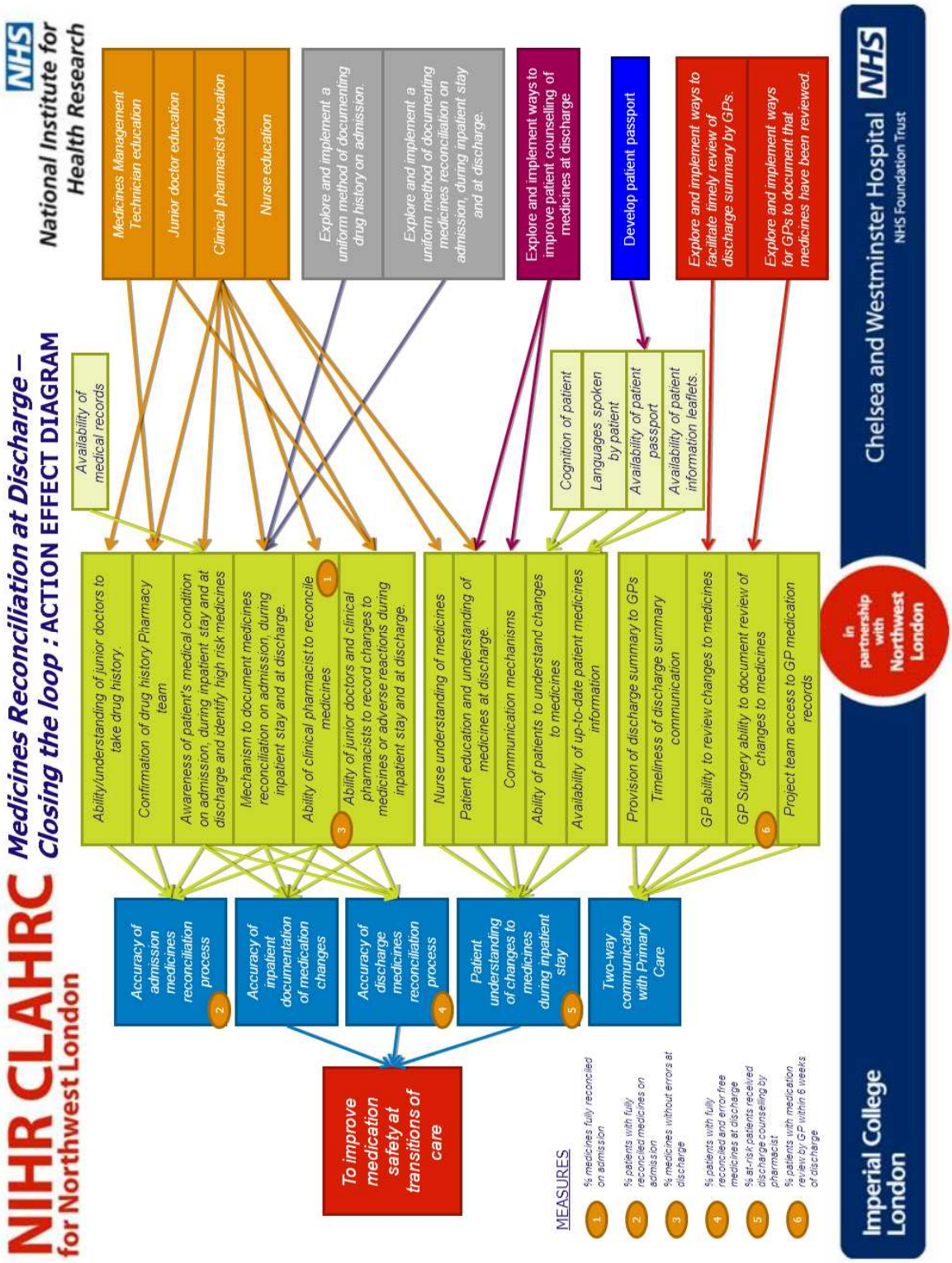
### 2. Process maps – higher level



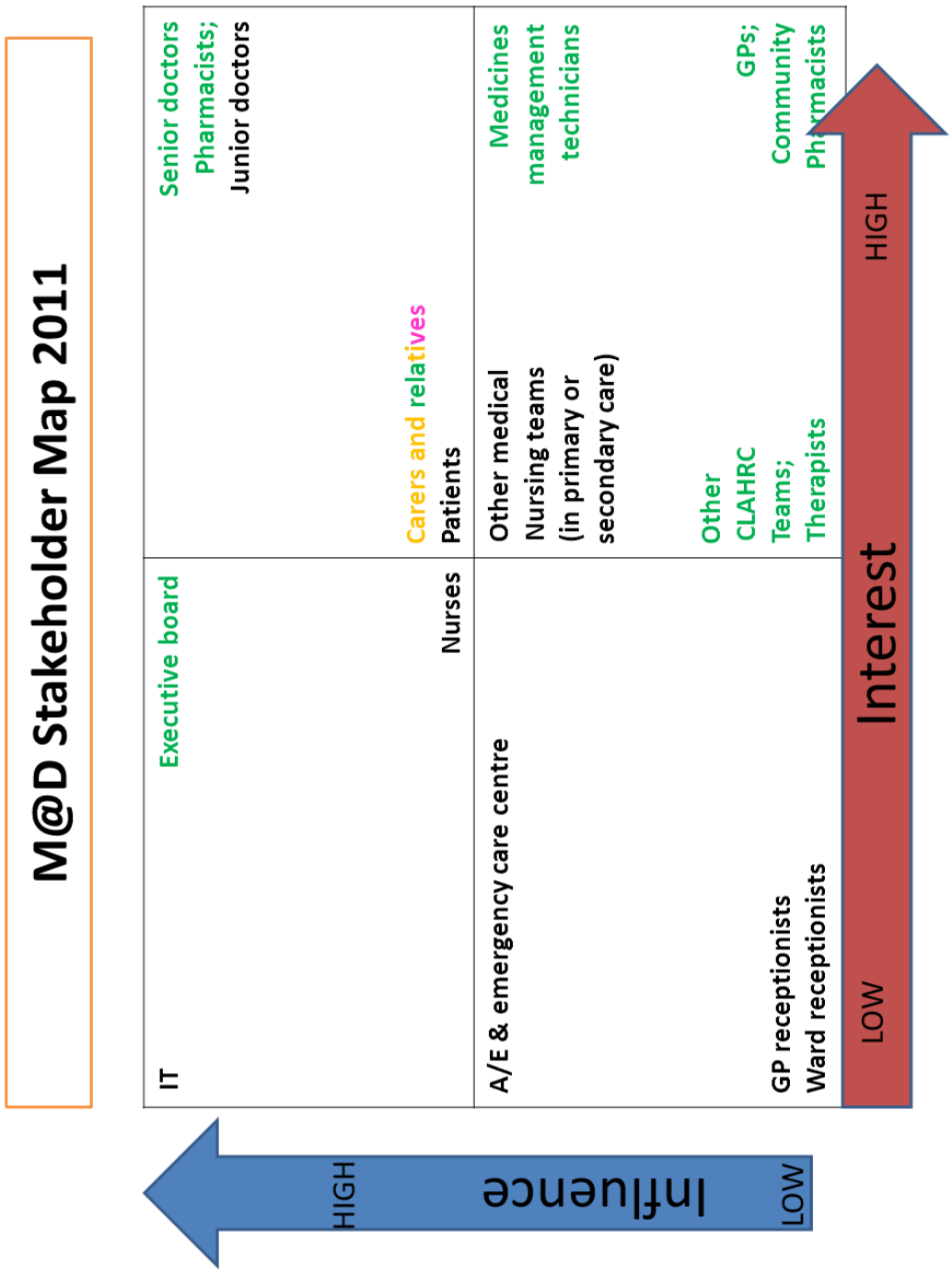
### 3. Process maps – lower level (AAU)



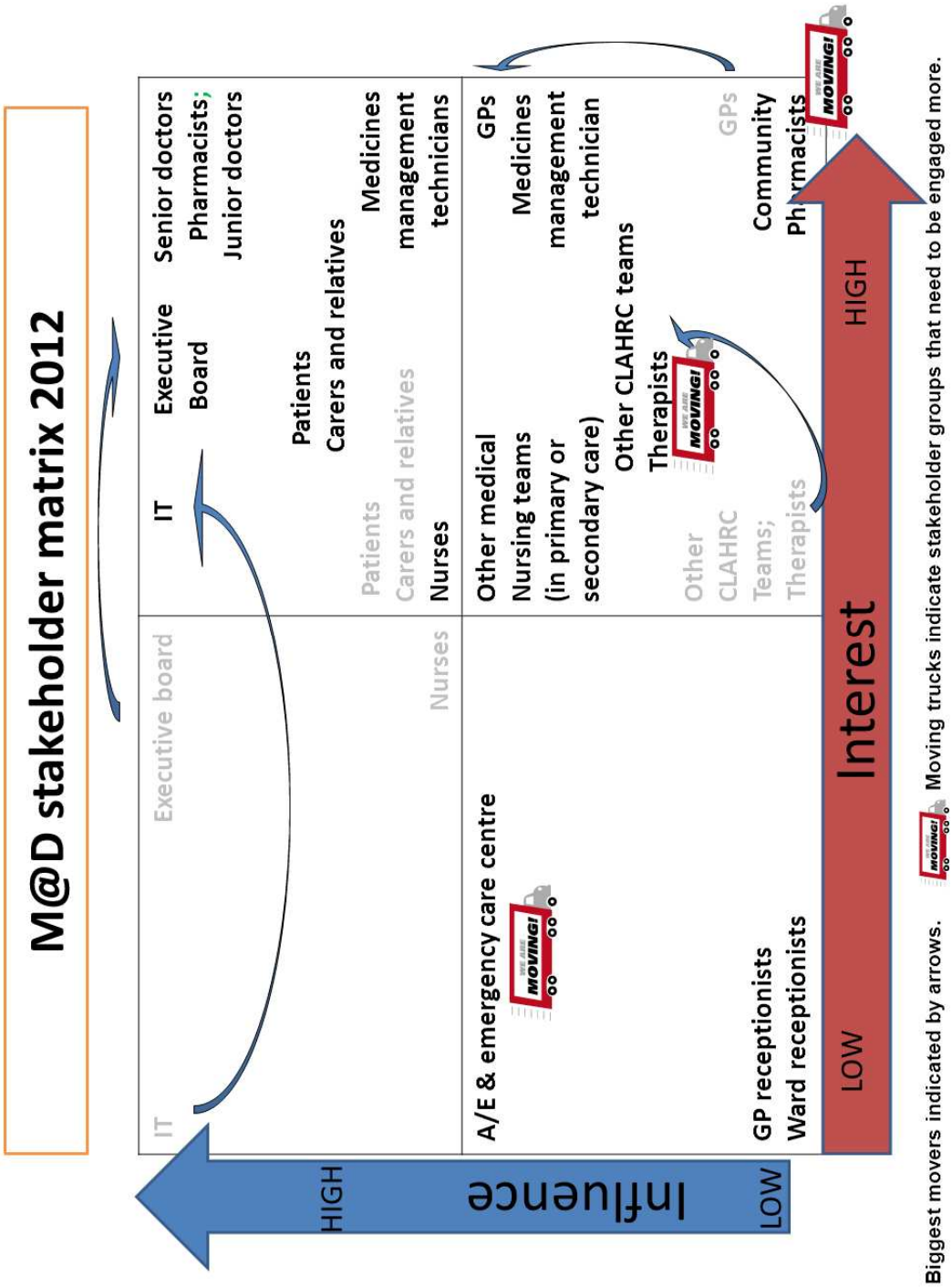
## 4. Action Effect Diagram



**5. Stakeholder Management Matrix – baseline**



**6. Stakeholder Management Matrix – 15 months**



## 7. Plan-Do-Study-Act Cycles

| Series Number | Cycle title |
|---|---|
| Series 1a | Transfer of medicines from AAU - ATOs |
| Series 1b | Transfer of medicines from AAU - ATOs |
| Series 1c | Transfer of medicines from AAU - Downstream wards |
| Series 1d | Transfer of medicines from AAU - Nurses survey |
| Series 2 | TTO turnaround time - Pharmacist tracking |
| Series 3a | Uncollected TTOs |
| Series 3b | Uncollected TTOs |
| Series 4a | Nurse training package - Nurse questionnaire (AAU) |
| Series 4b | Nurse training package - Nurse questionnaire (Trust-wide) |
| Series 5 | AAU pharmacy process review |
| Series 6 | GP survey |
| Series 7 | Improvement measures |

STROBE Statement—checklist of items that should be included in reports of observational studies

| | Item No | Recommendation |
|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found |
| **Introduction** | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses |
| **Methods** | | |
| Study design | 4 | Present key elements of study design early in the paper |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection |
| Participants | 6 | (*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up<br>*Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls<br>*Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants |
| | | (*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed<br>*Case-control study*—For matched studies, give matching criteria and the number of controls per case |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group |
| Bias | 9 | Describe any efforts to address potential sources of bias |
| Study size | 10 | Explain how the study size was arrived at |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding |
| | | (*b*) Describe any methods used to examine subgroups and interactions |
| | | (*c*) Explain how missing data were addressed |
| | | (*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed<br>*Case-control study*—If applicable, explain how matching of cases and controls was addressed<br>*Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy |
| | | (*e*) Describe any sensitivity analyses |

Continued on next page

| | | |
|---|---|---|
| **Results** | | |
| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed |
| | | (b) Give reasons for non-participation at each stage |
| | | (c) Consider use of a flow diagram |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders |
| | | (b) Indicate number of participants with missing data for each variable of interest |
| | | (c) *Cohort study*—Summarise follow-up time (eg, average and total amount) |
| Outcome data | 15* | *Cohort study*—Report numbers of outcome events or summary measures over time |
| | | *Case-control study*—Report numbers in each exposure category, or summary measures of exposure |
| | | *Cross-sectional study*—Report numbers of outcome events or summary measures |
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included |
| | | (*b*) Report category boundaries when continuous variables were categorized |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses |
| **Discussion** | | |
| Key results | 18 | Summarise key results with reference to study objectives |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results |
| **Other information** | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based |

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

# Applying Quality Improvement methods to address gaps in medicines reconciliation at transfers of care from an acute UK hospital



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| Keywords: | Medication reconciliation, Patient safety, hospital pharmacist, quality improvement |

**Title:** Applying Quality Improvement methods to address gaps in medicines reconciliation at transfers of care from an acute UK hospital

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**Title: Applying Quality Improvement methods to address gaps in medicines reconciliation at transfers of care from an acute UK hospital**


## ABSTRACT

Objectives: Reliable reconciliation of medicines at admission and discharge from hospital is key to reducing unintentional prescribing discrepancies at transitions of health care. We introduced a team approach to the reconciliation process at an acute hospital with the aim of improving the provision of information and documentation of reliable medication lists to enable clear, timely communications on discharge.

Setting: An acute 400 bedded teaching hospital in London UK.

Participants: The effects of change were measured in a simple random sample of ten adult patients a week on the Acute Admissions Unit over 18 months.

Interventions: Quality Improvement methods were used throughout. Interventions included education and training of staff involved at ward level and in the pharmacy department, introduction of medication documentation templates for electronic prescribing and for communicating information on medicines in discharge summaries co-designed with patient representatives.

Results: Statistical Process Control analysis showed reliable documentation (complete, verified and intentional changes clarified) of current medication on 49.2% of patients' discharge summaries. This appears to have improved (to 85.2%) according to a post-study audit the year after the project end. Pharmacist involvement in discharge reconciliation significantly increased, and improvements in the numbers of medicines prescribed in error or omitted from the discharge prescription are demonstrated. Some variation is seen but any short term decline in performance was not sustained and a positive trend is seen at the end of the project period.

Conclusion: New processes led to a sustained increase in reconciled medications and thereby an improvement in the number of patients discharged from hospital with unintentional discrepancies (errors or omissions) on their discharge prescription.
The initiatives were pharmacist-led but involved close working and shared understanding about roles and responsibilities between doctors, nurses, therapists, patients and their carers.


## Strengths and Limitations of this study

- We recognised the importance of organisation and structure in reducing unintended discrepancies at transfer of care.
- Documentation by pharmacists of medicines reconciliation at discharge in addition to that undertaken on admission was improved.
- We showed a critical relationship between discharge summary quality and junior doctor rotations. Interventions were specifically made at these key

times and appear to have had a positive effect on the numbers of patients with error-free medication lists.
- QI methods ensured a clear structure to the project organisation and management, while allowing room for creativity.
- Appropriate systems changes were embedded to ensure sustainability.
- Limitations in our methodology meant we are unable to show whether the decrease in errors was directly related to introduction of pharmacist-led discharge medicines reconciliation.
- We do not know if improvements in communications had any impact on patient outcomes post discharge from hospital.

**Key words:** Medication reconciliation; patient safety; hospitals; pharmacist; quality improvement

## INTRODUCTION

Transfers between interfaces of care, especially discharge from acute hospital into the community, are recognised as high-risk transitions for the development of medicines-related problems, a leading cause of morbidity and mortality.[1] Medication 'continuity' errors are frequent, involving up to 70% of inpatients on admission to hospital [2] and contributing to avoidable re-admissions.[3] Considering between 28-40% of medicines are discontinued or altered during hospitalization[4] and fewer than ten percent of elderly inpatients go home on the same medication as on admission, [5] accurate communication of changes at discharge is an increasingly important contribution to patient safety and quality of care.
Medicines reconciliation, the process of identifying the most accurate list of a patient's medicines and comparing it to current prescribing, recognizing any discrepancies and documenting any changes, is essential for minimizing continuity errors. [6] The elements of reliable reconciliation are at each transition in care:
• verification (of the list of current medications the patient is actually taking),
• validation (acute review noting whether to continue, alter doses, hold or stop)
• clarification (comparing the medication list with current prescription order)[6]

Increased pharmacist involvement at admission, documentation of changes and systems facilitating transfer of information from the General Practitioner (GP) to hospital all appear to reduce medication error.[7] Previous local audit had revealed that though actively involved in the timely resolution of discrepancies between patients' medicines list from the GP and the hospital doctor, there was a lack of discharge communication from hospital pharmacists. In addition, the quantity and quality of information on medication changes made during hospitalisation was low; only 1 in 10 patients were discharged from hospital with sufficient information on their discharge summaries to enable safe ongoing prescribing. The information required was considered insufficient if one or more medicines were omitted; a stopped medicine was included erroneously or without explanation; the dose, route,

course length or formulation (or change reason) was wrong or omitted; or essential monitoring information was lacking [further data available] .
We recognised the need to integrate discharge reconciliation into the processes involving ward pharmacists; that is in confirming the clinical appropriateness of prescribing during the inpatient stay and checking back to the medicines history when organising take home medicines. Pharmacy-led reconciliation is considered a cost-effective intervention.[7]
The overall aim of this study was to provide seamless, high quality medicines reconciliation from admission through to discharge for all patients and improve communication with community service providers.
The objectives were to:

- reduce unintentional discrepancies in transcribing medication during admission to hospital
- improve documentation of medicines reconciliation at discharge
- improve the quality of communications regarding new and intentional changes to medication in the hospital discharge summary

### Ethical approval

Ethics approval was not required for this work as it was part of a service evaluation and improvement activity and not human subjects research. An ethics waiver was granted by Chelsea and Westminster Hospital NHS foundation trust (CWH) Research and Development lead.

## METHODS

### Setting

The main study was conducted at an acute hospital over 18 months from September 2011 to March 2013. A post-study audit to check whether any improvements have been sustained, was carried out in June to August 2014. The focus of the study was the Acute Assessment Unit (AAU) a 44 bed adult ward seeing an average of 25 admissions a day with a mean age approximately 61 years. These are predominantly medical patients (17% surgical admissions) discharged home or to a longer stay ward usually within 4 days. The average length of stay in hospital was 9.3 days at the time of the study. Junior doctors are responsible for documenting the patient's history on admission (including their medicines), prescribing on-going medication and preparing the discharge summary. The pharmacist on AAU verifies the medication history, validates and checks that all current continuing medicines are correctly prescribed on the in-patient electronic prescribing system (EPR). If a discrepancy is found or a change is made without the reason or indication documented as part of the medication order, it is clarified by the pharmacist. The prescriber is contacted to ascertain if the change was intentional. The completion of this pharmacist-led process of reliable reconciliation at admission is also documented appropriately on the EPR. Discharge prescribing is supported by pharmacists who check (or transcribe) take-home medicines (TTO). When the hospital has reduced capacity to admit to AAU, the focus for medical teams shifts to support speedier discharge including writing TTOs as early as possible. Early discharge relieves the bed pressures and allows for admission of new patients. Pharmacist activity on AAU is not usually affected by these changes and was maintained throughout the project.

## Planning the intervention

Following recognition of low overall numbers of patients whose medicines are fully reconciled, a core team of pharmacists and physicians convened with the objective of improving rates locally. Quality improvement (QI) methodologies were employed throughout.[8] [9] Workshops took place at the start of the project to identify stakeholders (appendix figure 1) and their engagement was plotted on the matrix again at 15 months (appendix figure 2). Process mapping identified the various stages of medicines reconciliation in the hospital (appendix figure 3) and was repeated with the focus on AAU (appendix figure 4). For this we convened a multidisciplinary team which included senior clinical leaders, senior nurses, junior doctors, consultant physicians, therapists, pharmacists and a data analyst. All contributed to the mapping and development of the interventions (see appendix figure 5). For example the physiotherapists advised on how they check patient's use of medication compliance aids and occupational therapists on finding 'old' medicines during home visits. Stakeholder engagement events open to staff and public were held and regular patient focus groups around medicines management topics continued through to July 2012. Members of the public were called upon on an *ad hoc* basis at first and subsequently patient representatives were fully recruited to the core team resulting in co-design of our interventions and systems updates. An Action Effect Diagram was drawn with contributions from all stakeholders and the overall aim agreed (see appendix figure 6). [8] Plan Do Study Act (PDSA) cycles further informed the project from the beginning and as it progressed (see appendix table 7). [9] Stakeholders received feed-back through emails and personal communications when the process maps were finalised.

Interventions were agreed as the most likely to lead to measurable improvements, assigned into one of three work streams:

1. Education
2. Documentation
3. Communication out of hospital

## Analytic plans

The study was a qualitative and quantitative improvement project using statistical process control (SPC) to monitor improvement measures.

SPC analyses are a graphical family of techniques designed for looking at data over time. SPC uses a number of "rule sets" to determine whether a process has unusual variation (special causes) or if fluctuations observed are simply a representative of the inherent properties of that process.[10] In this study, we use the flexible XmR analysis and consider special causes to be indicated by points falling outside the natural limits; a trend of 6 or more all increasing or decreasing values, and 7 or more points consecutively above or below the mean line. Qualitative analysis of outputs from workshops, focus groups and stakeholder events was undertaken as they took place throughout the project. [Further data available] Themes emerging from the analyses were used to help form the structure and content of staff education and induction sessions (see later, Interventions).

Data collation was carried out each week by the research pharmacist (SK). A sample of ten discharge prescriptions was identified weekly using randomly generated numbers. Checks were put in place to ensure that no patient was

included more than once; readmissions were identified and noted (but not analysed for this project). Data was obtained retrospectively from EPR and dispensing records to identify any unintentional discrepancies between the inpatient prescription chart and discharge list of medicines. Confirmation of pharmacist-led verification of a patient's medication history was obtained from documentation in the electronic pharmaceutical care notes and the discharge summary for admission and discharge respectively.
Process measures were designed to monitor improvements see Table 1

Table 1 Process Measures

| Measure | Measure in sample of 10 patients per week randomly selected from all discharges for the week | Detail |
|---|---|---|
| 1 | Percentage of patients with pharmacist-verified reconciliation on admission | Pharmacist has documented on EPR that they have checked the admission medication list with the patient and verified with a second source and clarified or resolved any discrepancies on the inpatient order with the prescriber |
| 2 | Percentage of patients with pharmacist-verified reconciliation at discharge | Reconciliation at discharge is possible only for patients with a verified admissions medication list. For this measure any change to any admission medicine, dose, frequency or route is confirmed by a pharmacist as intentional and documented clearly on the discharge summary as such |
| 3 | Percentage of patients with error-free TTO prescriptions | TTO has no unexplained discrepancy compared with the verified list of medicines on admission. The reason is stated for any omission, change in dose, frequency or route; course lengths and monitoring advice are given where needed. If no reason is given for a discrepancy then the patient does not have an error-free prescription |
| 4 | Percentage of medications unreconciled at discharge out of the total number of medicines within the sample of 10 discharge summaries per week | Measure 4 is directly related to measure 3. The number of individual medicines unreconciled were recorded. Patients on no medicines were included in the study; medicines reconciliation was considered reliable only if 'nil regular medication' was verified and documented as such. |
| 5 | Percentage of medications with an error (or omission) on TTO out of the total number of medicines within the sample of 10 discharge summaries per week | Measures 5 is directly related to measure 3. The number of individual medicines with an error or omitted without explanation were recorded. For each patient several medicines may be prescribed in error or omitted from the TTO |

An error was recorded if any medicine was ordered that should have been stopped (including wrong medicine) or if a dose, route, course length or

formulation was incorrect. An omission was any medicine left off the TTO that should be entered as it is to be continued. Any change from the verified admissions list of medicines without explanation or monitoring requirement was also considered an error.

Weekly analysis of these measures was facilitated through the web improvement support for healthcare (WISH) tool.[11] The tool provides reports with SPC analyses, by calculating the mean and respective upper and lower natural limits of the measures in question, tracked over time. Results were fed back to the core project team weekly.

The improvement measures supported the iterative changes during implementation process and the use of Plan-Do-Study-Act cycles, also documented through the WISH software. Several audits measuring standards of medicines history taking and reconciliation of discrepancies were undertaken during the study period and helped to inform and support the project. Further details of QI methodologies and outputs are given in the Appendices.

Data were collected from patients discharged between weeks commencing 30 October 2011 and17 February 2013 (70 weeks, with one missing week). A post-study audit was carried out using the same sampling method from 06 June to 31 August 2014 (nine weeks), to check whether any improvements made during the project were sustained. Small variations in selected numbers occurred in-week where there were delays in a patient's discharge. These patients were not excluded but appeared at a later date in the measures data.

**Interventions**

A diagrammatic representation of all interventions carried out during the project is given in the Appendices.

Education

All pharmacists and medicines management technicians received a training update and accreditation in medicines reconciliation and were instructed in the importance of full documentation of pre-admission medication histories. Feedback was provided on a regular basis, at least twice monthly advocating 'good practice' in summarising changes made to medication during hospitalisation. Training was held collaboratively with other staff groups including nurses and therapists.

The team negotiated with AAU physicians to take a ten minute 'Pharmacy session' on AAU during the weekly 'learning at lunch' for doctors. At these sessions and also at induction, around mid-year changeover (November/ December and March/April) and before end of year change (July/August) a pharmacist describes the principles of medicines reconciliation, good prescribing and monitoring. They also advise on timely administration of critical medicines, reviewing and continuing regular medication and how pharmacists support the processes involved.

Two junior doctor champions were recruited to assist with the delivery of training and act as a channel for providing feedback to their peers. The project champions were well received (informal feedback from peers) and reported high levels of satisfaction with their role (informally direct to the rest of the project team and at appraisal with their clinical leads).

Documentation

EPR provides an easily accessible central documentation of patients' current medication and relevant history including what the patient actually takes, their allergies, intolerances and preferences, on the same screen as inpatient prescribing. This allows access to the original list while prescribing so that changes made by the hospital clinicians can be transcribed onto the discharge documentation with ease. However, locally the medication history list and medicines reconciliation detail required free-typing, without a set format or obligatory fields. Following consultation with IT support and the junior doctor champions, changes to the system were designed by the project team and approved by the executive lead for EPR creating tools to prompt and aid documentation of medication reconciliation. (These were brought in during the project data collection period in October 2012, as an intervention so that we are able to measure any effect on documentation and communication) and included:

- Changing screen colours to distinguish between reconciled and unreconciled medication lists
- Changing existing "Pharmacy Discharge Summary Text" box visible on GP, Patient and Pharmacy copy to "Pharmacy Screening/Dispensing Text" only visible on Pharmacy copy. GPs and Patients previously received unnecessary dispensing information on their discharge summary.
- Creating a "Pharmacy Medicines Management Text" box, to allow clear timely documentation by pharmacists of medicines reconciliation, and information about changes visible as required on all copies.
- The addition of space headed "Information for Patient" on the patient copy of the discharge summary for the pharmacist to add selected counselling points specific to their new medicines [further data available]
- Signposting to the hospital Medicines Information Helpline to aid access to further information they may need once they are home, developed in response to patient experience feedback.[12,13]

Communication with the GP

At first presentation at hospital an individual patient's complete list of current medication is required either via the patient or their carer (e.g. a repeat prescribing document or detail on a referral letter from the GP) or if this is not with the patient, the GP surgery is usually contacted at the earliest opportunity. There is as yet no direct e-communication locally between the hospital EPR and GP practices. We use the telephone to request and fax to receive patient medication record details. On transfer home we create the discharge summary including the TTO which is for many medicines, a simple transfer from the inpatient EPR. A copy is emailed or posted to the GP. Communication out to the GP about any changes made to medication in hospital requires free-typing into the discharge summary; local audit found this was missing in over 40% of cases.[further data available] The approved changes to the EPR documentation as above were designed to improve medication reconciliation communication including with the GP.

## RESULTS

A step-wise improvement is seen across measures relating to discharge medicines reconciliation throughout the project (Figures 1 to 4). For the post-study audit all measures indicate sustained improvement, summarised in Table 2.

During the study period an average of 66.3% of patients have pharmacist-verified medicines reconciliation on admission (see Figure 1a). The average (mean) showed some short-term improvement to 82.7% coinciding with when initiatives were put in place to engage staff in pharmacist-led processes. On one week with high bed pressures (31st May 2012, see Figure 2) performance was below average, recovering over a six week period of increasing trend (constituting an SPC rule break).The periods of bed pressures did not appear to affect pharmacists' admission activity.

The short term improvement mid-project appears to have been achieved one year on as it was found that in a nine-week period of measures during summer 2014, an average of 88.1% of patients had pharmacist-led medicines reconciliation documented on admission.

Table 2 Audit data to examine for sustainability of changes

| *For audit period: weeks commencing 06-Jul-2014 to 31-08-2014* | | | | |
|---|---|---|---|---|
| *Number of patients in audit = 88, number of medications = 1148, mean number per patient = 13* | | | | |
| % Patients with Pharmacist verified reconciliation on admission | % Patients with Pharmacist verified reconciliation at discharge | % Patients with error-free medication | % medications unreconciled at discharge | % medications in error |
| 87.5% | 64.8% | 85.2% | 3.7% | 2.3% |

Reconciliation at discharge is possible only for those who had a verified list of admission medicines.

Pharmacist documentation of medicines reconciliation at discharge improved from an average of 26.2% of patients to 56.7% (Figure 1b). This improvement appears to be sustained and improved upon as it was found during summer 2014, that an average of 64.8% of discharged patients had their medicines reconciled and documented on the discharge summary (Table 2).

After an initial low period an average of 47.2% percent of patients with no medication errors or omissions on discharge is seen, but with marked variation in late 2012 coinciding with the changes being embedded in the editable part of the discharge summary (Figure 2). In the period of measures during summer 2014, an improvement was seen with 85.2% patients having error-free medication using the same criteria for reconciliation as during the project 18 months previously (Table 2).

Key events mapped onto the process control chart for error-free medications from admission and through to discharge during one calendar year of the project, show the relationship between junior doctor rotations and the weeks when the hospital was under bed pressures (Figure 2). A fall the percentage of error-free medications is seen during September 2012 though this is not

sustained and improvements are apparent when teaching sessions had been completed.

The average for medications unreconciled was 13.5% (Figure 3). In the summer of 2014, improvement was found with 3.7% of medicines recorded as unreconciled at discharge (Table 2).

The percentage of medications with an error (or omission) was an average of 15.8% (Figure 4). During summer 2014, improvement was seen with an average of 2.3% of medicines (prescribed or omitted) in error using the same criteria as during the project (Table 2). Note that in Figures 3 and 4 there are transient uplifts in values, before reversion to previous performance, across August and September 12; period in which newly qualified doctors begin their training.

## DISCUSSION

Hospital based, pharmacist-led medicines reconciliation processes frequently identify and resolve unintended prescribing discrepancies between healthcare providers.[14] We have made improvements to these local processes particularly in provision of documentation and communication of medication changes at discharge from hospital.

The effect of this quality improvement is demonstrated in the decrease in numbers of patients leaving hospital with unintentional discrepancies (errors or omissions) on their discharge prescription. Though there was marked variation in this figure during the study, it appears to be sustained overall with an expectation that it remains consistently below 20% (as shown in 2014). However, the period from August to October in 2012 shows an increase in the number of unreconciled discrepancies in discharge medications. We have looked for explanations for this as it does not coincide with the hospital being particularly busy or under pressure for beds or other parameters that we were monitoring at the time. It may have been influenced by the period of high staff turnover in pharmacy which occurs every new academic year. Though not the project team per se, we were inducting new juniors and managing unprecedented vacancies including staff leave (postponed during the London Olympics and taken in September and October that year).

There is clearly a need for further improvement; regular teaching and support particularly for junior doctors has been put in place and remains a key aspect of current practice and the subject of further medicines optimisation research locally. In addition the pharmacist induction programme locally now includes training in documentation of medicines reconciliation on EPR.

We found a high level of variation in the percentage of patients with error–free discharge prescriptions in particular around the time of introducing the changes to processes on EPR. The changes required different inputs by the prescriber and though all were trained by the implementation date, many had their training several weeks before. Variations may also have been the result of the small sample set for weekly measures. Ten patients were selected each week. If a fully trained ‘good’ prescribing team were on duty for the sampling period it could contrast with one less familiar with TTO requirements on duty the following week.

Overall, our EPR updates appear to have had a positive effect on the quality of discharge summaries as error-free TTOs rates are seen to rise in the

period from its inception in October 2012 to February 2013 when measurement stopped, and again when measured in 2014.

A median of 45% of hospital patients in USA and Canada have at least one clinically significant discrepancy in their medications at transfer of care according to a systematic review of reconciliation in 2013.[14] Garfield and colleagues in the UK found unintentional discrepancies in 70% of medication prescribed on admission for around 60% of patients. [15] Unintentional discrepancies in discharge medication received by patients occurred up to 27% of items and these translated to discrepancies in repeat medication subsequently received from the GP in 57% patients. [15] In our study we looked at documentation on the discharge summary, exactly as it would be received by the GP. An 'error' was recorded if a medicine was missing from this communication or details of a change in medication not noted. The number of medicines unreconciled at discharge fell to 10% and then to 4% (2014 figures). Ascertaining whether any changes to medication reported are actually received and acted upon by the recipient was outside the scope of this project.

Follow-up of patients at another UK hospital where medicines reconciliation was found to be incomplete, revealed that the majority of failures occur when the standard admission documentation is not used. This was more likely to occur where specialist admission pathways were in place and paper pro formas were not updated or if they had to be used in parallel with several other documents.[16] A survey of pharmacy services for patients at discharge from hospitals in Ireland suggested development of national standards of practice may help to eliminate the variation found in practice and would support improvement.[17] During our study we embedded new EPR tools to prompt and aid documentation of medication reconciliation particularly on the discharge summary. In addition, at admission we sought to standardise the pharmaceutical care entries made by pharmacy staff regarding medication histories. An audit undertaken in 45 English hospitals (including this study site) suggests that pharmacist-led medicines reconciliation at admission prevents adverse events occurring during an inpatient stay.[18]

In the 2013 systematic review the authors note that the actual benefits of resolving unintended discrepancies are not seen; medicines reconciliation does not seem to reduce emergency department visits or readmission within 30 days. The reviewers found most medication discrepancies appeared to have no clinical significance and, given limited resources in hospitals, it is suggested it may be prudent to target patients at high risk rather than all admissions.[14] Our study did not include patient follow-up so does not add to this but follow-on projects are planned where we will target vulnerable patients (especially elderly) identified through medicines reconciliation and other processes for further pharmacist intervention with examination of the clinical significance of intervening on unintentional discrepancies and readmission rates.

In part to inform this research we recently compared medicines reconciliation by doctors on first contact with patients to pharmacy-verified medication lists. Full and accurate documentation was found for only 27% of patients prior pharmacy check. [Further data available] The value of the pharmacist in medicines reconciliation was also shown in a Swedish Medical ward though the researchers suggested more work is needed.[19]

Documentation by pharmacists of medicines reconciliation at discharge in addition to that undertaken on admission was a new concept locally. We have now integrated the process into the patient centred pharmaceutical care carried out by our team of clinical (ward) pharmacists as part of their regular duties. All inpatient prescriptions are reviewed by a pharmacist at the first opportunity, including medicines reconciliation within 24 hours of admission where possible. It is a challenge at weekends where staffing levels are lower; currently under review locally and across the UK. The changes we have put in place around discharge reconciliation have been achieved without extra resource but with critical refocussing of pharmacist input. Prior to this project any changes made to patients' medicines had to be communicated by the prescriber as part of the free-type letter to the GP on the discharge summary. There appears to be a relationship between discharge summary quality and junior doctor rotations. Interventions specifically made at key times in rotations to improve discharge summary documentation appear to have a positive effect on the numbers of patients with error-free TTOs.

We recognised the importance of organisation and structure in reducing unintended discrepancies at transfer of care. A 'whole system' approach in this discharge process involved members of staff from a range of disciplines, all of whom were involved in appropriate prescribing, ensuring the assessment of a patient's ability to take their medication, or education of a patient about their discharge medications. While other studies have underlined the importance of the interactions between medical and pharmacy staff, the success of this project partly lay in its ability to engage with nursing and allied health staff in addition.

The project team made ongoing sustainability a priority from the start, which is judged as important in embedding change,[20] and where appropriate, systems change was sought (e.g. improved electronic prescribing software functionality). Building improvements into the processes helps to minimise human error and reduce variability of outcomes. Better use of existing resources and embedding new tools for daily practice therein, ensures a sustainable change for the organisation which might be expected to be cost-neutral.

Integration of best practice project management using QI methods ensured a clear structure to the project organisation and management, while allowing room for creativity.

## LESSONS LEARNT

The project team was successful in engaging and influencing staff from all levels in changing practice. Communication barriers with doctors where they existed were removed with the recruitment of junior doctor champions to deliver training and providing feedback to peers. Culture within the pharmacy department was changed by seeking out early adopters to act as catalysts for change. Engaging the right people at the right time for the right tasks that complement their skills and interests, was a key to success (e.g. AAU sister in mapping discharge process; junior doctors in preparing posters).

This included effective engagement with the hospital's GP Relationships Manager who supported the project's initiatives where possible; this proved important as engaging directly with GPs was difficult.
Other aspects of the project, such as junior doctor and patient education, which are labour intensive, were successful but may prove less sustainable.

## RECOMMENDATIONS

Regular feedback of the quality of doctor's medication reconciliation at discharge is an important aspect of training that has resulted in an improvement in the number of patients discharged without errors on the discharge summary. However, maintaining weekly measures to allow such feedback is very time consuming. An option could be through incorporating the weekly measures into Trust clinical audit agenda.
The data in the current form are unable to distinguish whether the improvement in number of unreconciled medicines or number of errors is because of the introduction of pharmacist discharge medicines reconciliation and documentation. We do not know if they resulted in improved patient outcomes nor if communications in the discharge summaries are actioned by the recipient. We therefore recommend that a subset analysis and follow-up is carried out to compare outcomes for patients who have had pharmacist involvement in the preparation of the discharge summary.

## CONCLUSION

During the period of our medicines reconciliation project we put in place new processes that led to a sustained reduction in un-reconciled medications and thereby an improvement in the number of patients whose discharge medications were documented and communicated out from the hospital without error or omission. The initiatives were pharmacist-led but involved close working and shared understanding about roles and responsibilities between doctors, nurses and patients or their carers.

Care has been taken to embed the processes involved into standard working practices and computerised systems, ensuring that reliable reconciliation and documentation is sustainable.

**Contributorship statement**
VM project pharmacy lead; prepared the manuscript from original study reports written by SK
SK project manager
AJP analysed data and assisted in preparing the manuscript for publication
TW contribution to method design and input on analysis
LV project clinical lead; assisted in the analysis and original report write-up
DB Director NIHR CLAHRC NWL; oversaw original project, set objective and reported on progress

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**Competing Interests**: none

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**Data sharing statement:** No additional data available.
**Study Approval**
According to the policy activities that constitute research at Chelsea and Westminster Hospital NHS Foundation Trust this work met criteria for operational improvement activities exempt from ethics review.
Ethical approval was not required for this work as it was part of a service evaluation and improvement activity and not human subjects research. An ethics waiver was granted by Chelsea and Westminster Hospital NHS foundation trust (CWH) Research and Development lead

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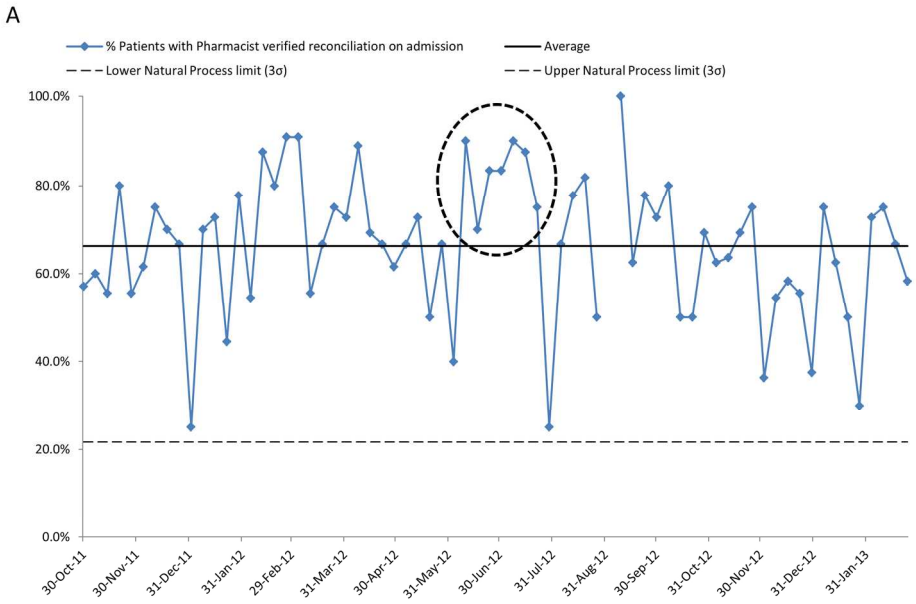


Figure 1a (Measures 1: higher percentage preferred): Percentage of patients with pharmacist-verified reconciliation on admission
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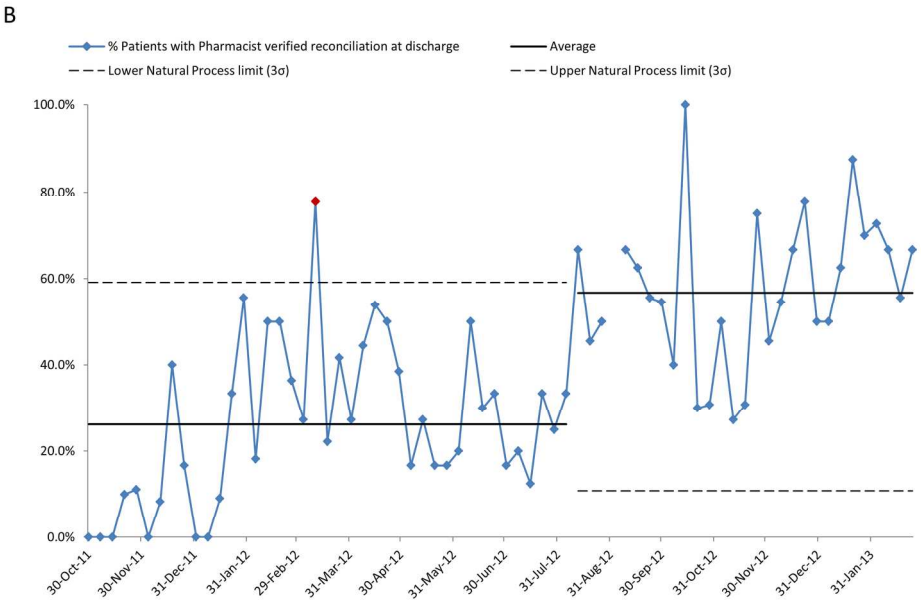


Figure 1b (Measure 2: higher percentage preferred): Percentage of patients with pharmacist-verified reconciliation at discharge
190x142mm (300 x 300 DPI)

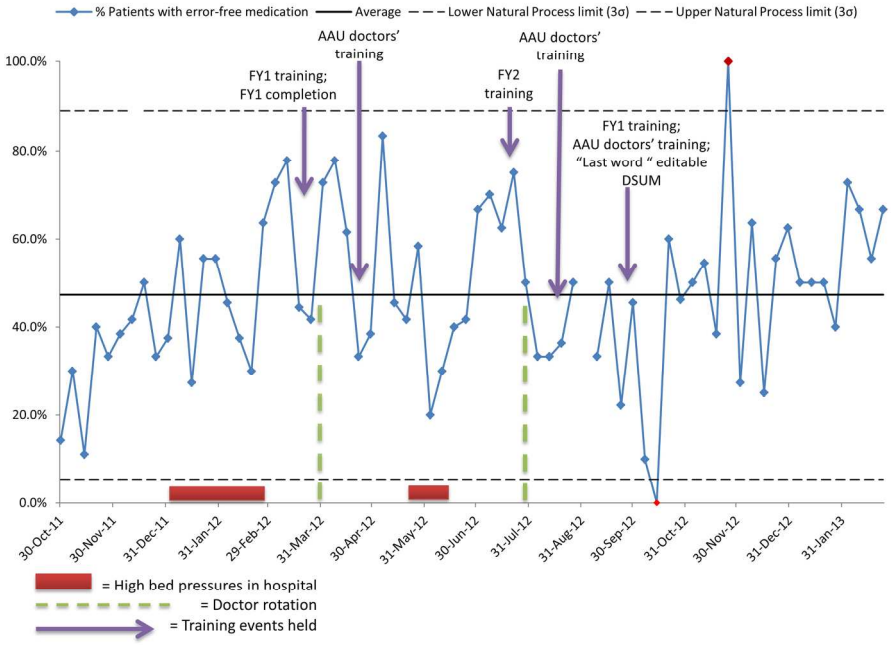


Figure 2 (Measure 3: higher percent preferred): Percentage of patients with error-free (and no omitted) medications on TTO prescriptions\r\nKey AAU: Acute Admissions Unit, DSUM: Discharge Summary, FY: foundation year junior doctors, "Lastword": the local EPR system
190x142mm (300 x 300 DPI)

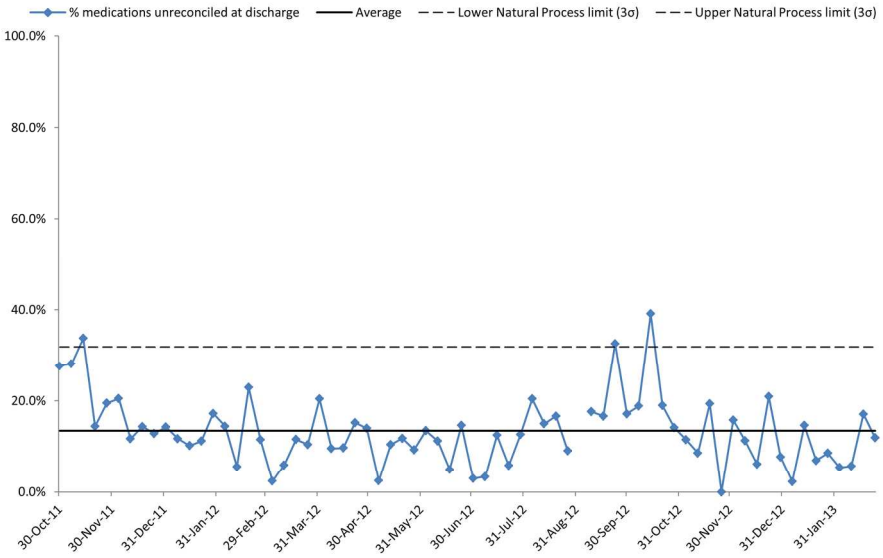


Figure 3 (Measure 4: lower percent preferred): The percentage of medications unreconciled at discharge
190x142mm (300 x 300 DPI)

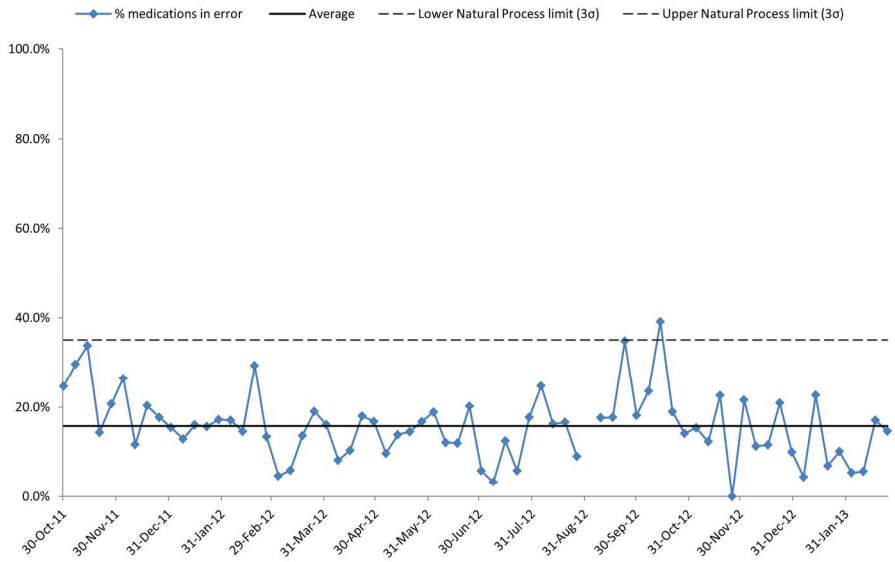


Figure 4 (Measure 5: lower percent preferred): The percentage of medications with an error or omission on TTO
190x142mm (300 x 300 DPI)

## Appendix

**Figure 1. Stakeholder Management Matrix – baseline**

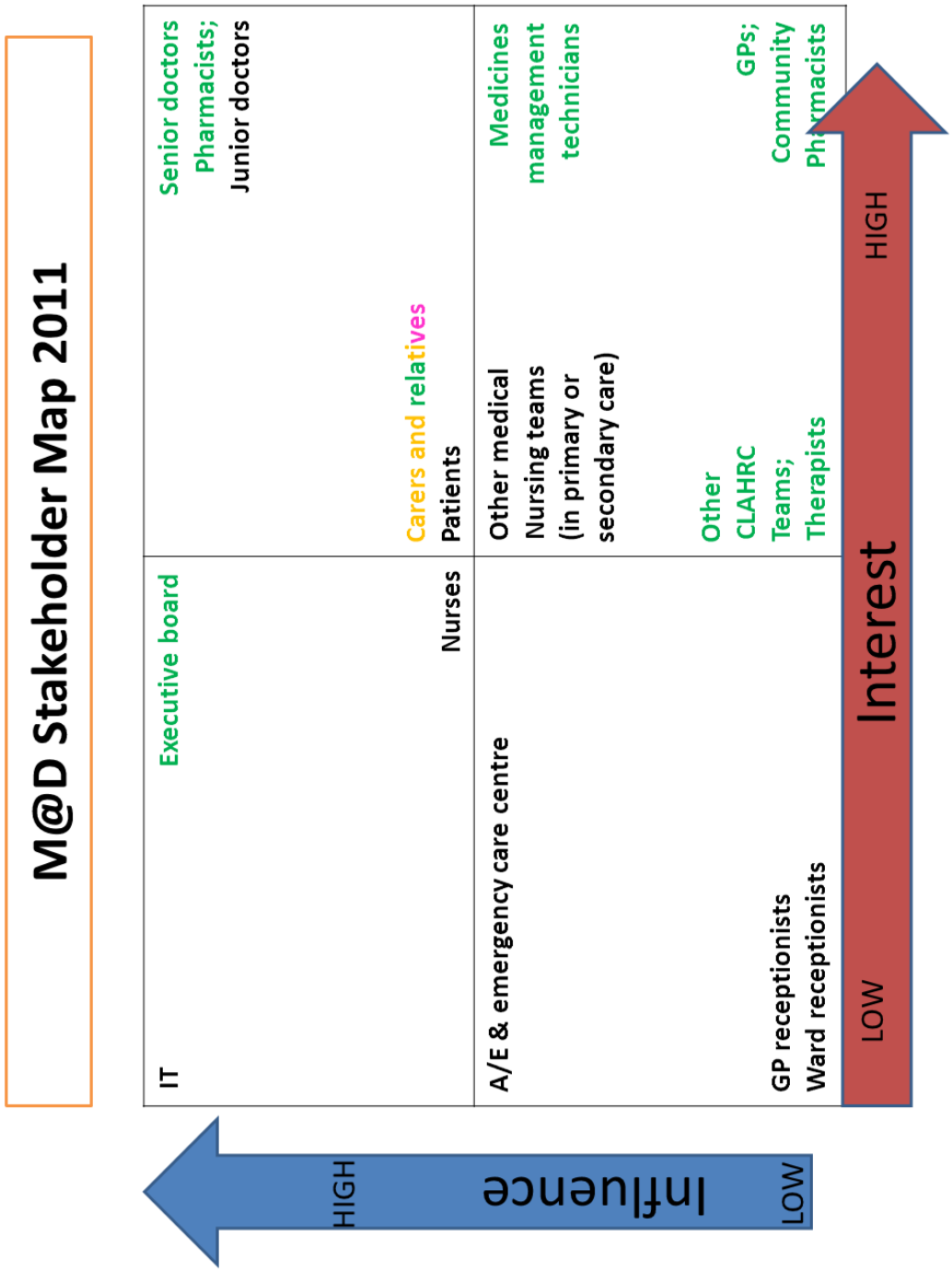

**Figure 2. Stakeholder Management Matrix – 15 months**

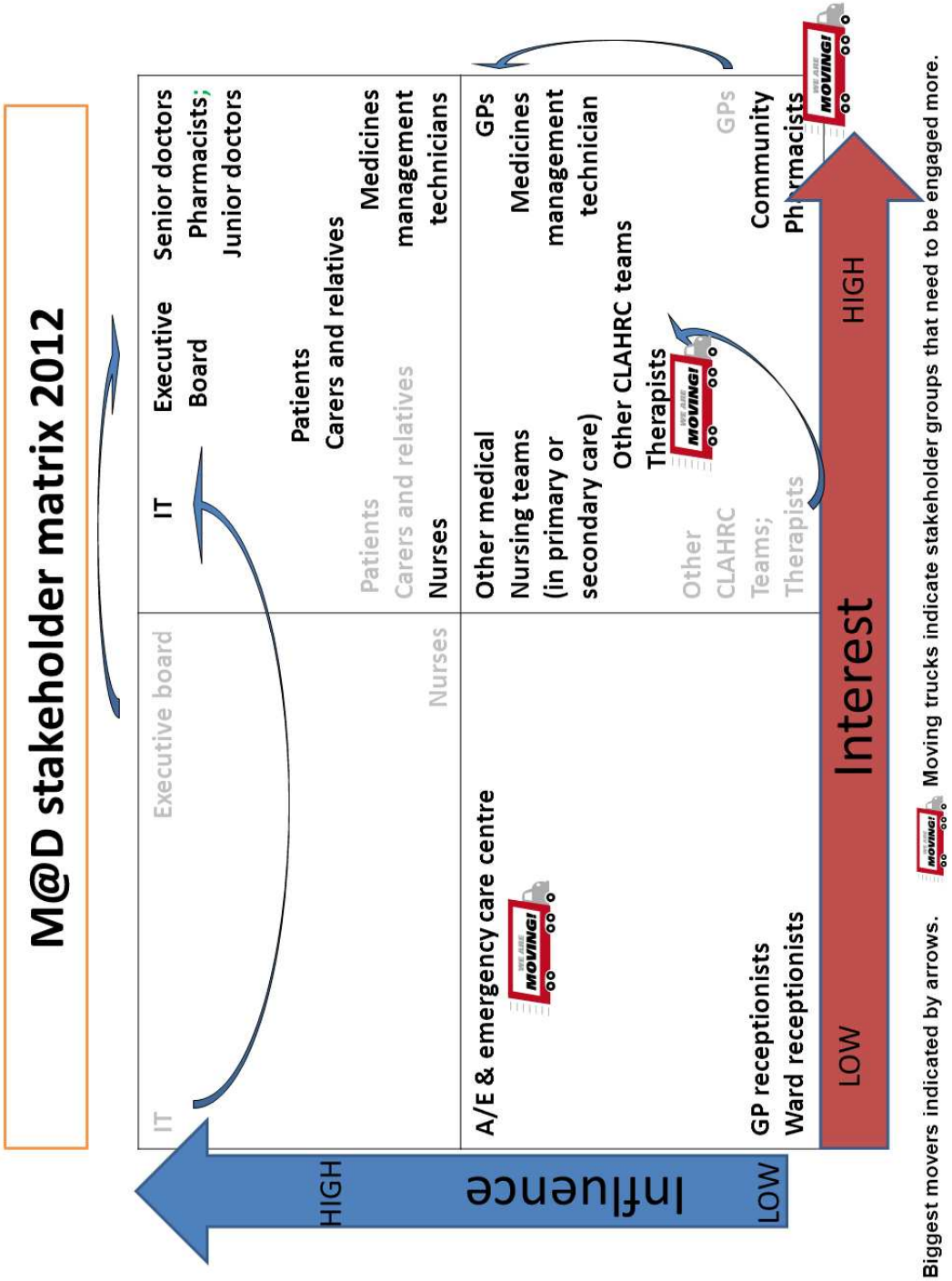

**Figure 3. Process map – higher level**

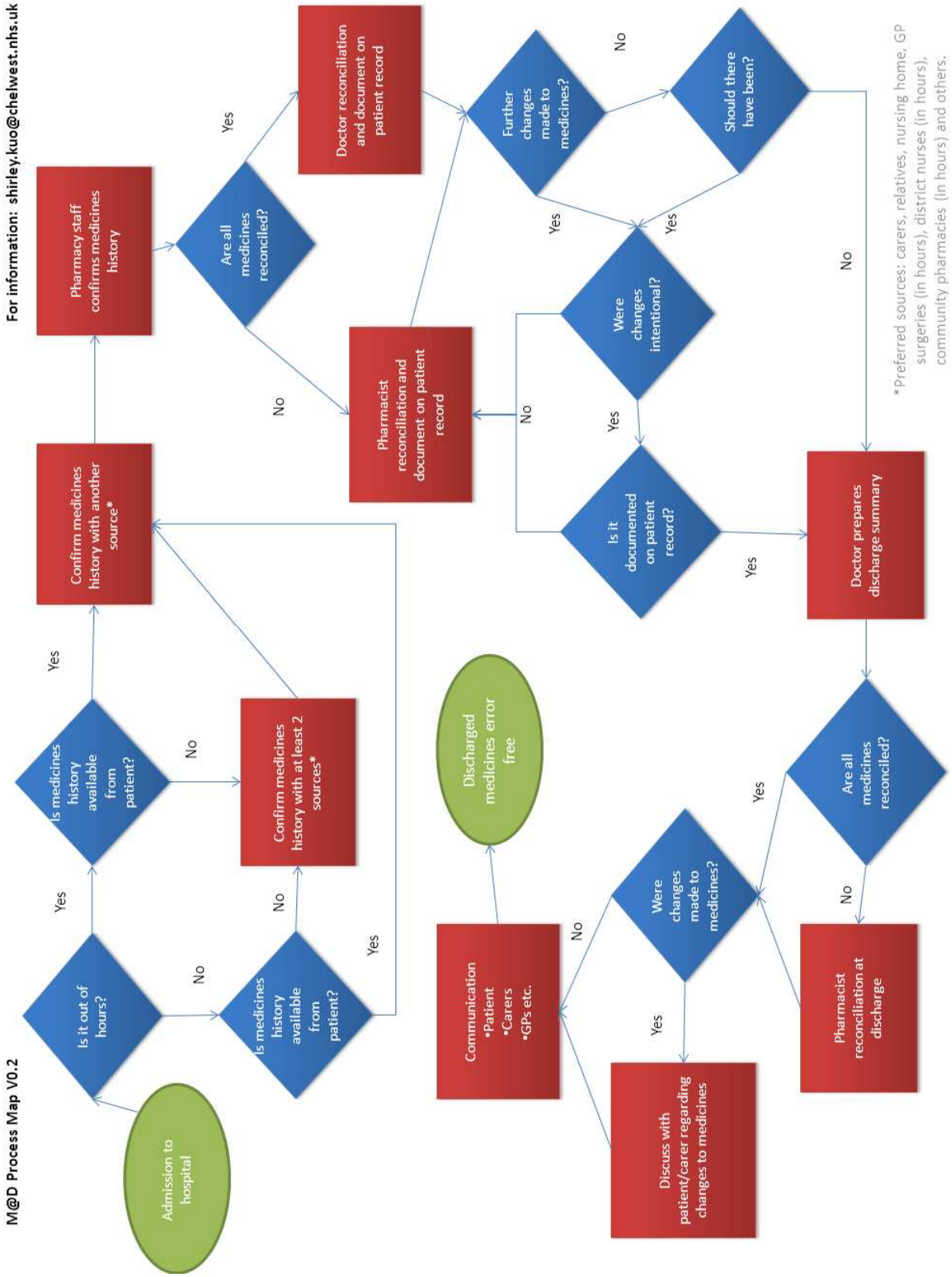

**Figure 4. Process map – lower level (AAU)**

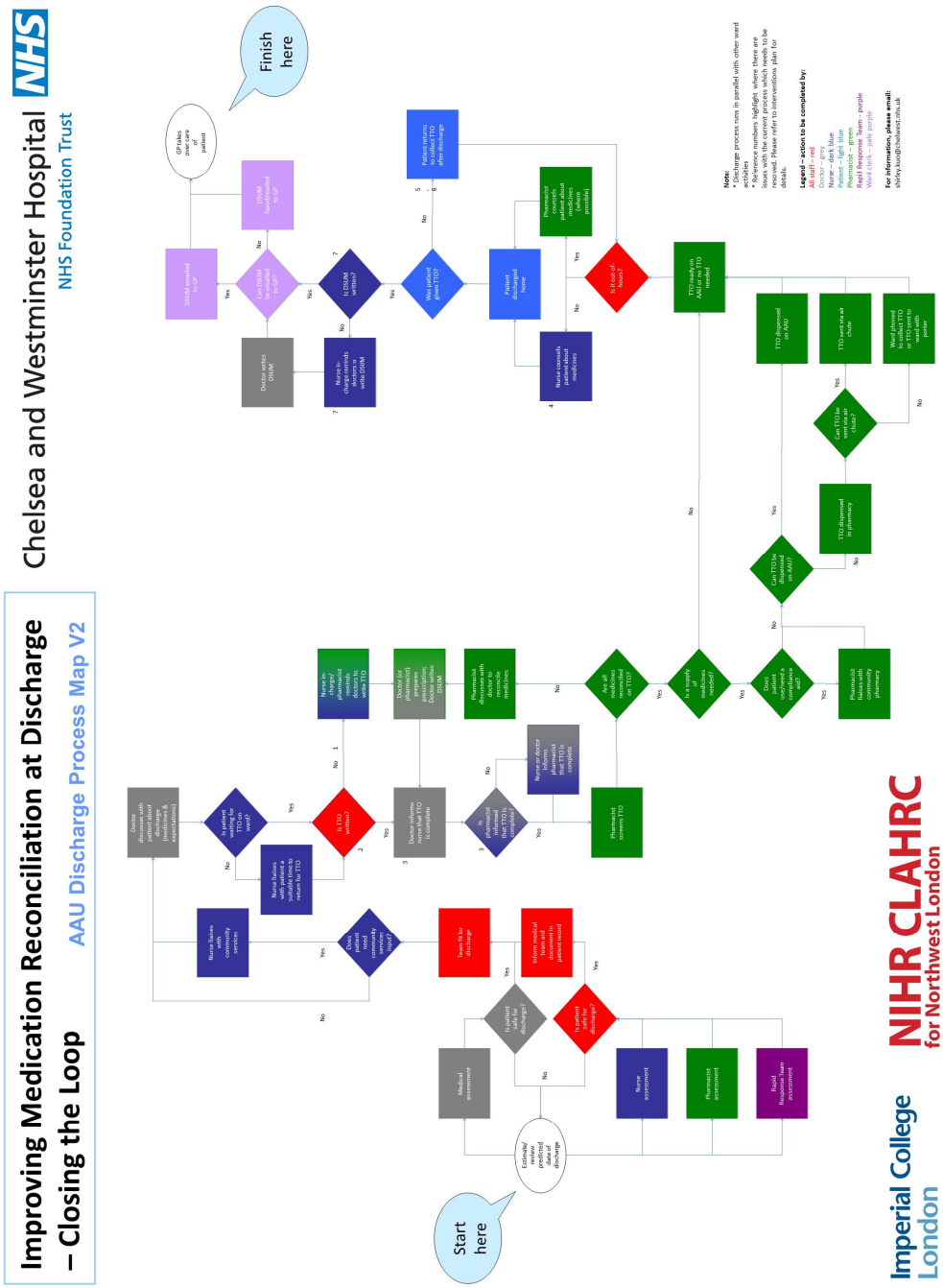

**Figure 5. Embedded interventions and stakeholder groups**

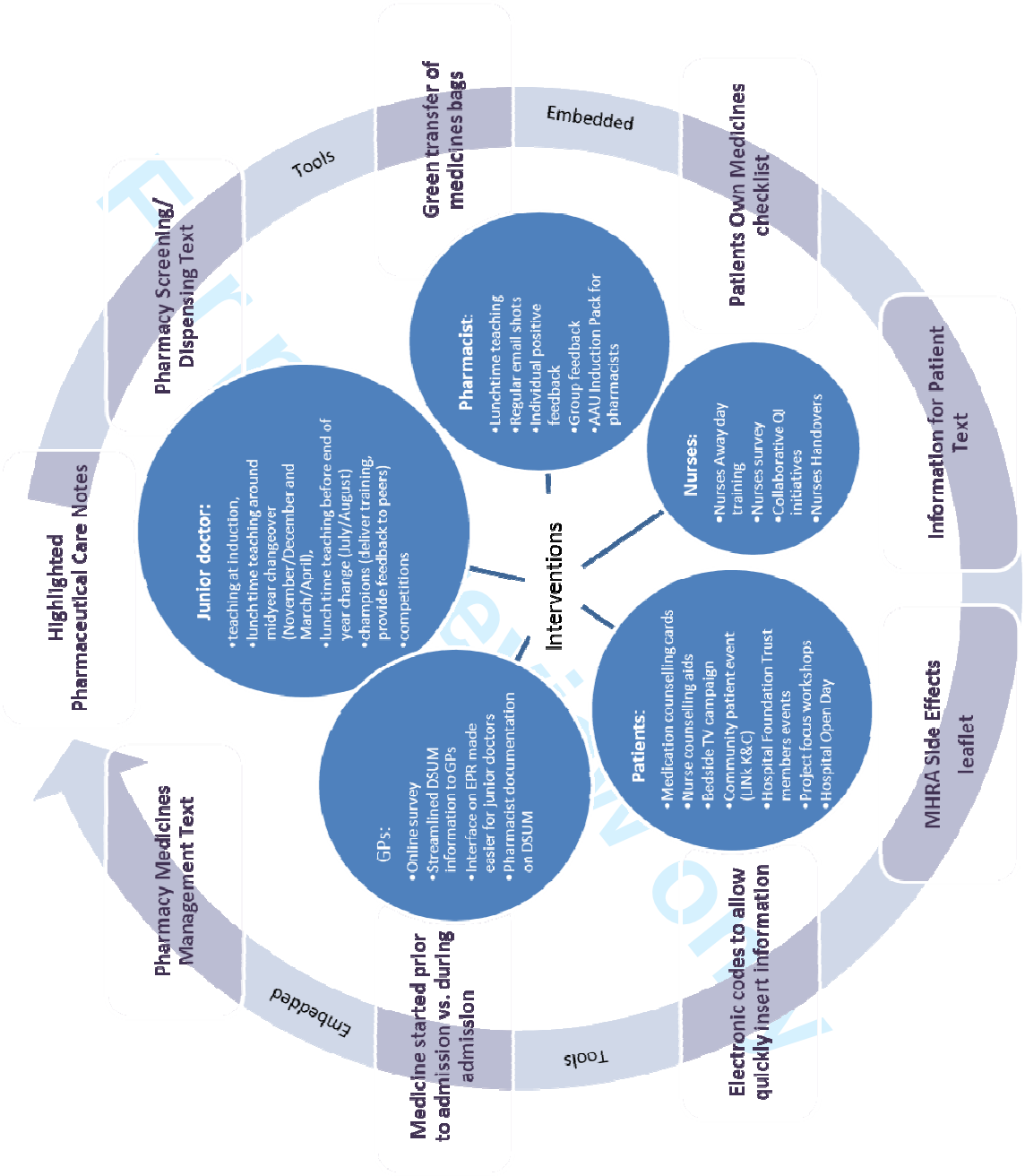

**Figure 6. Action Effect Diagram**

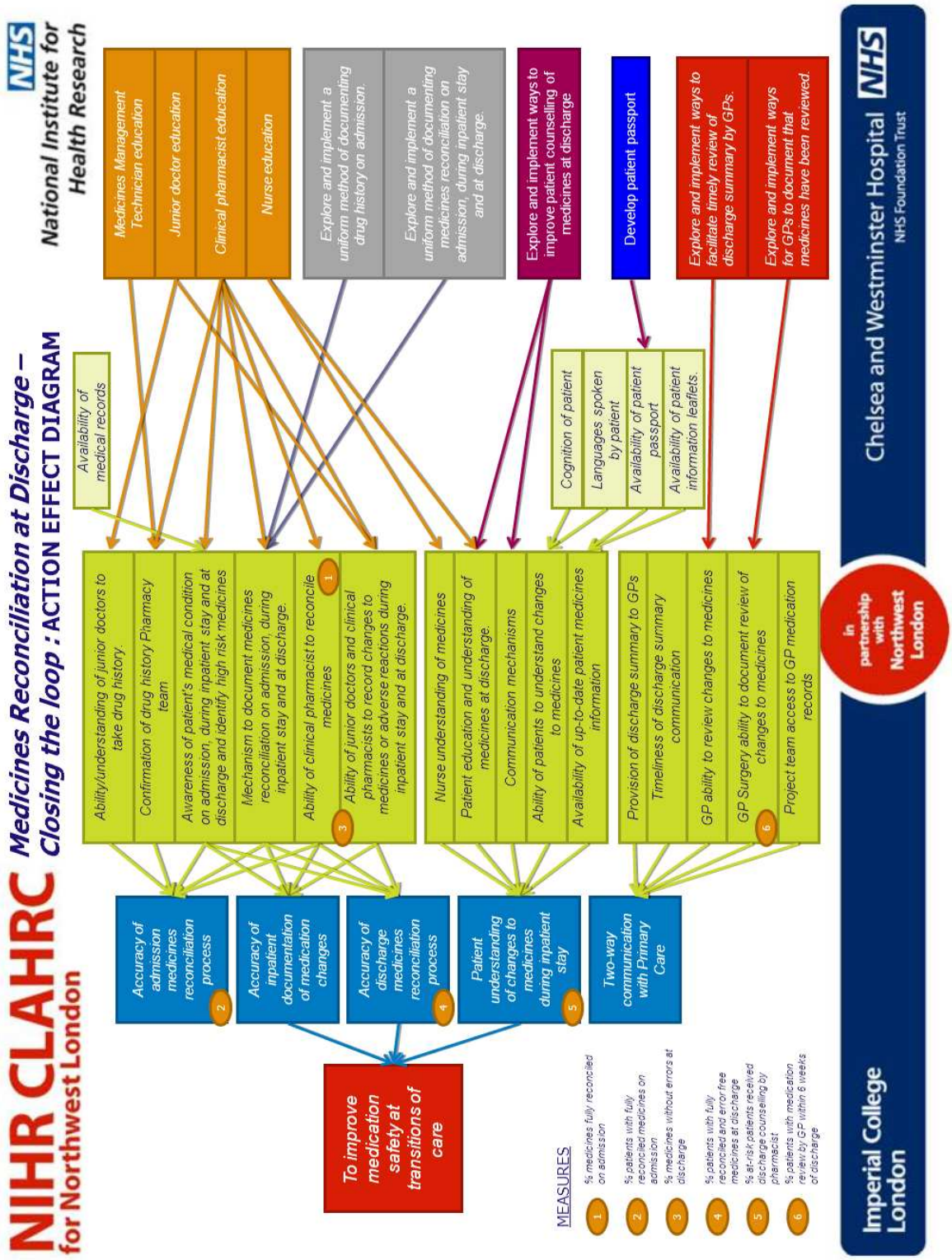

**Table 7. Plan-Do-Study-Act Cycles**

| Series Number | Cycle title |
|---|---|
| Series 1a: 19/5/11 | Transfer of medicines from AAU |
| Series 1b: 27/5/11 | Transfer of medicines from AAU |
| Series 1c: 8/7/11 | Transfer of medicines from AAU - Downstream wards |
| Series 1d: 22/9/11 | Transfer of medicines from AAU - Nurses survey |
| Series 2: 21/5/12 | TTO turnaround time - Pharmacist tracking |
| Series 3a: 6/12/11 | Uncollected TTOs |
| Series 3b: 1/5/12 | Uncollected TTOs |
| Series 4a: 11/2/12 | Nurse training package - Nurse questionnaire (AAU) |
| Series 4b: 27/2/12 | Nurse training package - Nurse questionnaire (Trust-wide) |
| Series 5: 28/5/12 | AAU pharmacy process review |
| Series 6: 3/9/12 | GP survey |
| Series 7: 14/6/12 | Improvement measures |

Key:
AAU = Acute Admissions Unit
TTO = To take out (medicines)
GP = General Practitioner

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# Applying Quality Improvement methods to address gaps in medicines reconciliation at transfers of care from an acute UK hospital



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| Secondary Subject Heading: | Patient-centred medicine |
| Keywords: | Medication reconciliation, Patient safety, hospital pharmacist, quality improvement |
| | |

**Title:** Applying Quality Improvement methods to address gaps in medicines reconciliation at transfers of care from an acute UK hospital

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**Title: Applying Quality Improvement methods to address gaps in medicines reconciliation at transfers of care from an acute UK hospital**


## ABSTRACT

Objectives: Reliable reconciliation of medicines at admission and discharge from hospital is key to reducing unintentional prescribing discrepancies at transitions of health care. We introduced a team approach to the reconciliation process at an acute hospital with the aim of improving the provision of information and documentation of reliable medication lists to enable clear, timely communications on discharge.

Setting: An acute 400 bedded teaching hospital in London UK.

Participants: The effects of change were measured in a simple random sample of ten adult patients a week on the Acute Admissions Unit over 18 months.

Interventions: Quality Improvement methods were used throughout. Interventions included education and training of staff involved at ward level and in the pharmacy department, introduction of medication documentation templates for electronic prescribing and for communicating information on medicines in discharge summaries co-designed with patient representatives.

Results: Statistical Process Control analysis showed reliable documentation (complete, verified and intentional changes clarified) of current medication on 49.2% of patients' discharge summaries. This appears to have improved (to 85.2%) according to a post-study audit the year after the project end. Pharmacist involvement in discharge reconciliation significantly increased, and improvements in the numbers of medicines prescribed in error or omitted from the discharge prescription are demonstrated. Variation in weekly measures is seen throughout but particularly at periods of changeover of new doctors and introduction of new systems.

Conclusion: New processes led to a sustained increase in reconciled medications and thereby an improvement in the number of patients discharged from hospital with unintentional discrepancies (errors or omissions) on their discharge prescription.
The initiatives were pharmacist-led but involved close working and shared understanding about roles and responsibilities between doctors, nurses, therapists, patients and their carers.


## Strengths and Limitations of this study

- We recognised the importance of organisation and structure in reducing unintended discrepancies at transfer of care.
- Documentation by pharmacists of medicines reconciliation at discharge in addition to that undertaken on admission was improved.
- We showed a critical relationship between discharge summary quality and junior doctor rotations. Interventions were specifically made at these key times and appear to have had a positive effect on the numbers of patients with error-free medication lists.

- QI methods ensured a clear structure to the project organisation and management, while allowing room for creativity.
- Appropriate systems changes were embedded to ensure sustainability.
- Limitations in our methodology meant we are unable to show whether the decrease in errors was directly related to introduction of pharmacist-led discharge medicines reconciliation.
- We do not know if improvements in communications had any impact on patient outcomes post discharge from hospital.


**Key words:** Medication reconciliation; patient safety; hospitals; pharmacist; quality improvement

## INTRODUCTION

Transfers between interfaces of care, especially discharge from acute hospital into the community, are recognised as high-risk transitions for the development of medicines-related problems, a leading cause of morbidity and mortality.[1] Medication 'continuity' errors are frequent, involving up to 70% of inpatients on admission to hospital [2] and contributing to avoidable re-admissions.[3] Considering between 28-40% of medicines are discontinued or altered during hospitalization[4] and fewer than ten percent of elderly inpatients go home on the same medication as on admission, [5] accurate communication of changes at discharge is an increasingly important contribution to patient safety and quality of care.
Medicines reconciliation, the process of identifying the most accurate list of a patient's medicines and comparing it to current prescribing, recognizing any discrepancies and documenting any changes, is essential for minimizing continuity errors. [6] The elements of reliable reconciliation are at each transition in care:
• verification (of the list of current medications the patient is actually taking),
• validation (acute review noting whether to continue, alter doses, hold or stop)
• clarification (comparing the medication list with current prescription order)[6]

Increased pharmacist involvement at admission, documentation of changes and systems facilitating transfer of information from the General Practitioner (GP) to hospital all appear to reduce medication error.[7] Previous local audit had revealed that though actively involved in the timely resolution of discrepancies between patients' medicines list from the GP and the hospital doctor, there was a lack of discharge communication from hospital pharmacists. In addition, the quantity and quality of information on medication changes made during hospitalisation was low; only 1 in 10 patients were discharged from hospital with sufficient information on their discharge summaries to enable safe ongoing prescribing. The information required was considered insufficient if one or more medicines were omitted; a stopped medicine was included erroneously or without explanation; the dose, route, course length or formulation (or change reason) was wrong or omitted; or essential monitoring information was lacking.

We recognised the need to integrate discharge reconciliation into the processes involving ward pharmacists; that is in confirming the clinical appropriateness of prescribing during the inpatient stay and checking back to the medicines history when organising take home medicines. Pharmacy-led reconciliation is considered a cost-effective intervention.[7]
The overall aim of this study was to provide seamless, high quality medicines reconciliation from admission through to discharge for all patients and improve communication with community service providers.
The objectives were to:

- reduce unintentional discrepancies in transcribing medication during admission to hospital
- improve documentation of medicines reconciliation at discharge
- improve the quality of communications regarding new and intentional changes to medication in the hospital discharge summary

### Ethical approval

Ethics approval was not required for this work as it was part of a service evaluation and improvement activity and not human subjects research. An ethics waiver was granted by Chelsea and Westminster Hospital NHS foundation trust (CWH) Research and Development lead.

## METHODS

### Setting

The main study was conducted at an acute hospital over 18 months from September 2011 to March 2013. A post-study audit to check whether any improvements have been sustained, was carried out in June to August 2014. The focus of the study was the Acute Assessment Unit (AAU) a 44 bed adult ward seeing an average of 25 admissions a day with a mean age approximately 61 years. These are predominantly medical patients (17% surgical admissions) discharged home or to a longer stay ward usually within 4 days. The average length of stay in hospital was 9.3 days at the time of the study. Junior doctors are responsible for documenting the patient's history on admission (including their medicines), prescribing on-going medication and preparing the discharge summary. The pharmacist on AAU verifies the medication history, validates and checks that all current continuing medicines are correctly prescribed on the in-patient electronic prescribing system (ePR). If a discrepancy is found or a change is made without the reason or indication documented as part of the medication order, it is clarified by the pharmacist. The prescriber is contacted to ascertain if the change was intentional. The completion of this pharmacist-led process of reliable reconciliation at admission is also documented appropriately on the ePR. Discharge prescribing is supported by pharmacists who check (or transcribe) take-home medicines (TTO). When the hospital has reduced capacity to admit to AAU, the focus for medical teams shifts to support speedier discharge including writing TTOs as early as possible. Early discharge relieves the bed pressures and allows for admission of new patients. Pharmacist activity on AAU is not usually affected by these changes and was maintained throughout the project.

## Planning the intervention

Following recognition of low overall numbers of patients whose medicines are fully reconciled, a core team of pharmacists and physicians convened with the objective of improving rates locally. Quality improvement (QI) methodologies were employed throughout.[8] [9] Workshops took place at the start of the project to identify stakeholders (appendix figure 1) and their engagement was plotted on the matrix again at 15 months (appendix figure 2). Process mapping identified the various stages of medicines reconciliation in the hospital (appendix figure 3) and was repeated with the focus on AAU (appendix figure 4). For this we convened a multidisciplinary team which included senior clinical leaders, senior nurses, junior doctors, consultant physicians, therapists, pharmacists and a data analyst. All contributed to the mapping and development of the interventions (see appendix figure 5). For example the physiotherapists advised on how they check patient's use of medication compliance aids and occupational therapists on finding 'old' medicines during home visits. Stakeholder engagement events open to staff and public were held and regular patient focus groups around medicines management topics continued through to July 2012. Members of the public were called upon on an *ad hoc* basis at first and subsequently patient representatives were fully recruited to the core team resulting in co-design of our interventions and systems updates. An Action Effect Diagram was drawn with contributions from all stakeholders and the overall aim agreed (see appendix figure 6). [8] Plan Do Study Act (PDSA) cycles further informed the project from the beginning and as it progressed (see appendix table 1). [9] Stakeholders received feed-back through emails and personal communications when the process maps were finalised.

Interventions were agreed as the most likely to lead to measurable improvements, assigned into one of three work streams:

1. Education
2. Documentation
3. Communication out of hospital

## Analytic plans

The study was a qualitative and quantitative improvement project using statistical process control (SPC) to monitor improvement measures.

SPC analyses are a graphical family of techniques designed for looking at data over time. SPC uses a number of "rules" to determine whether a process has unusual variation (special causes) or if fluctuations observed are simply representative of the inherent properties of that process.[10] In this study, we use the flexible XmR analysis and consider special causes to be indicated by points falling outside the natural process limits; a trend of 6 or more all increasing or decreasing values, and 7 or more points consecutively above or below the mean line. [11] Qualitative analysis of outputs from workshops, focus groups and stakeholder events was undertaken as they took place throughout the project. Themes emerging from the analyses including patients' wish to have their own summary of new medicines on discharge with a personalised list of side effects (rather than the full medicine package information) in plain language, were used to co-design the new style DSUM (see later, Interventions). In addition, the early analysis helped form the

structure and content of staff education and induction sessions (see later, Interventions).

Data collation was carried out each week by the research pharmacist (SK). A sample of ten discharge prescriptions was identified weekly using randomly generated numbers. Checks were put in place to ensure that no patient was included more than once; readmissions were identified and noted (but not analysed for this project). Data was obtained retrospectively from ePR and dispensing records to identify any unintentional discrepancies between the inpatient prescription chart and discharge list of medicines. Confirmation of pharmacist-led verification of a patient's medication history was obtained from documentation in the electronic pharmaceutical care notes and the discharge summary for admission and discharge respectively.

Process measures were designed to monitor improvements see Table 1

Table 1 Process Measures

| Measure | Measure in sample of 10 patients per week randomly selected from all discharges for the week | Detail |
|---|---|---|
| 1 | Percentage of patients with pharmacist-verified reconciliation on admission | Pharmacist has documented on ePR that they have checked the admission medication list with the patient and verified with a second source and clarified or resolved any discrepancies on the inpatient order with the prescriber |
| 2 | Percentage of patients with pharmacist-verified reconciliation at discharge out of the total number of patients sampled | Reconciliation at discharge is possible only for patients with a verified admissions medication list. For this measure any change to any admission medicine, dose, frequency or route is confirmed by a pharmacist as intentional and documented clearly on the discharge summary as such |
| 3 | Percentage of patients with error-free TTO prescriptions | TTO has no unexplained discrepancy compared with the verified list of medicines on admission. The reason is stated for any omission, change in dose, frequency or route; course lengths and monitoring advice are given where needed. If no reason is given for a discrepancy then the patient does not have an error-free prescription |
| 4 | Percentage of medications unreconciled at discharge out of the total number of medicines within the sample of 10 discharge summaries per week | Measure 4 is directly related to measure 3. The number of individual medicines unreconciled were recorded. Patients on no medicines were included in the study; medicines reconciliation was considered reliable only if 'nil regular medication' was verified and documented as such. |
| 5 | Percentage of medications with an error (or omission) on TTO out of the total number of medicines within the sample of 10 discharge summaries per week | Measure 5 is directly related to measure 3. The number of individual medicines with an error or omitted without explanation were recorded. For each patient several medicines may be prescribed in error or omitted |

| | | |
|---|---|---|
| | | from the TTO |

An error was recorded if any medicine was ordered that should have been stopped (including wrong medicine) or if a dose, route, course length or formulation was incorrect. An omission was any medicine left off the TTO that should be entered as it is to be continued. Any change from the verified admissions list of medicines without explanation or monitoring requirement was also considered an error.

Weekly analysis of these measures was facilitated through the web improvement support for healthcare (WISH) tool.[12] The tool provides reports with SPC analyses, by calculating the mean and respective upper and lower natural process limits of the measures in question, tracked over time. Results were fed back to the core project team weekly.

The improvement measures supported the iterative changes during implementation process and the use of Plan-Do-Study-Act cycles, also documented through the WISH software. Several audits measuring standards of medicines history taking and reconciliation of discrepancies were undertaken during the study period and helped to inform and support the project. Further details of QI methodologies and outputs are given in the Appendices.

Data were collected from patients discharged between weeks commencing 30 October 2011 and 17 February 2013 (70 weeks, with one missing week). A post-study audit was carried out using the same sampling method from 06 June to 31 August 2014 (nine weeks), to check whether any improvements made during the project were sustained. Small variations in selected numbers occurred in-week where there were delays in a patient's discharge. These patients were not excluded but appeared at a later date in the measures data.

## Interventions

All interventions took place during October 2011 to February 2013. Further details are provided in the Appendices.

### Education

All pharmacists and medicines management technicians received a training update and accreditation in medicines reconciliation and were instructed in the importance of full documentation of pre-admission medication histories. Feedback was provided on a regular basis, at least twice monthly advocating 'good practice' in summarising changes made to medication during hospitalisation. Training was held collaboratively with other staff groups including nurses and therapists.

The team negotiated with AAU physicians to take a ten minute 'Pharmacy session' on AAU during the weekly 'learning at lunch' for doctors. At these sessions and also at induction, around mid-year changeover (November/ December and March/April) and before end of year change (July/August), a pharmacist describes the principles of medicines reconciliation, good prescribing and monitoring. They also advise on timely administration of critical medicines, reviewing and continuing regular medication and how pharmacists support the processes involved.

Two junior doctor champions were recruited to assist with the delivery of training and act as a channel for providing feedback to their peers. The project champions were well received (informal feedback from peers) and reported high levels of satisfaction with their role (informally direct to the rest of the project team and at appraisal with their clinical leads).

Documentation

ePR provides an easily accessible central documentation of patients' current medication and relevant history including what the patient actually takes, their allergies, intolerances and preferences, on the same screen as inpatient prescribing. This allows access to the original list while prescribing so that changes made by the hospital clinicians can be transcribed onto the discharge documentation with ease. However, locally the medication history list and medicines reconciliation detail required free-typing, without a set format or obligatory fields. Following consultation with IT support and the junior doctor champions, changes to the system were designed by the project team and approved by the executive lead for ePR creating tools to prompt and aid documentation of medication reconciliation. (These were brought in during the project data collection period in October 2012, as an intervention so that we are able to measure any effect on documentation and communication) and included:

- Changing screen colours to distinguish between reconciled and unreconciled medication lists
- Changing existing "Pharmacy Discharge Summary Text" box visible on GP, Patient and Pharmacy copy to "Pharmacy Screening/Dispensing Text" only visible on Pharmacy copy. GPs and Patients previously received unnecessary dispensing information on their discharge summary.
- Creating a "Pharmacy Medicines Management Text" box, to allow clear timely documentation by pharmacists of medicines reconciliation, and information about changes visible as required on all copies. This includes confirming where medicines reconciliation was not completed at admission.
- The addition of space headed "Information for Patient" on the patient copy of the discharge summary for the pharmacist to add selected counselling points specific to their new medicines
- Signposting to the hospital Medicines Information Helpline to aid access to further information they may need once they are home, developed in response to patient experience feedback.[13,14]

Communication with the GP

At first presentation at hospital an individual patient's complete list of current medication is required either via the patient or their carer (e.g. a repeat prescribing document or detail on a referral letter from the GP) or if this is not with the patient, the GP surgery is usually contacted at the earliest opportunity. There is as yet no direct e-communication locally between the hospital ePR and GP practices. We use the telephone to request and fax to receive patient medication record details. On transfer home we create the discharge summary including the TTO which is for many medicines, a simple transfer from the inpatient ePR. A copy is emailed or posted to the GP.

Communication out to the GP about any changes made to medication in hospital requires free-typing into the discharge summary; local audit found this was missing in over 40% of cases. The approved changes to the ePR documentation as above were designed to improve medication reconciliation communication including with the GP.

## RESULTS

A step-wise improvement is seen across measures relating to discharge medicines reconciliation throughout the project (Figures 1 to 4). For the post-study audit all measures indicate sustained improvement, summarised in Table 2.

During the study period an average of 66.3% of patients have pharmacist-verified medicines reconciliation on admission (see Figure 1a). A temporary uplift in the process is observed starting in June 2012 with seven points above the mean line, however, the process reverts to previous performance levels after this period. The average (mean) showed some short-term improvement to 82.7% coinciding with when initiatives were put in place to engage staff in pharmacist-led processes. Reconciliation at discharge is possible only for those who had a verified list of admission medicines.

Pharmacist documentation of medicines reconciliation at discharge improved from an average of 26.2% of patients to 56.7% (Figure 1b). A single point outside the natural process limits is observed in March 2012, indicating a special cause. From August 2012 onwards all points lie above the previous mean performance (special cause variation), hence the natural process limits are calculated separately for this period to better represent the improved process. This improvement appears to be sustained and improved upon as it was found during summer 2014, that an average of 64.8% of discharged patients had their medicines reconciled and documented on the discharge summary (Table 2).

On one week with high bed pressures (31st May 2012, see Figure 2) performance was below average, recovering over a six week period of increasing trend (constituting an SPC rule break).There are two indications of special cause with data lying beyond the natural process limits in October 2012 and November 2012. The periods of bed pressures did not appear to affect pharmacists' admission activity.

The short term improvement mid-project appears to have been achieved one year on as it was found that in a nine-week period of measures during summer 2014, an average of 88.1% of patients had pharmacist-led medicines reconciliation documented on admission.

Table 2 Audit data to examine for sustainability of changes

| *For audit period: weeks commencing 06-Jul-2014 to 31-08-2014* | | | | |
|---|---|---|---|---|
| *Number of patients in audit = 88, number of medications = 1148, mean number per patient = 13* | | | | |
| % Patients with Pharmacist verified | % Patients with Pharmacist verified reconciliation at | % Patients with error-free medication | % medications unreconciled at discharge | % medications in error |

| reconciliation on admission | discharge | | | |
|---|---|---|---|---|
| 87.5% | 64.8% | 85.2% | 3.7% | 2.3% |

After an initial low period an average of 47.2% percent of patients with no medication errors or omissions on discharge is seen, but with marked variation in late 2012 coinciding with the changes being embedded in the editable part of the discharge summary (Figure 2). In the period of measures during summer 2014, an improvement was seen with 85.2% patients having error-free medication using the same criteria for reconciliation as during the project 18 months previously (Table 2).

Key events mapped onto the process control chart for error-free medications from admission and through to discharge during one calendar year of the project, show the relationship between junior doctor rotations and the weeks when the hospital was under bed pressures (Figure 2). A fall the percentage of error-free medications is seen during September 2012 though this is not sustained and improvements are apparent when teaching sessions had been completed.

The average for medications unreconciled was 13.5% (Figure 3). There are three indications of special cause, October 2011, September 2012 and October 2012. In the summer of 2014, improvement was found with 3.7% of medicines recorded as unreconciled at discharge (Table 2).

The percentage of medications with an error (or omission) was an average of 15.8% (Figure 4). There are two indications of special cause variation, September 2012 and October 2012. During summer 2014, improvement was seen with an average of 2.3% of medicines (prescribed or omitted) in error using the same criteria as during the project (Table 2). Note that in Figures 3 and 4 there are transient uplifts in values, before reversion to previous performance, across August and September 12; period in which newly qualified doctors begin their training.

## DISCUSSION

Hospital based, pharmacist-led medicines reconciliation processes frequently identify and resolve unintended prescribing discrepancies between healthcare providers.[1] We have made improvements to these local processes particularly in provision of documentation and communication of medication changes at discharge from hospital.

The effect of this quality improvement is demonstrated in the decrease in numbers of patients leaving hospital with unintentional discrepancies (errors or omissions) on their discharge prescription. Though there was marked variation in this figure during the study, it appears to be sustained overall with an expectation that it remains consistently below 20% (as shown in 2014). However, the period from August to October in 2012 shows an increase in the number of unreconciled discrepancies in discharge medications. We have looked for explanations for this as it does not coincide with the hospital being particularly busy or under pressure for beds or other parameters that we were monitoring at the time. It may have been influenced by the period of high staff turnover in pharmacy which occurs every new academic year. Though not the project team per se, we were inducting new juniors and managing

unprecedented vacancies including staff leave (postponed during the London Olympics and taken in September and October that year).

There is clearly a need for further improvement; regular teaching and support particularly for junior doctors has been put in place and remains a key aspect of current practice and the subject of further medicines optimisation research locally. In addition the pharmacist induction programme locally now includes training in documentation of medicines reconciliation on ePR.

We found a high level of variation in the percentage of patients with error–free discharge prescriptions in particular around the time of introducing the changes to processes on ePR. The changes required different inputs by the prescriber and though all were trained by the implementation date, many had their training several weeks before. Variations may also have been the result of the small sample set for weekly measures. Ten patients were selected each week. If a fully trained 'good' prescribing team were on duty for the sampling period it could contrast with one less familiar with TTO requirements on duty the following week.

Overall, our ePR updates appear to have had a positive effect on the quality of discharge summaries as error-free TTOs rates are seen to rise in the period from its inception in October 2012 to February 2013 when measurement stopped, and again when measured in 2014.

A median of 45% of hospital patients in USA and Canada have at least one clinically significant discrepancy in their medications at transfer of care according to a systematic review of reconciliation in 2013.[15] Garfield and colleagues in the UK found unintentional discrepancies in 70% of medication prescribed on admission for around 60% of patients. [16] Unintentional discrepancies in discharge medication received by patients occurred up to 27% of items and these translated to discrepancies in repeat medication subsequently received from the GP in 57% patients. [17] In our study we looked at documentation on the discharge summary, exactly as it would be received by the GP. An 'error' was recorded if a medicine was missing from this communication or details of a change in medication not noted. The number of medicines unreconciled at discharge fell to 10% and then to 4% (2014 figures). Ascertaining whether any changes to medication reported are actually received and acted upon by the recipient was outside the scope of this project.

Follow-up of patients at another UK hospital where medicines reconciliation was found to be incomplete, revealed that the majority of failures occur when the standard admission documentation is not used. This was more likely to occur where specialist admission pathways were in place and paper pro formas were not updated or if they had to be used in parallel with several other documents.[17] A survey of pharmacy services for patients at discharge from hospitals in Ireland suggested development of national standards of practice may help to eliminate the variation found in practice and would support improvement.[18] During our study we embedded new ePR tools to prompt and aid documentation of medication reconciliation particularly on the discharge summary. In addition, at admission we sought to standardise the pharmaceutical care entries made by pharmacy staff regarding medication histories. An audit undertaken in 45 English hospitals (including this study site) suggests that pharmacist-led medicines reconciliation at admission prevents adverse events occurring during an inpatient stay.[19]

In the 2013 systematic review the authors note that the actual benefits of resolving unintended discrepancies are not seen; medicines reconciliation does not seem to reduce emergency department visits or readmission within 30 days. The reviewers found most medication discrepancies appeared to have no clinical significance and, given limited resources in hospitals, it is suggested it may be prudent to target patients at high risk rather than all admissions.[15] Our study did not include patient follow-up so does not add to this but follow-on projects are planned where we will target vulnerable patients (especially elderly) identified through medicines reconciliation and other processes for further pharmacist intervention with examination of the clinical significance of intervening on unintentional discrepancies and readmission rates.

In part to inform this research we recently compared medicines reconciliation by doctors on first contact with patients to pharmacy-verified medication lists. Full and accurate documentation was found for only 27% of patients prior pharmacy check. The value of the pharmacist in medicines reconciliation was also shown in a Swedish Medical ward though the researchers suggested more work is needed.[20]

Documentation by pharmacists of medicines reconciliation at discharge in addition to that undertaken on admission was a new concept locally. We have now integrated the process into the patient centred pharmaceutical care carried out by our team of clinical (ward) pharmacists as part of their regular duties. All inpatient prescriptions are reviewed by a pharmacist at the first opportunity, including medicines reconciliation within 24 hours of admission where possible. It is a challenge at weekends where staffing levels are lower; currently under review locally and across the UK. The changes we have put in place around discharge reconciliation have been achieved without extra resource but with critical refocussing of pharmacist input. Prior to this project any changes made to patients' medicines had to be communicated by the prescriber as part of the free-type letter to the GP on the discharge summary. There appears to be a relationship between discharge summary quality and junior doctor rotations. Interventions specifically made at key times in rotations to improve discharge summary documentation appear to have a positive effect on the numbers of patients with error-free TTOs.

We recognised the importance of organisation and structure in reducing unintended discrepancies at transfer of care. A 'whole system' approach in this discharge process involved members of staff from a range of disciplines, all of whom were involved in appropriate prescribing, ensuring the assessment of a patient's ability to take their medication, or education of a patient about their discharge medications. While other studies have underlined the importance of the interactions between medical and pharmacy staff, the success of this project partly lay in its ability to engage with nursing and allied health staff in addition.

The project team made ongoing sustainability a priority from the start, which is judged as important in embedding change,[21] and where appropriate, systems change was sought (e.g. improved electronic prescribing software functionality). Building improvements into the processes helps to minimise human error and reduce variability of outcomes. Better use of existing resources and embedding new tools for daily practice therein, ensures a

sustainable change for the organisation which might be expected to be cost-neutral.
Integration of best practice project management using QI methods ensured a clear structure to the project organisation and management, while allowing room for creativity.

## LIMITATIONS AND LESSONS LEARNT

We were unable to show if our improvements in communication out of hospital had any impact post discharge. This will be the subject of future project work in the community. The data presented here suggests a link between pharmacist involvement and a decrease in errors but is not conclusive and merits further study.
The project team was successful in engaging and influencing staff from all levels in changing practice. Communication barriers with doctors where they existed were removed with the recruitment of junior doctor champions to deliver training and providing feedback to peers. Culture within the pharmacy department was changed by seeking out early adopters to act as catalysts for change. Engaging the right people at the right time for the right tasks that complement their skills and interests, was a key to success (e.g. AAU sister in mapping discharge process; junior doctors in preparing posters).
This included effective engagement with the hospital's GP Relationships Manager who supported the project's initiatives where possible; this proved important as engaging directly with GPs was difficult.
Other aspects of the project, such as junior doctor and patient education, which are labour intensive, were successful but may prove less sustainable.

## RECOMMENDATIONS

Regular feedback of the quality of doctor's medication reconciliation at discharge is an important aspect of training that has resulted in an improvement in the number of patients discharged without errors on the discharge summary. However, maintaining weekly measures to allow such feedback is very time consuming. An option could be through incorporating the weekly measures into Trust clinical audit agenda.
The data in the current form are unable to distinguish whether the improvement in number of unreconciled medicines or number of errors is because of the introduction of pharmacist discharge medicines reconciliation and documentation. We do not know if they resulted in improved patient outcomes nor if communications in the discharge summaries are actioned by the recipient. We therefore recommend that a subset analysis and follow-up is carried out to compare outcomes for patients who have had pharmacist involvement in the preparation of the discharge summary.

## CONCLUSION

During the period of our medicines reconciliation project we put in place new processes that led to a sustained reduction in un-reconciled medications and thereby an improvement in the number of patients whose discharge medications were documented and communicated out from the hospital without error or omission. The initiatives were pharmacist-led but involved close working and shared understanding about roles and responsibilities between doctors, nurses and patients or their carers.

Care has been taken to embed the processes involved into standard working practices and computerised systems, ensuring that reliable reconciliation and documentation is sustainable.

**Contributorship statement**
VM project pharmacy lead; prepared the manuscript from original study reports written by SK
SK project manager
AJP analysed data and assisted in preparing the manuscript for publication
TW contribution to method design and input on analysis
LV project clinical lead; assisted in the analysis and original report write-up
DB Director NIHR CLAHRC NWL; oversaw original project, set objective and reported on progress

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**Data sharing statement:** Further local audit data, poster content and conference abstracts are available by email from VM

**Study Approval**

According to the policy activities that constitute research at Chelsea and Westminster Hospital NHS Foundation Trust this work met criteria for operational improvement activities exempt from ethics review.
Ethical approval was not required for this work as it was part of a service evaluation and improvement activity and not human subjects research. An ethics waiver was granted by Chelsea and Westminster Hospital NHS foundation trust (CWH) Research and Development lead

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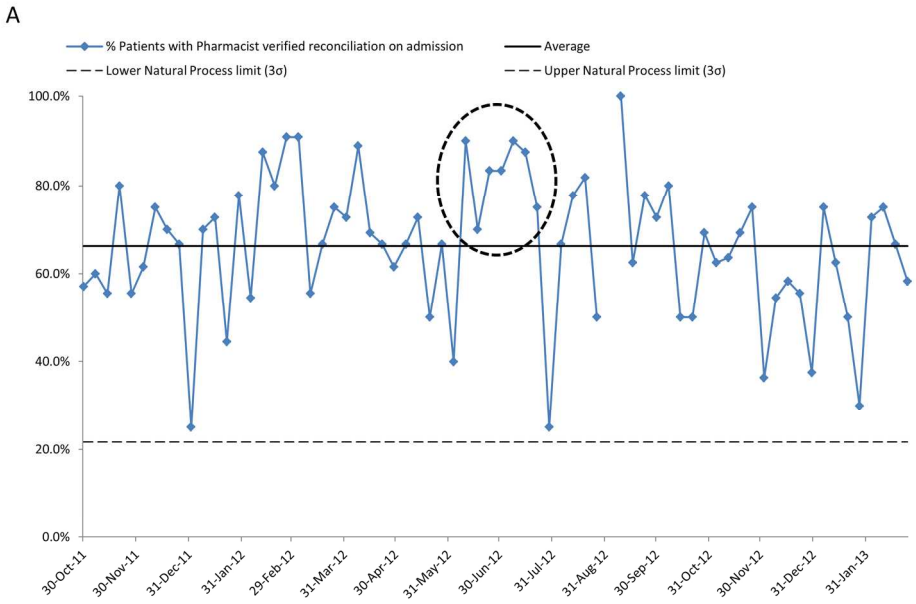


Figure 1a (Measures 1: higher percentage preferred): Percentage of patients with pharmacist-verified reconciliation on admission
190x142mm (300 x 300 DPI)

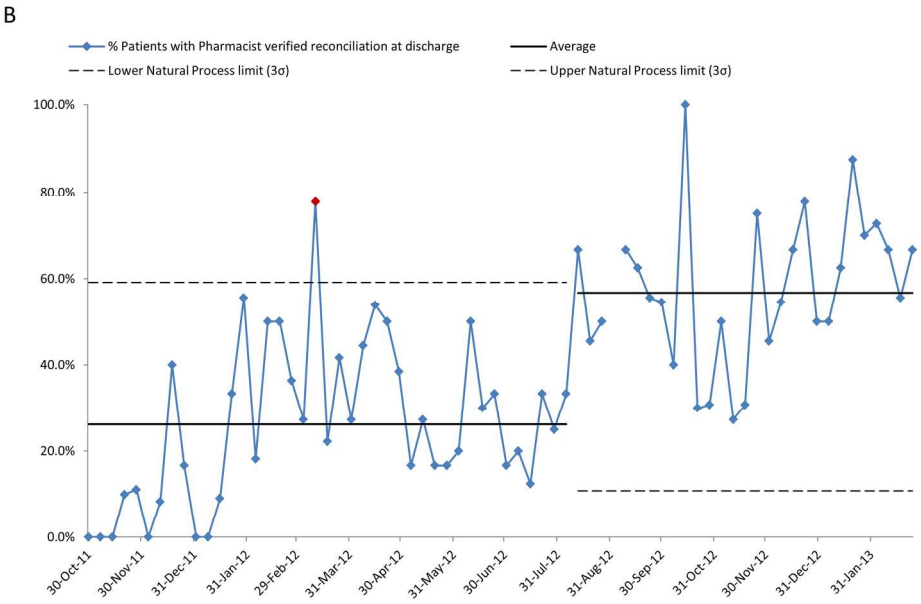


Figure 1b (Measure 2: higher percentage preferred): Percentage of patients with pharmacist-verified reconciliation at discharge
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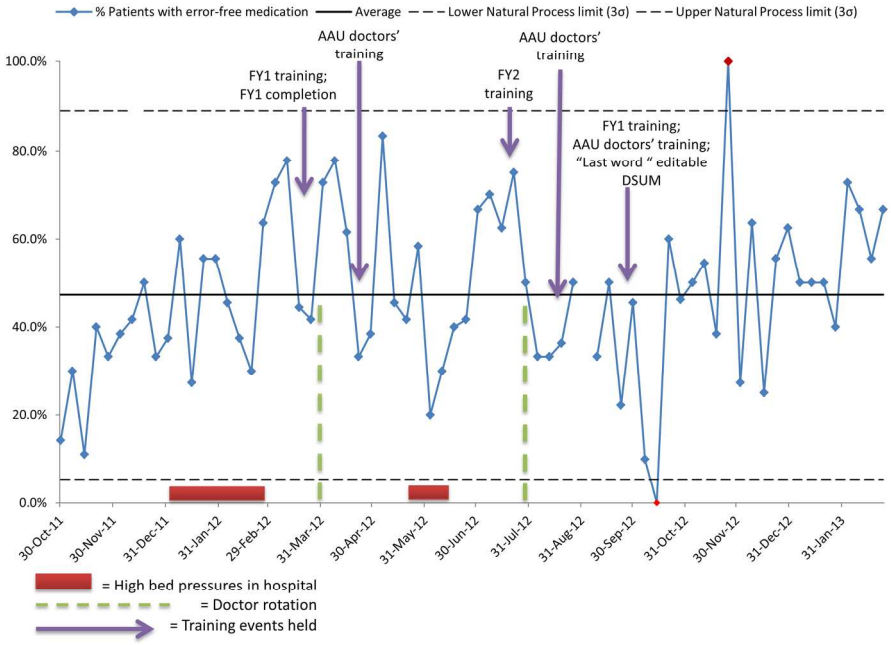


Figure 2 (Measure 3: higher percent preferred): Percentage of patients with error-free (and no omitted) medications on TTO prescriptions\r\nKey AAU: Acute Admissions Unit, DSUM: Discharge Summary, FY: foundation year junior doctors, "Lastword": the local EPR system
190x142mm (300 x 300 DPI)

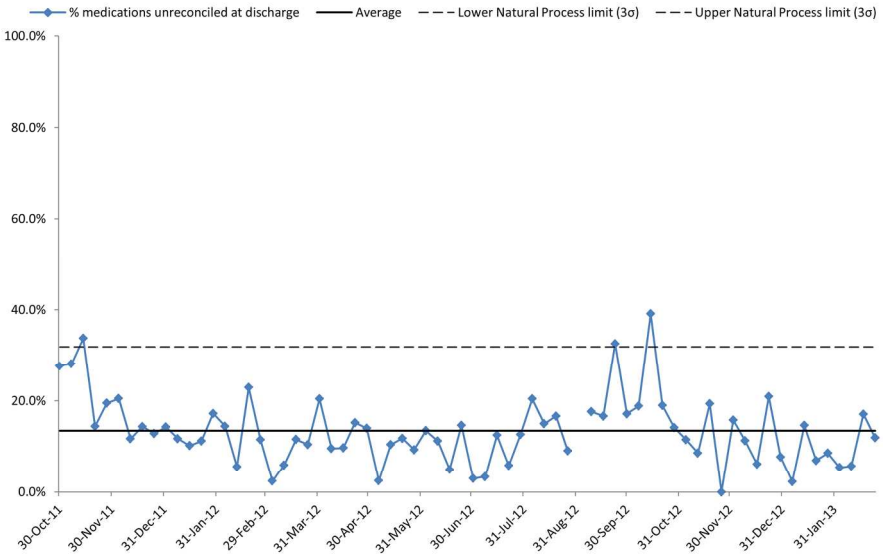


Figure 3 (Measure 4: lower percent preferred): The percentage of medications unreconciled at discharge
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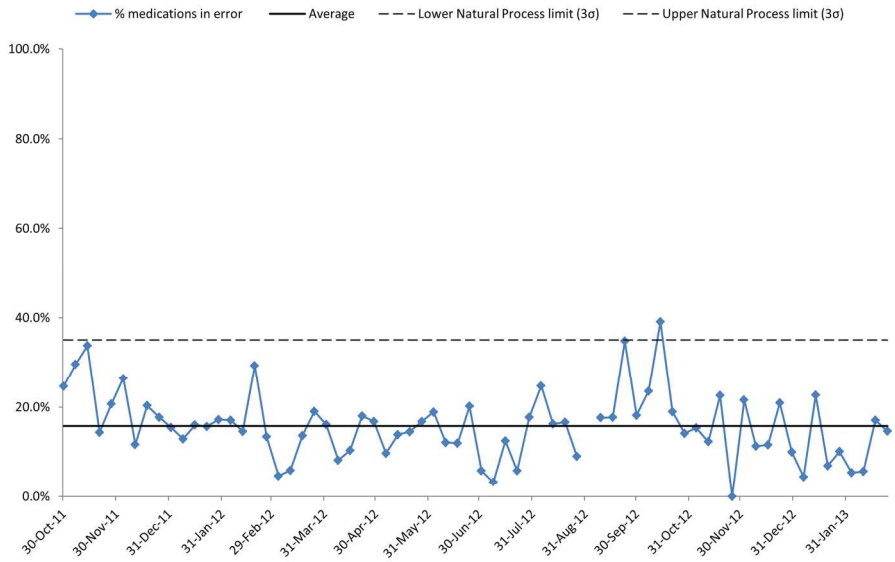


Figure 4 (Measure 5: lower percent preferred): The percentage of medications with an error or omission on TTO
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## Appendix

**Figure 1. Stakeholder Management Matrix – baseline**

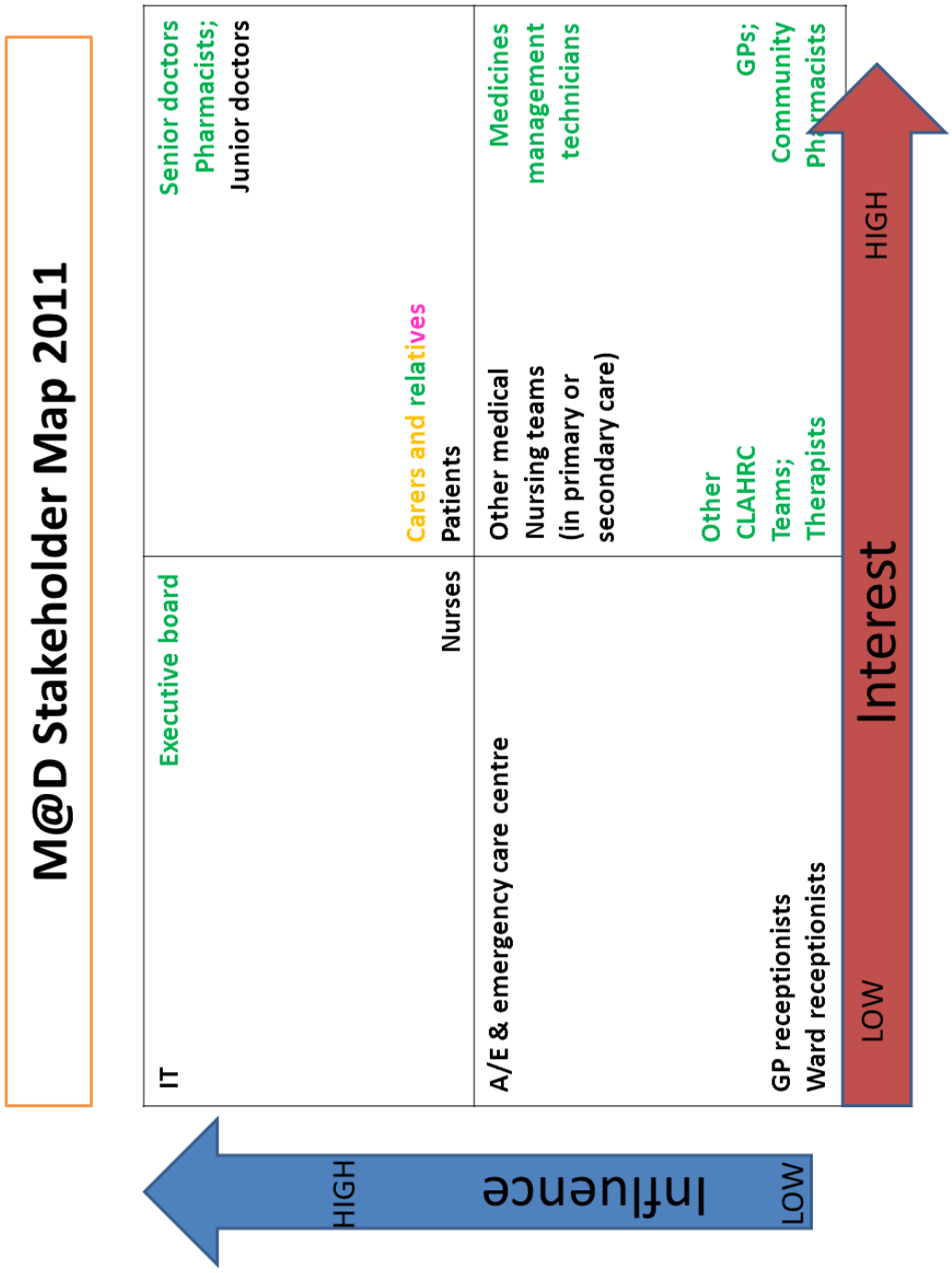


**Figure 2. Stakeholder Management Matrix – 15 months**

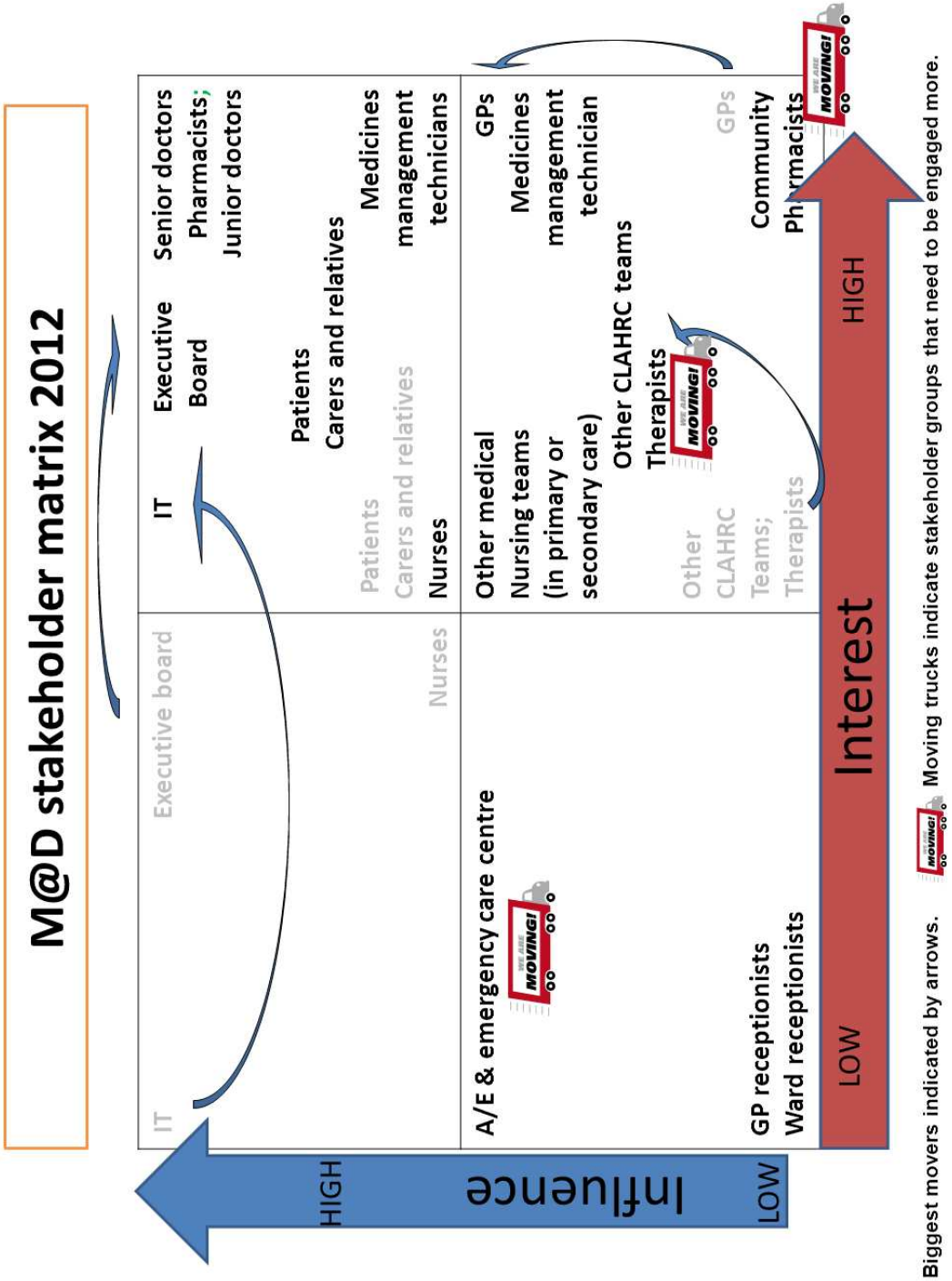


**Figure 3. Process map – higher level**

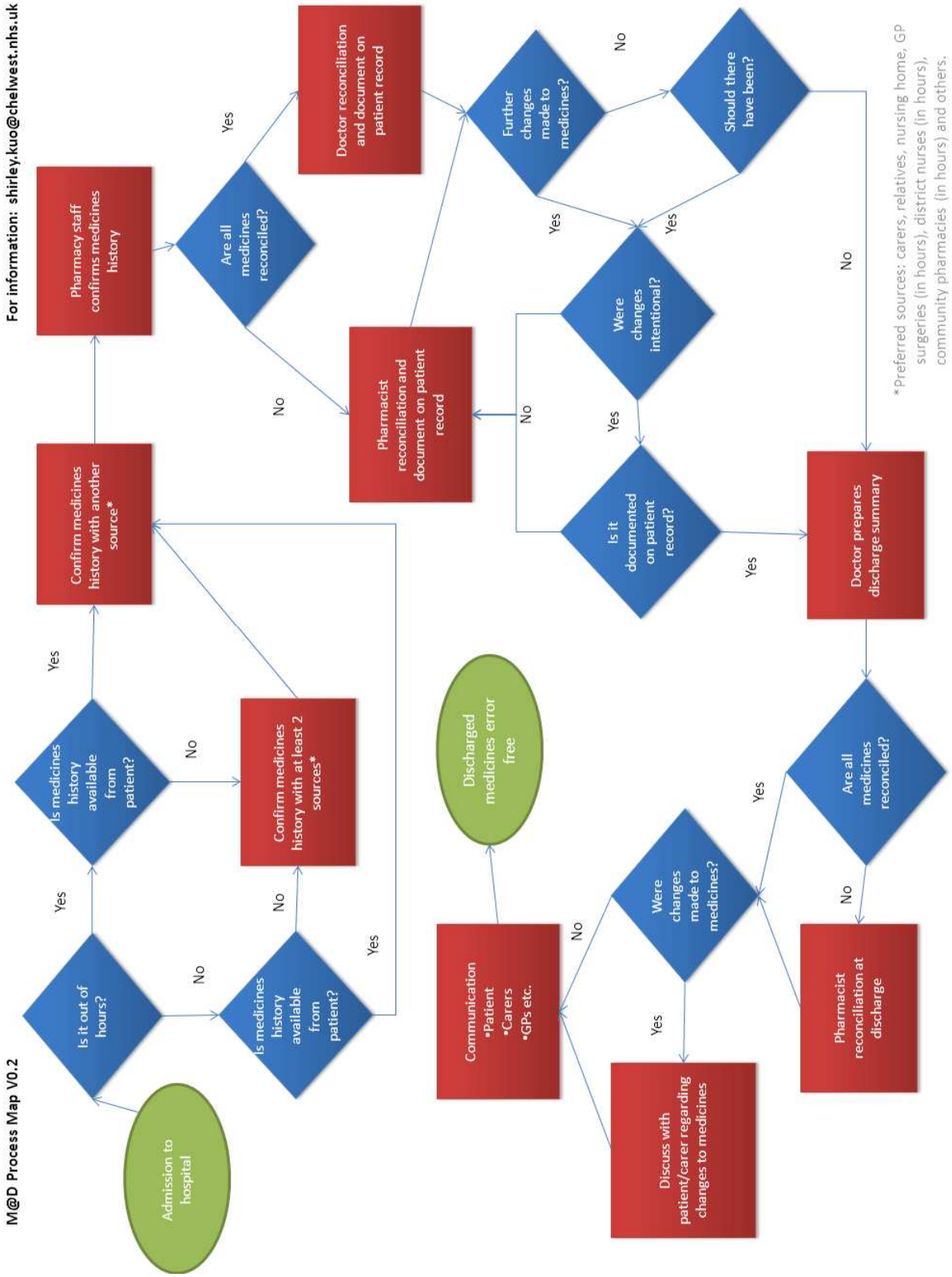


**Figure 4. Process map – lower level (AAU)**

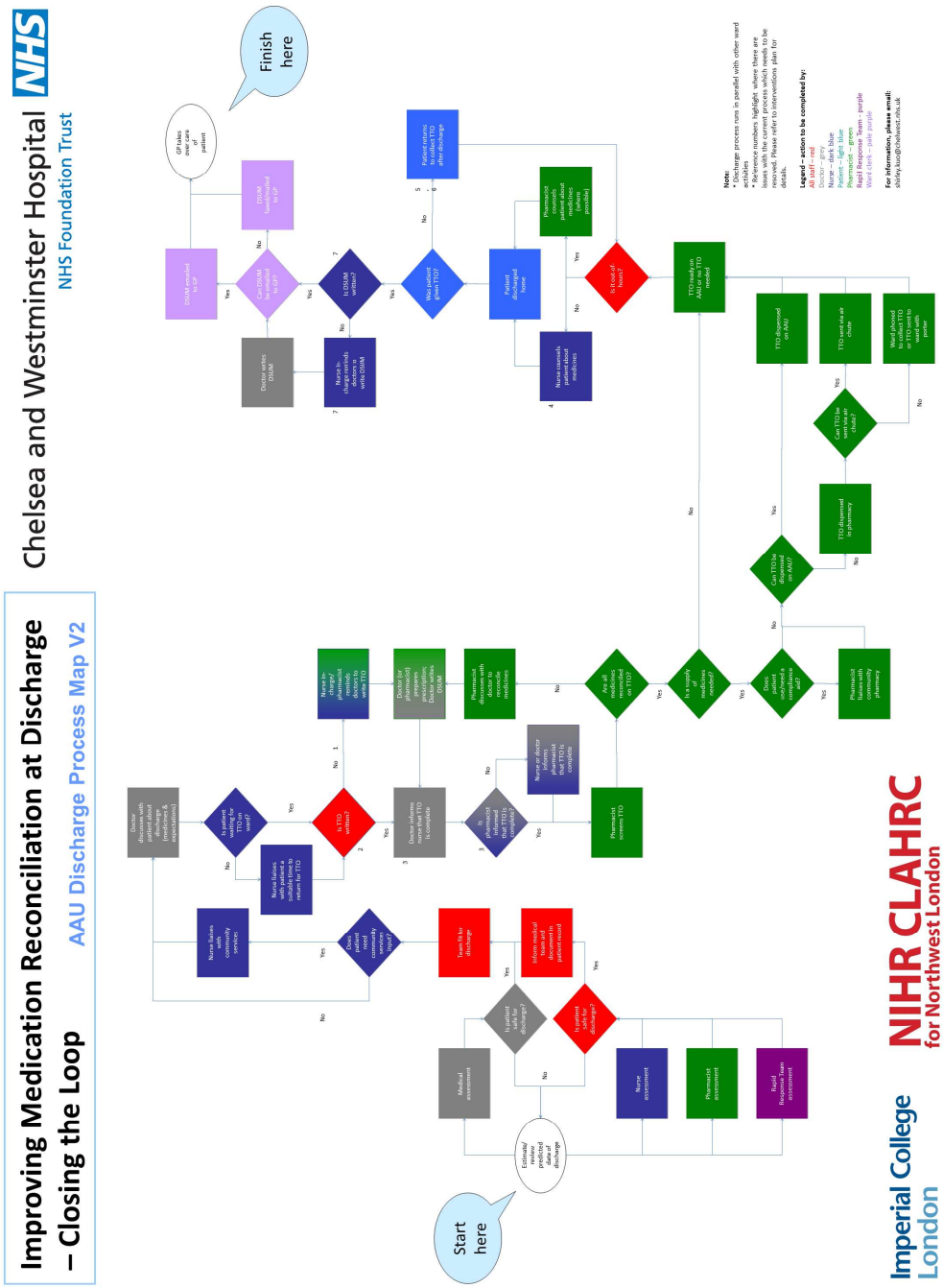


**Figure 5. Embedded interventions and stakeholder groups**

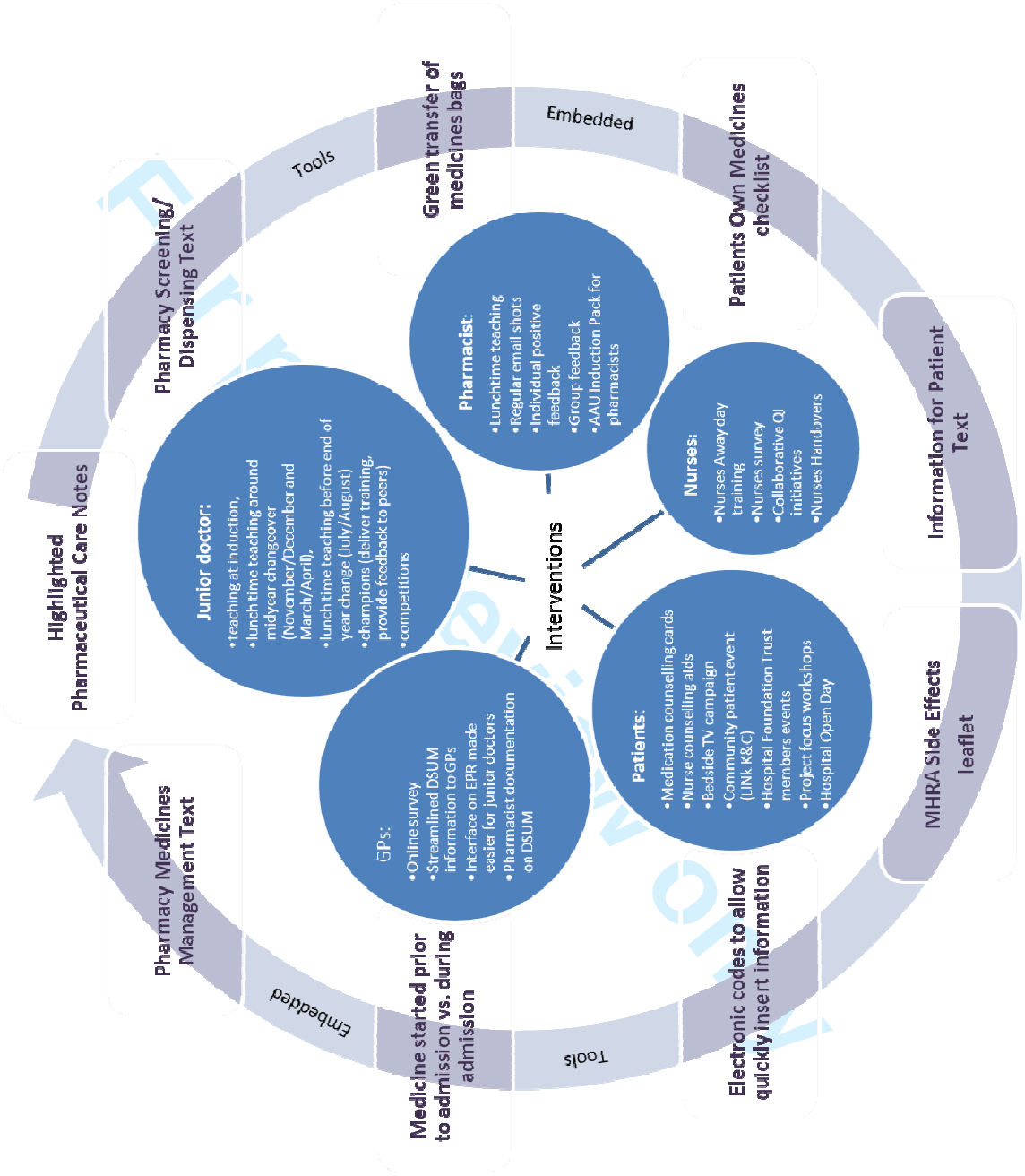
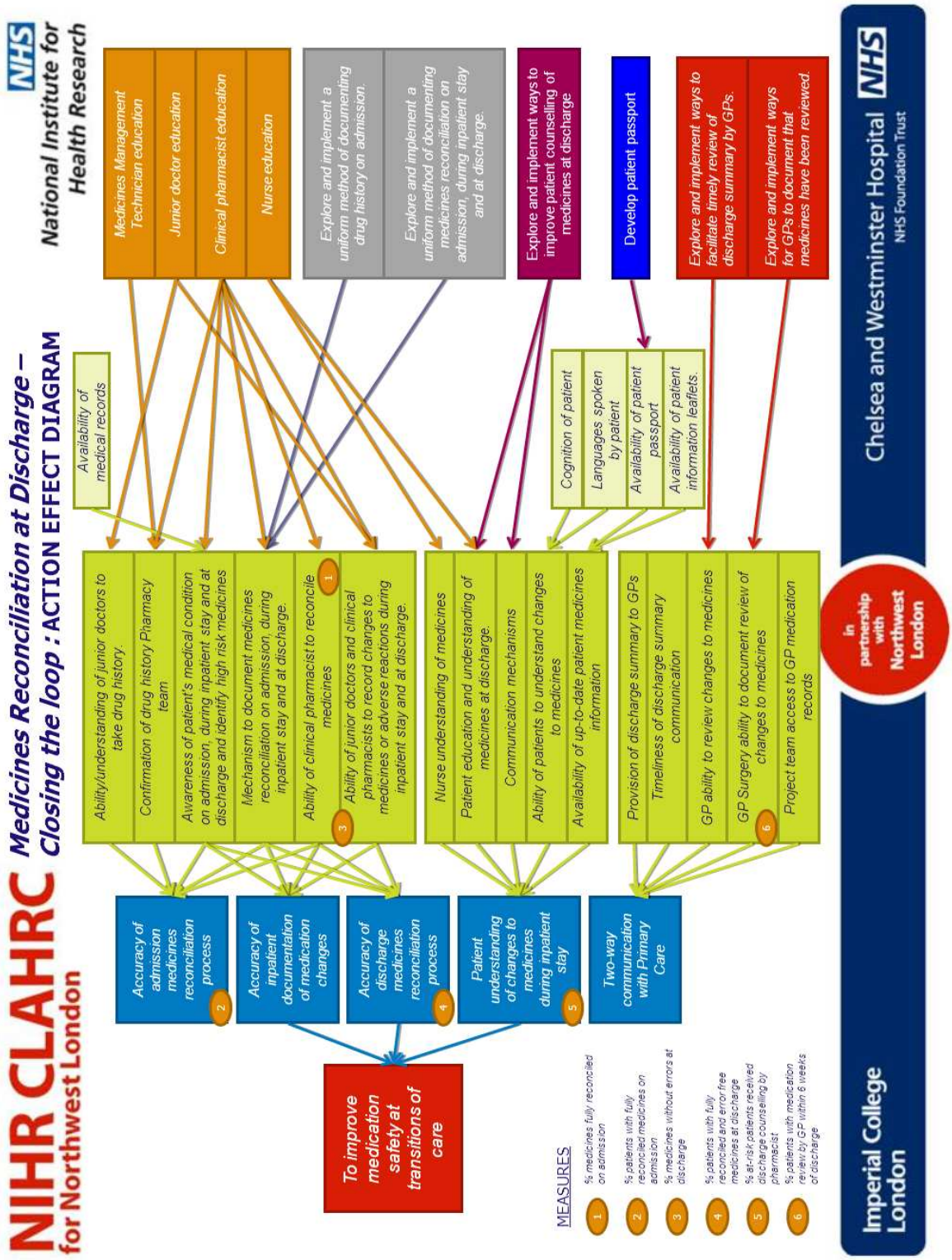


**Figure 6. Action Effect Diagram**



## Appendix Table 1. Plan-Do-Study-Act Cycles

| Series Number | Cycle title |
|---|---|
| Series 1a: 19/5/11 | Transfer of medicines from AAU |
| Series 1b: 27/5/11 | Transfer of medicines from AAU |
| Series 1c: 8/7/11 | Transfer of medicines from AAU - Downstream wards |
| Series 1d: 22/9/11 | Transfer of medicines from AAU - Nurses survey |
| Series 2: 21/5/12 | TTO turnaround time - Pharmacist tracking |
| Series 3a: 6/12/11 | Uncollected TTOs |
| Series 3b: 1/5/12 | Uncollected TTOs |
| Series 4a: 11/2/12 | Nurse training package - Nurse questionnaire (AAU) |
| Series 4b: 27/2/12 | Nurse training package - Nurse questionnaire (Trust-wide) |
| Series 5: 28/5/12 | AAU pharmacy process review |
| Series 6: 3/9/12 | GP survey |
| Series 7: 14/6/12 | Improvement measures |

Key:
AAU = Acute Admissions Unit
TTO = To take out (medicines)
GP = General Practitioner

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# Applying Quality Improvement methods to address gaps in medicines reconciliation at transfers of care from an acute UK hospital



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| | |

**Title:** Applying Quality Improvement methods to address gaps in medicines reconciliation at transfers of care from an acute UK hospital

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## ABSTRACT

Objectives: Reliable reconciliation of medicines at admission and discharge from hospital is key to reducing unintentional prescribing discrepancies at transitions of health care. We introduced a team approach to the reconciliation process at an acute hospital with the aim of improving the provision of information and documentation of reliable medication lists to enable clear, timely communications on discharge.

Setting: An acute 400 bedded teaching hospital in London UK.

Participants: The effects of change were measured in a simple random sample of ten adult patients a week on the Acute Admissions Unit over 18 months.

Interventions: Quality Improvement methods were used throughout. Interventions included education and training of staff involved at ward level and in the pharmacy department, introduction of medication documentation templates for electronic prescribing and for communicating information on medicines in discharge summaries co-designed with patient representatives.

Results: Statistical Process Control analysis showed reliable documentation (complete, verified and intentional changes clarified) of current medication on 49.2% of patients' discharge summaries. This appears to have improved (to 85.2%) according to a post-study audit the year after the project end. Pharmacist involvement in discharge reconciliation significantly increased, and improvements in the numbers of medicines prescribed in error or omitted from the discharge prescription are demonstrated. Variation in weekly measures is seen throughout but particularly at periods of changeover of new doctors and introduction of new systems.

Conclusion: New processes led to a sustained increase in reconciled medications and thereby an improvement in the number of patients discharged from hospital with unintentional discrepancies (errors or omissions) on their discharge prescription.
The initiatives were pharmacist-led but involved close working and shared understanding about roles and responsibilities between doctors, nurses, therapists, patients and their carers.


## Strengths and Limitations of this study

- We recognised the importance of organisation and structure in reducing unintended discrepancies at transfer of care.
- Documentation by pharmacists of medicines reconciliation at discharge in addition to that undertaken on admission was improved.
- We showed a critical relationship between discharge summary quality and junior doctor rotations. Interventions were specifically made at these key times and appear to have had a positive effect on the numbers of patients with error-free medication lists.

- QI methods ensured a clear structure to the project organisation and management, while allowing room for creativity.
- Appropriate systems changes were embedded to ensure sustainability.
- Limitations in our methodology meant we are unable to show whether the decrease in errors was directly related to introduction of pharmacist-led discharge medicines reconciliation or secular trends.
- We do not know if improvements in communications had any impact on patient outcomes post discharge from hospital.

**Key words:** Medication reconciliation; patient safety; hospitals; pharmacist; quality improvement

## INTRODUCTION

Transfers between interfaces of care, especially discharge from acute hospital into the community, are recognised as high-risk transitions for the development of medicines-related problems, a leading cause of morbidity and mortality.[1] Medication 'continuity' errors are frequent, involving up to 70% of inpatients on admission to hospital [2] and contributing to avoidable re-admissions.[3] Considering between 28-40% of medicines are discontinued or altered during hospitalization[4] and fewer than ten percent of elderly inpatients go home on the same medication as on admission, [5] accurate communication of changes at discharge is an increasingly important contribution to patient safety and quality of care.
Medicines reconciliation, the process of identifying the most accurate list of a patient's medicines and comparing it to current prescribing, recognizing any discrepancies and documenting any changes, is essential for minimizing continuity errors. [6] The elements of reliable reconciliation are at each transition in care:
• verification (of the list of current medications the patient is actually taking),
• validation (acute review noting whether to continue, alter doses, hold or stop)
• clarification (comparing the medication list with current prescription order)[6]

Increased pharmacist involvement at admission, documentation of changes and systems facilitating transfer of information from the General Practitioner (GP) to hospital all appear to reduce medication error.[7] Previous local audit had revealed that though actively involved in the timely resolution of discrepancies between patients' medicines list from the GP and the hospital doctor, there was a lack of discharge communication from hospital pharmacists. In addition, the quantity and quality of information on medication changes made during hospitalisation was low; only 1 in 10 patients were discharged from hospital with sufficient information on their discharge summaries to enable safe ongoing prescribing. The information required was considered insufficient if one or more medicines were omitted; a stopped medicine was included erroneously or without explanation; the dose, route, course length or formulation (or change reason) was wrong or omitted; or essential monitoring information was lacking.

We recognised the need to integrate discharge reconciliation into the processes involving ward pharmacists; that is in confirming the clinical appropriateness of prescribing during the inpatient stay and checking back to the medicines history when organising take home medicines. Pharmacy-led reconciliation is considered a cost-effective intervention.[7]
The overall aim of this study was to provide seamless, high quality medicines reconciliation from admission through to discharge for all patients and improve communication with community service providers.
The objectives were to:

- reduce unintentional discrepancies in transcribing medication during admission to hospital
- improve documentation of medicines reconciliation at discharge
- improve the quality of communications regarding new and intentional changes to medication in the hospital discharge summary

### Ethical approval

Ethics approval was not required for this work as it was part of a service evaluation and improvement activity and not human subjects research. An ethics waiver was granted by Chelsea and Westminster Hospital NHS foundation trust (CWH) Research and Development lead.

## METHODS

### Setting

The main study was conducted at an acute hospital over 18 months from September 2011 to March 2013. A post-study audit to check whether any improvements have been sustained, was carried out in June to August 2014. The focus of the study was the Acute Assessment Unit (AAU) a 44 bed adult ward seeing an average of 25 admissions a day with a mean age approximately 61 years. These are predominantly medical patients (17% surgical admissions) discharged home or to a longer stay ward usually within 4 days. The average length of stay in hospital was 9.3 days at the time of the study. Junior doctors are responsible for documenting the patient's history on admission (including their medicines), prescribing on-going medication and preparing the discharge summary. The pharmacist on AAU verifies the medication history, validates and checks that all current continuing medicines are correctly prescribed on the in-patient electronic prescribing system (ePR). If a discrepancy is found or a change is made without the reason or indication documented as part of the medication order, it is clarified by the pharmacist. The prescriber is contacted to ascertain if the change was intentional. The completion of this pharmacist-led process of reliable reconciliation at admission is also documented appropriately on the ePR. Discharge prescribing is supported by pharmacists who check (or transcribe) take-home medicines (TTO). When the hospital has reduced capacity to admit to AAU, the focus for medical teams shifts to support speedier discharge including writing TTOs as early as possible. Early discharge relieves the bed pressures and allows for admission of new patients. Pharmacist activity on AAU is not usually affected by these changes and was maintained throughout the project.

## Planning the intervention

Following recognition of low overall numbers of patients whose medicines are fully reconciled, a core team of pharmacists and physicians convened with the objective of improving rates locally. Quality improvement (QI) methodologies were employed throughout.[8] [9] Workshops took place at the start of the project to identify stakeholders (appendix figure 1) and their engagement was plotted on the matrix again at 15 months (appendix figure 2). Process mapping identified the various stages of medicines reconciliation in the hospital (appendix figure 3) and was repeated with the focus on AAU (appendix figure 4). For this we convened a multidisciplinary team which included senior clinical leaders, senior nurses, junior doctors, consultant physicians, therapists, pharmacists and a data analyst. All contributed to the mapping and development of the interventions (see appendix figure 5). For example the physiotherapists advised on how they check patient's use of medication compliance aids and occupational therapists on finding 'old' medicines during home visits. Stakeholder engagement events open to staff and public were held and regular patient focus groups around medicines management topics continued through to July 2012. Members of the public were called upon on an *ad hoc* basis at first and subsequently patient representatives were fully recruited to the core team resulting in co-design of our interventions and systems updates. An Action Effect Diagram was drawn with contributions from all stakeholders and the overall aim agreed (see appendix figure 6). [8] Plan Do Study Act (PDSA) cycles further informed the project from the beginning and as it progressed (see appendix table 1). [9] Stakeholders received feed-back through emails and personal communications when the process maps were finalised.

Interventions were agreed as the most likely to lead to measurable improvements, assigned into one of three work streams:

1. Education
2. Documentation
3. Communication out of hospital

## Analytic plans

The study was a qualitative and quantitative improvement project using statistical process control (SPC) to monitor improvement measures.

SPC analyses are a graphical family of techniques designed for looking at data over time. SPC uses a number of "rules" to determine whether a process has unusual variation (special causes) or if fluctuations observed are simply representative of the inherent properties of that process.[10] In this study, we use the flexible XmR analysis and consider special causes to be indicated by points falling outside the natural process limits; a trend of 6 or more all increasing or decreasing values, and 7 or more points consecutively above or below the mean line. [11] Qualitative analysis of outputs from workshops, focus groups and stakeholder events was undertaken as they took place throughout the project. Themes emerging from the analyses including patients' wish to have their own summary of new medicines on discharge with a personalised list of side effects (rather than the full medicine package information) in plain language, were used to co-design the new style DSUM (see later, Interventions). In addition, the early analysis helped form the

structure and content of staff education and induction sessions (see later, Interventions).

Data collation was carried out each week by the research pharmacist (SK). A sample of ten discharge prescriptions was identified weekly using randomly generated numbers. Checks were put in place to ensure that no patient was included more than once; readmissions were identified and noted (but not analysed for this project). Data was obtained retrospectively from ePR and dispensing records to identify any unintentional discrepancies between the inpatient prescription chart and discharge list of medicines. Confirmation of pharmacist-led verification of a patient's medication history was obtained from documentation in the electronic pharmaceutical care notes and the discharge summary for admission and discharge respectively.

Process measures were designed to monitor improvements see Table 1

Table 1 Process Measures

| Measure | Measure in sample of 10 patients per week randomly selected from all discharges for the week | Detail |
|---|---|---|
| 1 | Percentage of patients with pharmacist-verified reconciliation on admission | Pharmacist has documented on ePR that they have checked the admission medication list with the patient and verified with a second source and clarified or resolved any discrepancies on the inpatient order with the prescriber |
| 2 | Percentage of patients with pharmacist-verified reconciliation at discharge out of the total number of patients sampled | Reconciliation at discharge is possible only for patients with a verified admissions medication list. For this measure any change to any admission medicine, dose, frequency or route is confirmed by a pharmacist as intentional and documented clearly on the discharge summary as such |
| 3 | Percentage of patients with error-free TTO prescriptions | TTO has no unexplained discrepancy compared with the verified list of medicines on admission. The reason is stated for any omission, change in dose, frequency or route; course lengths and monitoring advice are given where needed. If no reason is given for a discrepancy then the patient does not have an error-free prescription |
| 4 | Percentage of medications unreconciled at discharge out of the total number of medicines within the sample of 10 discharge summaries per week | Measure 4 is directly related to measure 3. The number of individual medicines unreconciled were recorded. Patients on no medicines were included in the study; medicines reconciliation was considered reliable only if 'nil regular medication' was verified and documented as such. |
| 5 | Percentage of medications with an error (or omission) on TTO out of the total number of medicines within the sample of 10 discharge summaries per week | Measure 5 is directly related to measure 3. The number of individual medicines with an error or omitted without explanation were recorded. For each patient several medicines may be prescribed in error or omitted |

| | | |
|---|---|---|
| | | from the TTO |

An error was recorded if any medicine was ordered that should have been stopped (including wrong medicine) or if a dose, route, course length or formulation was incorrect. An omission was any medicine left off the TTO that should be entered as it is to be continued. Any change from the verified admissions list of medicines without explanation or monitoring requirement was also considered an error.

Weekly analysis of these measures was facilitated through the web improvement support for healthcare (WISH) tool.[12] The tool provides reports with SPC analyses, by calculating the mean and respective upper and lower natural process limits of the measures in question, tracked over time. Results were fed back to the core project team weekly.

The improvement measures supported the iterative changes during implementation process and the use of Plan-Do-Study-Act cycles, also documented through the WISH software. Several audits measuring standards of medicines history taking and reconciliation of discrepancies were undertaken during the study period and helped to inform and support the project. Further details of QI methodologies and outputs are given in the Appendices.

Data were collected from patients discharged between weeks commencing 30 October 2011 and 17 February 2013 (70 weeks, with one missing week). A post-study audit was carried out using the same sampling method from 06 June to 31 August 2014 (nine weeks), to check whether any improvements made during the project were sustained. Small variations in selected numbers occurred in-week where there were delays in a patient's discharge. These patients were not excluded but appeared at a later date in the measures data.

## Interventions

All interventions took place during October 2011 to February 2013. Further details are provided in the Appendices.

### Education

All pharmacists and medicines management technicians received a training update and accreditation in medicines reconciliation and were instructed in the importance of full documentation of pre-admission medication histories. Feedback was provided on a regular basis, at least twice monthly advocating 'good practice' in summarising changes made to medication during hospitalisation. Training was held collaboratively with other staff groups including nurses and therapists.

The team negotiated with AAU physicians to take a ten minute 'Pharmacy session' on AAU during the weekly 'learning at lunch' for doctors. At these sessions and also at induction, around mid-year changeover (November/ December and March/April) and before end of year change (July/August), a pharmacist describes the principles of medicines reconciliation, good prescribing and monitoring. They also advise on timely administration of critical medicines, reviewing and continuing regular medication and how pharmacists support the processes involved.

Two junior doctor champions were recruited to assist with the delivery of training and act as a channel for providing feedback to their peers. The project champions were well received (informal feedback from peers) and reported high levels of satisfaction with their role (informally direct to the rest of the project team and at appraisal with their clinical leads).

Documentation

ePR provides an easily accessible central documentation of patients' current medication and relevant history including what the patient actually takes, their allergies, intolerances and preferences, on the same screen as inpatient prescribing. This allows access to the original list while prescribing so that changes made by the hospital clinicians can be transcribed onto the discharge documentation with ease. However, locally the medication history list and medicines reconciliation detail required free-typing, without a set format or obligatory fields. Following consultation with IT support and the junior doctor champions, changes to the system were designed by the project team and approved by the executive lead for ePR creating tools to prompt and aid documentation of medication reconciliation. (These were brought in during the project data collection period in October 2012, as an intervention so that we are able to measure any effect on documentation and communication) and included:

- Changing screen colours to distinguish between reconciled and unreconciled medication lists
- Changing existing "Pharmacy Discharge Summary Text" box visible on GP, Patient and Pharmacy copy to "Pharmacy Screening/Dispensing Text" only visible on Pharmacy copy. GPs and Patients previously received unnecessary dispensing information on their discharge summary.
- Creating a "Pharmacy Medicines Management Text" box, to allow clear timely documentation by pharmacists of medicines reconciliation, and information about changes visible as required on all copies. This includes confirming where medicines reconciliation was not completed at admission.
- The addition of space headed "Information for Patient" on the patient copy of the discharge summary for the pharmacist to add selected counselling points specific to their new medicines
- Signposting to the hospital Medicines Information Helpline to aid access to further information they may need once they are home, developed in response to patient experience feedback.[13,14]

Communication with the GP

At first presentation at hospital an individual patient's complete list of current medication is required either via the patient or their carer (e.g. a repeat prescribing document or detail on a referral letter from the GP) or if this is not with the patient, the GP surgery is usually contacted at the earliest opportunity. There is as yet no direct e-communication locally between the hospital ePR and GP practices. We use the telephone to request and fax to receive patient medication record details. On transfer home we create the discharge summary including the TTO which is for many medicines, a simple transfer from the inpatient ePR. A copy is emailed or posted to the GP.

Communication out to the GP about any changes made to medication in hospital requires free-typing into the discharge summary; local audit found this was missing in over 40% of cases. The approved changes to the ePR documentation as above were designed to improve medication reconciliation communication including with the GP.

## RESULTS

A step-wise improvement is seen across measures relating to discharge medicines reconciliation throughout the project (Figures 1 to 4). For the post-study audit all measures indicate sustained improvement, summarised in Table 2.

During the study period an average of 66.3% of patients have pharmacist-verified medicines reconciliation on admission (see Figure 1a). A temporary uplift in the process is observed starting in June 2012 with seven points above the mean line, however, the process reverts to previous performance levels after this period. The average (mean) showed some short-term improvement to 82.7% coinciding with when initiatives were put in place to engage staff in pharmacist-led processes. Reconciliation at discharge is possible only for those who had a verified list of admission medicines.

Pharmacist documentation of medicines reconciliation at discharge improved from an average of 26.2% of patients to 56.7% (Figure 1b). A single point outside the natural process limits is observed in March 2012, indicating a special cause. From August 2012 onwards all points lie above the previous mean performance (special cause variation), hence the natural process limits are calculated separately for this period to better represent the improved process. This improvement appears to be sustained and improved upon as it was found during summer 2014, that an average of 64.8% of discharged patients had their medicines reconciled and documented on the discharge summary (Table 2).

On one week with high bed pressures (31st May 2012, see Figure 2) performance was below average, recovering over a six week period of increasing trend (constituting an SPC rule break).There are two indications of special cause with data lying beyond the natural process limits in October 2012 and November 2012. The periods of bed pressures did not appear to affect pharmacists' admission activity.

The short term improvement mid-project appears to have been achieved one year on as it was found that in a nine-week period of measures during summer 2014, an average of 88.1% of patients had pharmacist-led medicines reconciliation documented on admission.

Table 2 Audit data to examine for sustainability of changes

| *For audit period: weeks commencing 06-Jul-2014 to 31-08-2014* | | | | |
|---|---|---|---|---|
| *Number of patients in audit = 88, number of medications = 1148, mean number per patient = 13* | | | | |
| % Patients with Pharmacist verified | % Patients with Pharmacist verified reconciliation at | % Patients with error-free medication | % medications unreconciled at discharge | % medications in error |

| reconciliation on admission | discharge | | | |
|---|---|---|---|---|
| 87.5% | 64.8% | 85.2% | 3.7% | 2.3% |

After an initial low period an average of 47.2% percent of patients with no medication errors or omissions on discharge is seen, but with marked variation in late 2012 coinciding with the changes being embedded in the editable part of the discharge summary (Figure 2). In the period of measures during summer 2014, an improvement was seen with 85.2% patients having error-free medication using the same criteria for reconciliation as during the project 18 months previously (Table 2).

Key events mapped onto the process control chart for error-free medications from admission and through to discharge during one calendar year of the project, show the relationship between junior doctor rotations and the weeks when the hospital was under bed pressures (Figure 2). A fall the percentage of error-free medications is seen during September 2012 though this is not sustained and improvements are apparent when teaching sessions had been completed.

The average for medications unreconciled was 13.5% (Figure 3). There are three indications of special cause, October 2011, September 2012 and October 2012. In the summer of 2014, improvement was found with 3.7% of medicines recorded as unreconciled at discharge (Table 2).

The percentage of medications with an error (or omission) was an average of 15.8% (Figure 4). There are two indications of special cause variation, September 2012 and October 2012. During summer 2014, improvement was seen with an average of 2.3% of medicines (prescribed or omitted) in error using the same criteria as during the project (Table 2). Note that in Figures 3 and 4 there are transient uplifts in values, before reversion to previous performance, across August and September 12; period in which newly qualified doctors begin their training.

## DISCUSSION

Hospital based, pharmacist-led medicines reconciliation processes frequently identify and resolve unintended prescribing discrepancies between healthcare providers.[1] We have made improvements to these local processes particularly in provision of documentation and communication of medication changes at discharge from hospital.

The effect of this quality improvement is demonstrated in the decrease in numbers of patients leaving hospital with unintentional discrepancies (errors or omissions) on their discharge prescription. Though there was marked variation in this figure during the study, it appears to be sustained overall with an expectation that it remains consistently below 20% (as shown in 2014). However, the period from August to October in 2012 shows an increase in the number of unreconciled discrepancies in discharge medications. We have looked for explanations for this as it does not coincide with the hospital being particularly busy or under pressure for beds or other parameters that we were monitoring at the time. It may have been influenced by the period of high staff turnover in pharmacy which occurs every new academic year. Though not the project team per se, we were inducting new juniors and managing

unprecedented vacancies including staff leave (postponed during the London Olympics and taken in September and October that year).

There is clearly a need for further improvement; regular teaching and support particularly for junior doctors has been put in place and remains a key aspect of current practice and the subject of further medicines optimisation research locally. In addition the pharmacist induction programme locally now includes training in documentation of medicines reconciliation on ePR.

We found a high level of variation in the percentage of patients with error–free discharge prescriptions in particular around the time of introducing the changes to processes on ePR. The changes required different inputs by the prescriber and though all were trained by the implementation date, many had their training several weeks before. Variations may also have been the result of the small sample set for weekly measures. Ten patients were selected each week. If a fully trained 'good' prescribing team were on duty for the sampling period it could contrast with one less familiar with TTO requirements on duty the following week.

Overall, our ePR updates appear to have had a positive effect on the quality of discharge summaries as error-free TTOs rates are seen to rise in the period from its inception in October 2012 to February 2013 when measurement stopped, and again when measured in 2014.

A median of 45% of hospital patients in USA and Canada have at least one clinically significant discrepancy in their medications at transfer of care according to a systematic review of reconciliation in 2013.[15] Garfield and colleagues in the UK found unintentional discrepancies in 70% of medication prescribed on admission for around 60% of patients. [16] Unintentional discrepancies in discharge medication received by patients occurred up to 27% of items and these translated to discrepancies in repeat medication subsequently received from the GP in 57% patients. [17] In our study we looked at documentation on the discharge summary, exactly as it would be received by the GP. An 'error' was recorded if a medicine was missing from this communication or details of a change in medication not noted. The number of medicines unreconciled at discharge fell to 10% and then to 4% (2014 figures). Ascertaining whether any changes to medication reported are actually received and acted upon by the recipient was outside the scope of this project.

Follow-up of patients at another UK hospital where medicines reconciliation was found to be incomplete, revealed that the majority of failures occur when the standard admission documentation is not used. This was more likely to occur where specialist admission pathways were in place and paper pro formas were not updated or if they had to be used in parallel with several other documents.[17] A survey of pharmacy services for patients at discharge from hospitals in Ireland suggested development of national standards of practice may help to eliminate the variation found in practice and would support improvement.[18] During our study we embedded new ePR tools to prompt and aid documentation of medication reconciliation particularly on the discharge summary. In addition, at admission we sought to standardise the pharmaceutical care entries made by pharmacy staff regarding medication histories. An audit undertaken in 45 English hospitals (including this study site) suggests that pharmacist-led medicines reconciliation at admission prevents adverse events occurring during an inpatient stay.[19]

In the 2013 systematic review the authors note that the actual benefits of resolving unintended discrepancies are not seen; medicines reconciliation does not seem to reduce emergency department visits or readmission within 30 days. The reviewers found most medication discrepancies appeared to have no clinical significance and, given limited resources in hospitals, it is suggested it may be prudent to target patients at high risk rather than all admissions.[15] Our study did not include patient follow-up so does not add to this but follow-on projects are planned where we will target vulnerable patients (especially elderly) identified through medicines reconciliation and other processes for further pharmacist intervention with examination of the clinical significance of intervening on unintentional discrepancies and readmission rates.

In part to inform this research we recently compared medicines reconciliation by doctors on first contact with patients to pharmacy-verified medication lists. Full and accurate documentation was found for only 27% of patients prior pharmacy check. The value of the pharmacist in medicines reconciliation was also shown in a Swedish Medical ward though the researchers suggested more work is needed.[20]

Documentation by pharmacists of medicines reconciliation at discharge in addition to that undertaken on admission was a new concept locally. We have now integrated the process into the patient centred pharmaceutical care carried out by our team of clinical (ward) pharmacists as part of their regular duties. All inpatient prescriptions are reviewed by a pharmacist at the first opportunity, including medicines reconciliation within 24 hours of admission where possible. It is a challenge at weekends where staffing levels are lower; currently under review locally and across the UK. The changes we have put in place around discharge reconciliation have been achieved without extra resource but with critical refocussing of pharmacist input. Prior to this project any changes made to patients' medicines had to be communicated by the prescriber as part of the free-type letter to the GP on the discharge summary. There appears to be a relationship between discharge summary quality and junior doctor rotations. Interventions specifically made at key times in rotations to improve discharge summary documentation appear to have a positive effect on the numbers of patients with error-free TTOs.

We recognised the importance of organisation and structure in reducing unintended discrepancies at transfer of care. A 'whole system' approach in this discharge process involved members of staff from a range of disciplines, all of whom were involved in appropriate prescribing, ensuring the assessment of a patient's ability to take their medication, or education of a patient about their discharge medications. While other studies have underlined the importance of the interactions between medical and pharmacy staff, the success of this project partly lay in its ability to engage with nursing and allied health staff in addition.

The project team made ongoing sustainability a priority from the start, which is judged as important in embedding change,[21] and where appropriate, systems change was sought (e.g. improved electronic prescribing software functionality). Building improvements into the processes helps to minimise human error and reduce variability of outcomes. Better use of existing resources and embedding new tools for daily practice therein, ensures a

sustainable change for the organisation which might be expected to be cost-neutral.
Integration of best practice project management using QI methods ensured a clear structure to the project organisation and management, while allowing room for creativity.

## LIMITATIONS AND LESSONS LEARNT

We were unable to show if our improvements in communication out of hospital had any impact post discharge. This will be the subject of future project work in the community. The data presented here suggests a link between pharmacist involvement and a decrease in errors but is not conclusive. We were not able to examine for secular trend as there are no prior data nor further sites; we recommend a step-wedge design for any scale up initiative to allow comparisons.
The project team was successful in engaging and influencing staff from all levels in changing practice. Communication barriers with doctors where they existed were removed with the recruitment of junior doctor champions to deliver training and providing feedback to peers. Culture within the pharmacy department was changed by seeking out early adopters to act as catalysts for change. Engaging the right people at the right time for the right tasks that complement their skills and interests, was a key to success (e.g. AAU sister in mapping discharge process; junior doctors in preparing posters).
This included effective engagement with the hospital's GP Relationships Manager who supported the project's initiatives where possible; this proved important as engaging directly with GPs was difficult.
Other aspects of the project, such as junior doctor and patient education, which are labour intensive, were successful but may prove less sustainable.

## RECOMMENDATIONS

Regular feedback of the quality of doctor's medication reconciliation at discharge is an important aspect of training that has resulted in an improvement in the number of patients discharged without errors on the discharge summary. However, maintaining weekly measures to allow such feedback is very time consuming. An option could be through incorporating the weekly measures into Trust clinical audit agenda.
The data in the current form are unable to distinguish whether the improvement in number of unreconciled medicines or number of errors is because of the introduction of pharmacist discharge medicines reconciliation and documentation. We do not know if they resulted in improved patient outcomes nor if communications in the discharge summaries are actioned by the recipient. We therefore recommend that a subset analysis and follow-up is carried out to compare outcomes for patients who have had pharmacist involvement in the preparation of the discharge summary.

## CONCLUSION

During the period of our medicines reconciliation project we put in place new processes that led to a sustained reduction in un-reconciled medications and thereby an improvement in the number of patients whose discharge medications were documented and communicated out from the hospital without error or omission. The initiatives were pharmacist-led but involved close working and shared understanding about roles and responsibilities between doctors, nurses and patients or their carers.

Care has been taken to embed the processes involved into standard working practices and computerised systems, ensuring that reliable reconciliation and documentation is sustainable.

**Contributorship statement**
VM project pharmacy lead; prepared the manuscript from original study reports written by SK
SK project manager
AJP analysed data and assisted in preparing the manuscript for publication
TW contribution to method design and input on analysis
LV project clinical lead; assisted in the analysis and original report write-up
DB Director NIHR CLAHRC NWL; oversaw original project, set objective and reported on progress

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**Competing Interests**: none

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**Data sharing statement:** Further local audit data, poster content and conference abstracts are available by email from VM

## Study Approval

According to the policy activities that constitute research at Chelsea and Westminster Hospital NHS Foundation Trust this work met criteria for operational improvement activities exempt from ethics review.
Ethical approval was not required for this work as it was part of a service evaluation and improvement activity and not human subjects research. An ethics waiver was granted by Chelsea and Westminster Hospital NHS foundation trust (CWH) Research and Development lead

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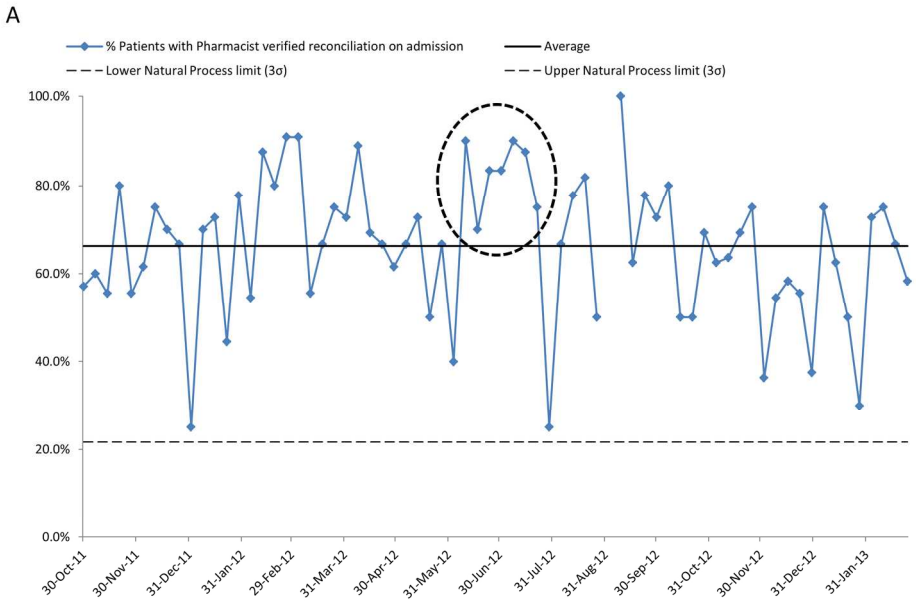


Figure 1a (Measures 1: higher percentage preferred): Percentage of patients with pharmacist-verified reconciliation on admission
190x142mm (300 x 300 DPI)

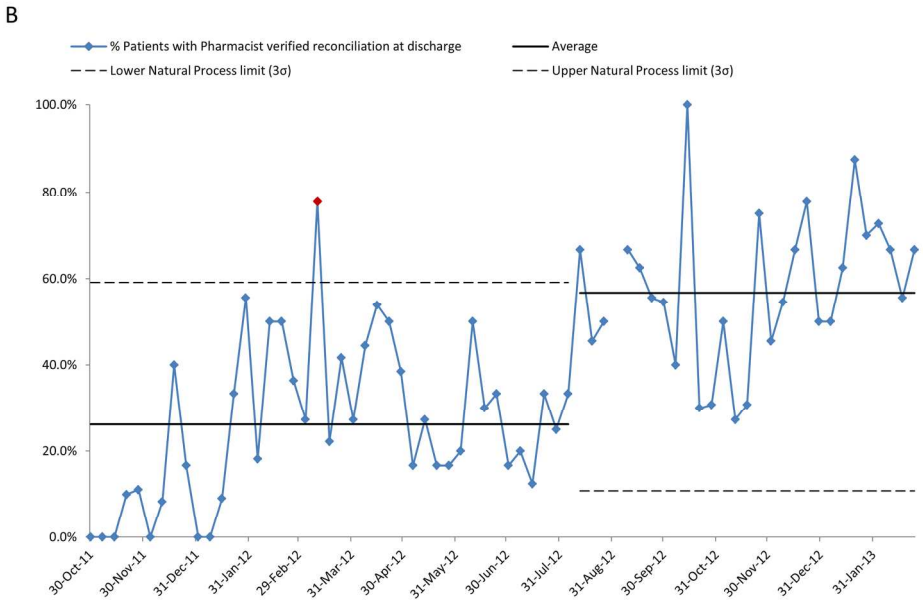


Figure 1b (Measure 2: higher percentage preferred): Percentage of patients with pharmacist-verified reconciliation at discharge
190x142mm (300 x 300 DPI)

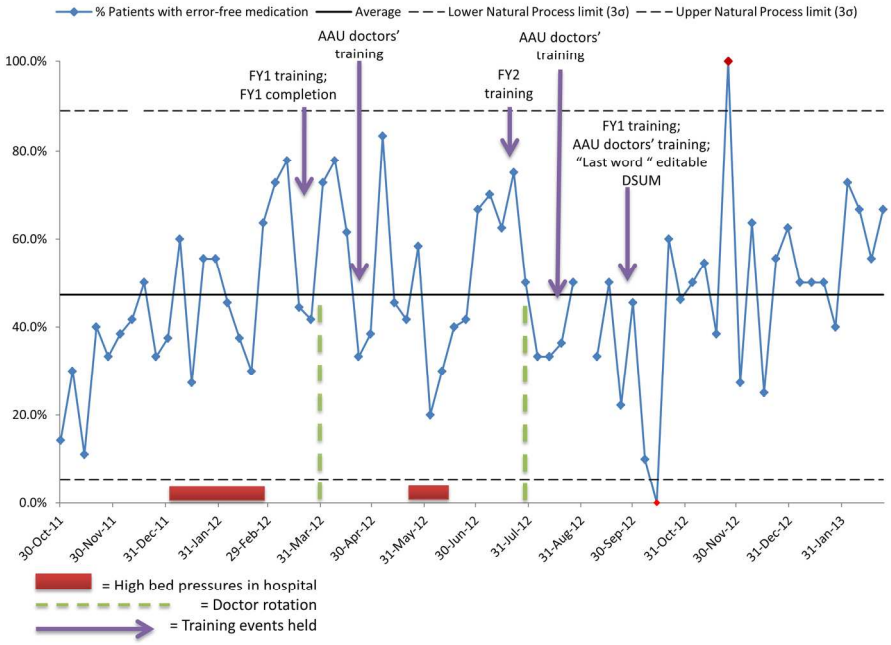


Figure 2 (Measure 3: higher percent preferred): Percentage of patients with error-free (and no omitted) medications on TTO prescriptions\r\nKey AAU: Acute Admissions Unit, DSUM: Discharge Summary, FY: foundation year junior doctors, "Lastword": the local EPR system
190x142mm (300 x 300 DPI)

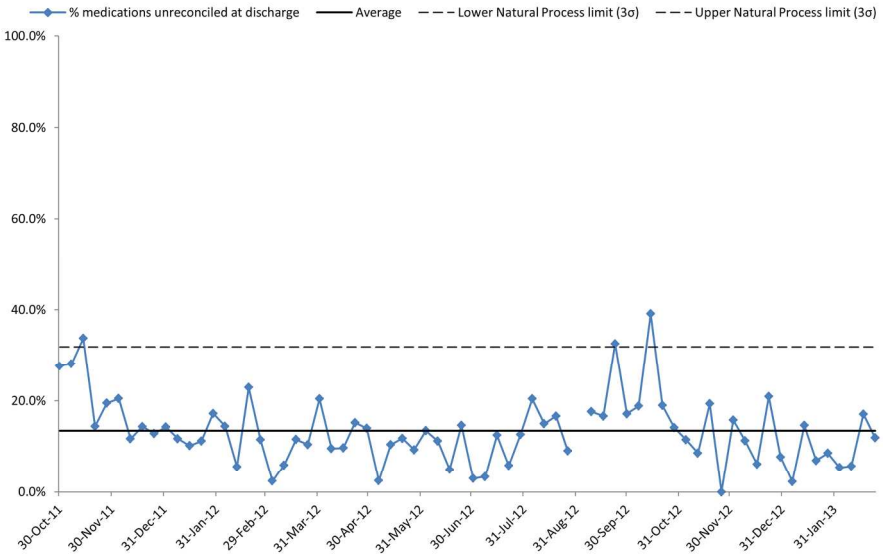


Figure 3 (Measure 4: lower percent preferred): The percentage of medications unreconciled at discharge
190x142mm (300 x 300 DPI)

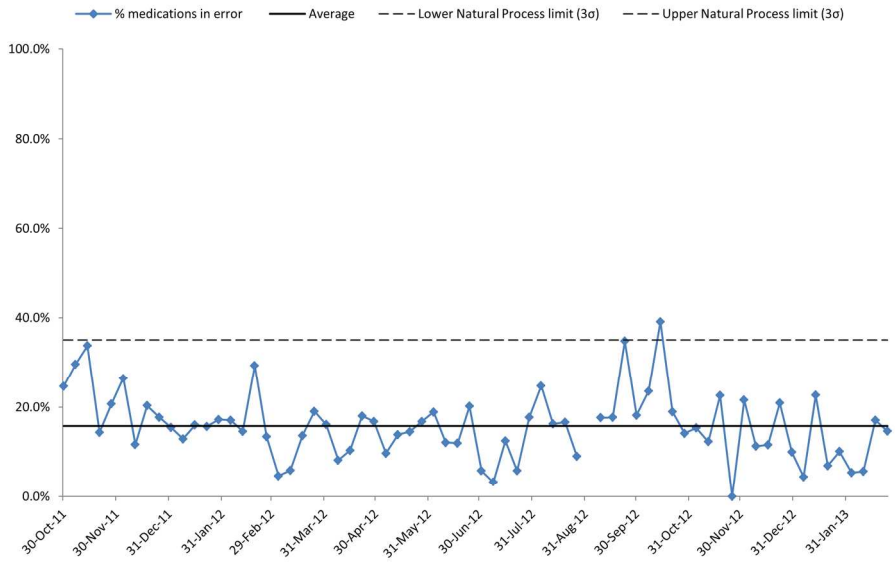


Figure 4 (Measure 5: lower percent preferred): The percentage of medications with an error or omission on TTO
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## Appendix

**Figure 1. Stakeholder Management Matrix – baseline**

**Figure 2. Stakeholder Management Matrix – 15 months**

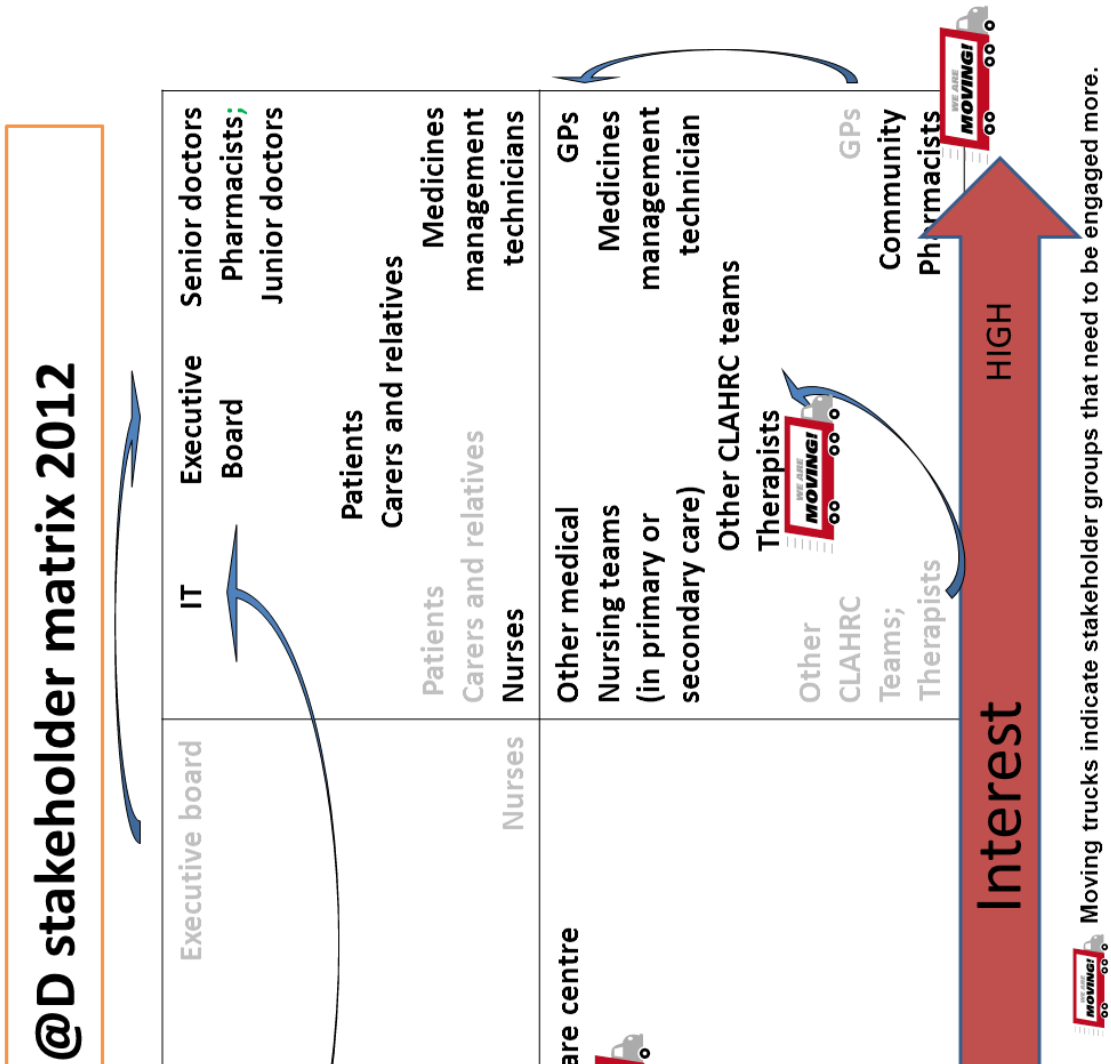


**Figure 3. Process map – higher level**

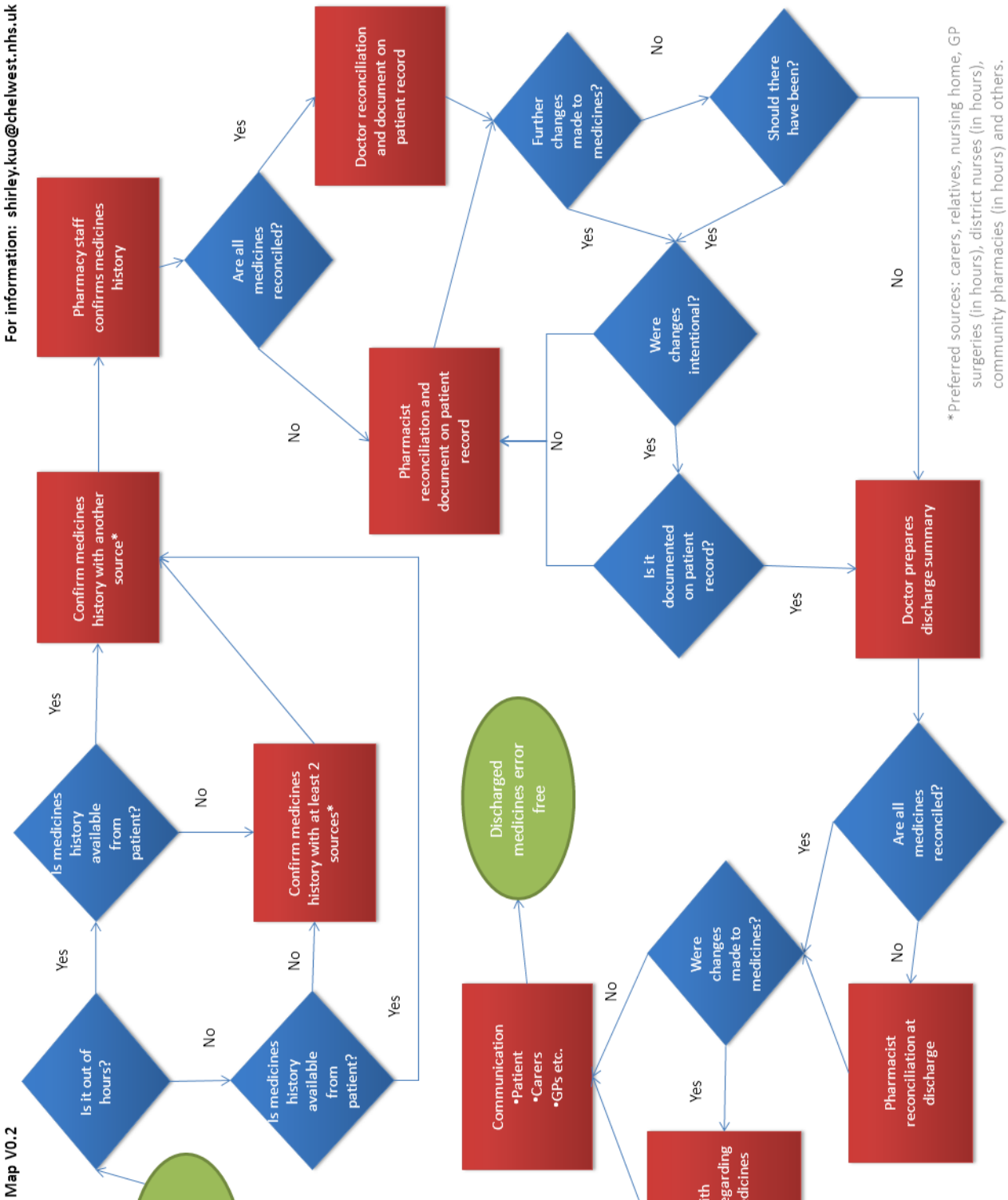


**Figure 4. Process map – lower level (AAU)**

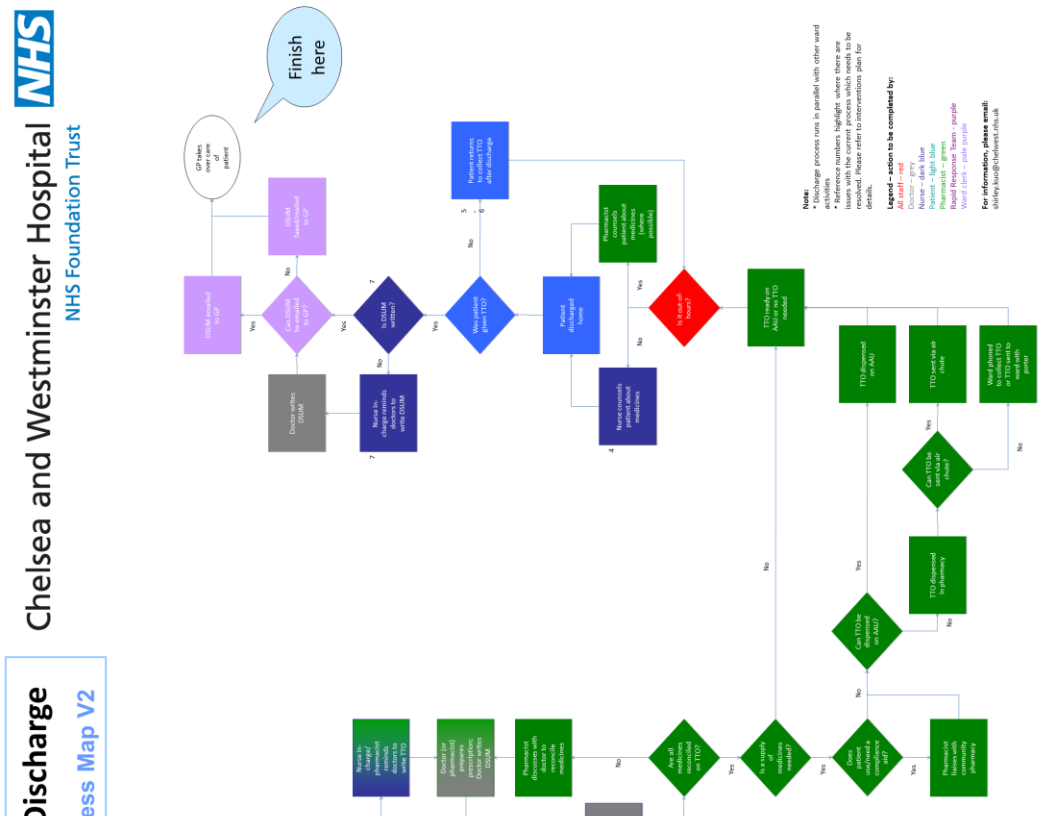


**Figure 5. Embedded interventions and stakeholder groups**

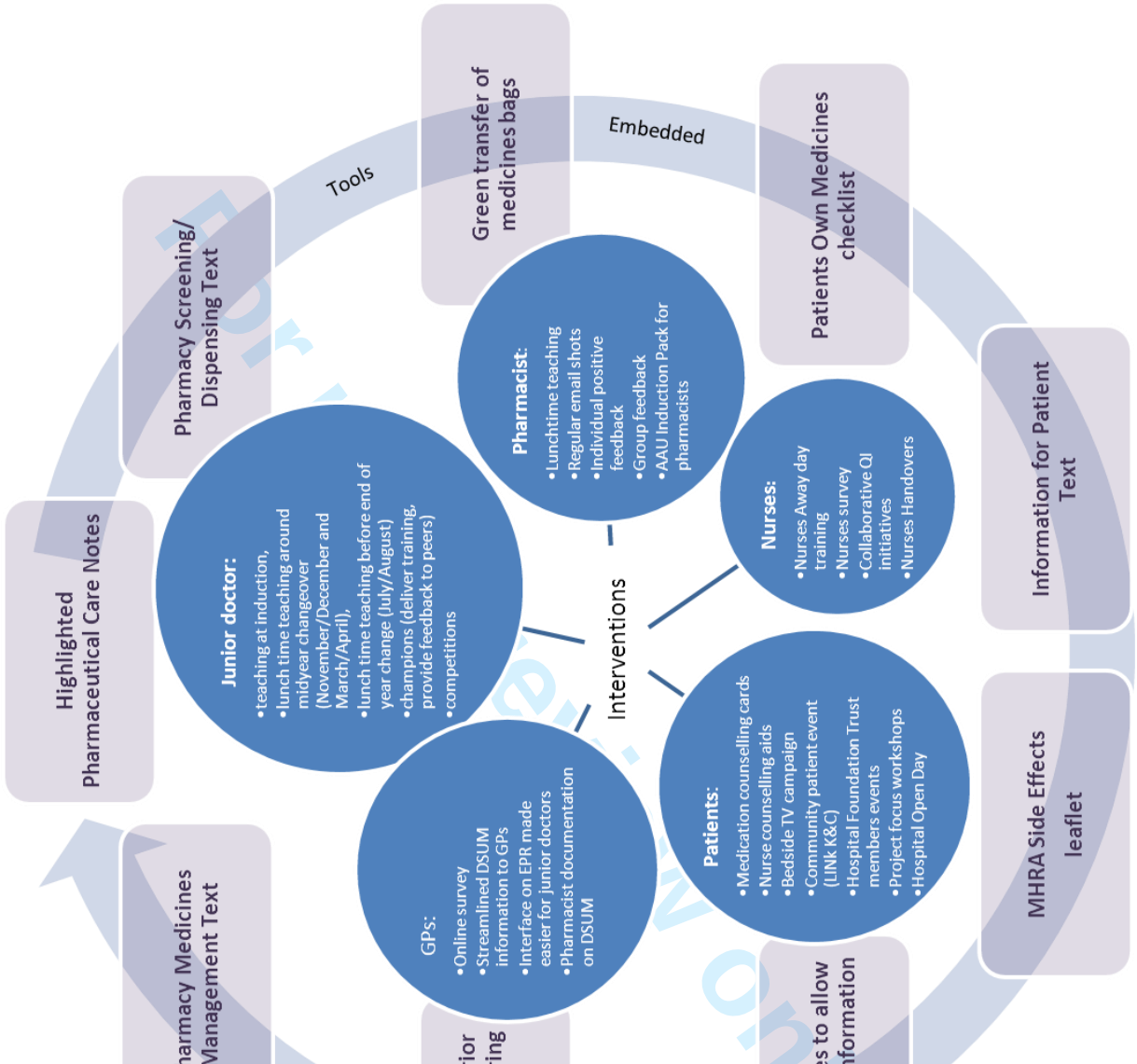
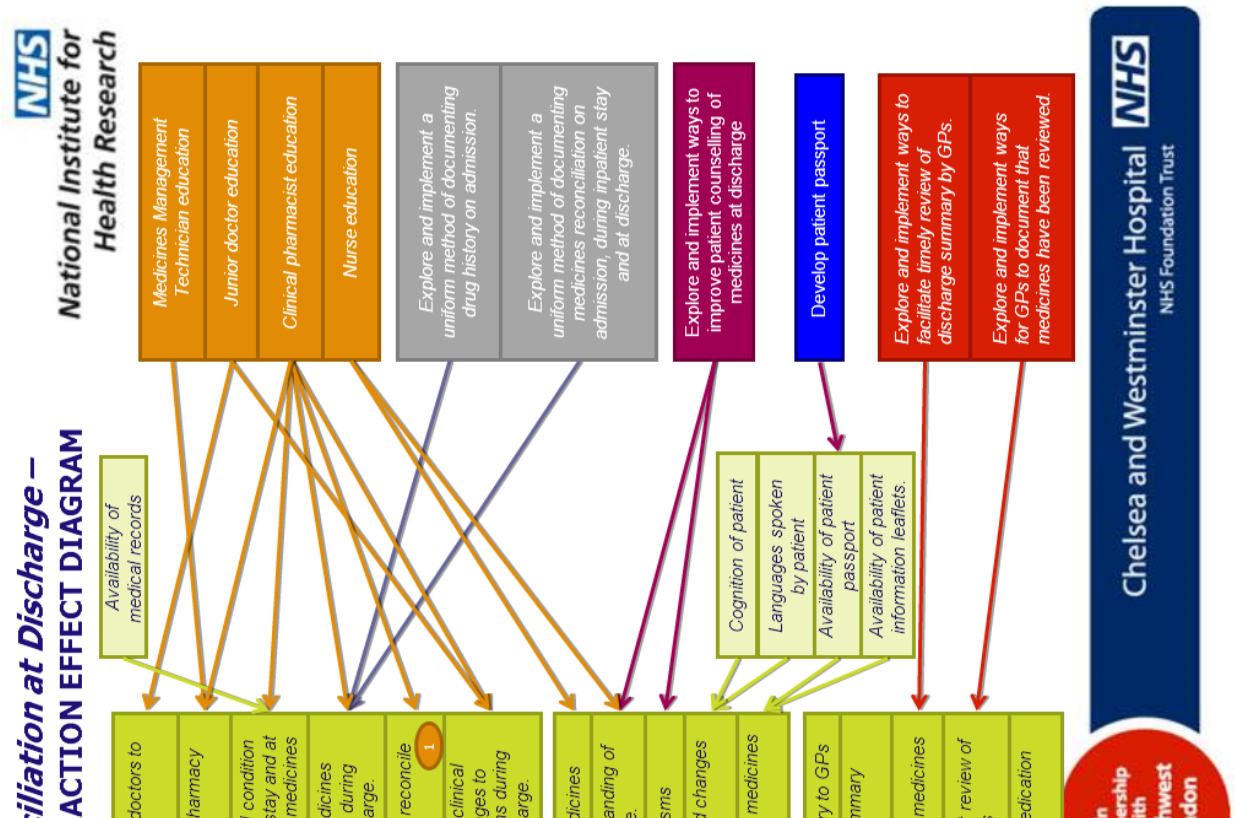


**Figure 6. Action Effect Diagram**



## Appendix Table 1. Plan-Do-Study-Act Cycles

| Series Number | Cycle title |
|---|---|
| Series 1a: 19/5/11 | Transfer of medicines from AAU |
| Series 1b: 27/5/11 | Transfer of medicines from AAU |
| Series 1c: 8/7/11 | Transfer of medicines from AAU - Downstream wards |
| Series 1d: 22/9/11 | Transfer of medicines from AAU - Nurses survey |
| Series 2: 21/5/12 | TTO turnaround time - Pharmacist tracking |
| Series 3a: 6/12/11 | Uncollected TTOs |
| Series 3b: 1/5/12 | Uncollected TTOs |
| Series 4a: 11/2/12 | Nurse training package - Nurse questionnaire (AAU) |
| Series 4b: 27/2/12 | Nurse training package - Nurse questionnaire (Trust-wide) |
| Series 5: 28/5/12 | AAU pharmacy process review |
| Series 6: 3/9/12 | GP survey |
| Series 7: 14/6/12 | Improvement measures |

Key:
AAU = Acute Admissions Unit
TTO = To take out (medicines)
GP = General Practitioner

# Revised Standards for Quality Improvement Reporting Excellence

# SQUIRE 2.0

## Notes to Authors

- The SQUIRE guidelines provide a framework for reporting new knowledge about how to improve healthcare.
- The SQUIRE guidelines are intended for reports that describe system level work to improve the quality, safety, and value of healthcare, and used methods to establish that observed outcomes were due to the intervention(s).
- A range of approaches exists for improving healthcare. SQUIRE may be adapted for reporting any of these.
- Authors should consider every SQUIRE item, but it may be inappropriate or unnecessary to include every SQUIRE element in a particular manuscript.
- The SQUIRE Glossary contains definitions of many of the key words in SQUIRE.
- The Explanation and Elaboration document provides specific examples of well-written SQUIRE items, and an in-depth explanation of each item.
- Please cite SQUIRE when it is used to write a manuscript.

## Title and Abstract

| | |
|---|---|
| **1. Title** | Indicate that the manuscript concerns an initiative to improve healthcare (broadly defined to include the quality, safety, effectiveness, patient-centeredness, timeliness, cost, efficiency, and equity of healthcare)<br><br>**Applying Quality Improvement methods to address gaps in medicines reconciliation at transfers of care from an acute UK hospital** |
| **2. Abstract** | a. Provide adequate information to aid in searching and indexing<br><br>b. Summarize all key information from various sections of the text using the abstract format of the intended publication or a structured summary such as: background, local problem, methods, interventions, results, conclusions<br><br>**Structured according to Journal requirements, includes strengths and limitations; key words are relevant and where possible MESH linked.** |
| **Introduction** | ***Why did you start?*** |
| **3. Problem Description** | Nature and significance of the local problem<br><br>**Detailed in the Introduction – transfers of care, medicines reconciliation and the UK setting.** |
| **4. Available Knowledge** | Summary of what is currently known about the problem, including relevant previous studies<br><br>**Detailed in the Introduction** |

# Revised Standards for Quality Improvement Reporting Excellence

## SQUIRE 2.0

| | |
|---|---|
| **5. Rationale** | Informal or formal frameworks, models, concepts, and/or theories used to explain the problem, any reasons or assumptions that were used to develop the intervention(s), and reasons why the intervention(s) was expected to work<br><br>**Detailed in the Introduction** |
| **6. Specific Aims** | Purpose of the project and of this report<br><br>**The overall aim of this study was to provide seamless, high quality medicines reconciliation from admission through to discharge for all patients and improve communication with community service providers. The objectives were to:**<br>**• reduce unintentional discrepancies in transcribing medication during admission to hospital**<br>**• improve documentation of medicines reconciliation at discharge**<br>**• improve the quality of communications regarding new and intentional changes to medication in the hospital discharge summary** |
| **Methods** | ***What did you do?*** |
| **7. Context** | Contextual elements considered important at the outset of introducing the intervention(s)<br><br>**Detailed in Planning the Intervention and the Interventions sections** |
| **8. Intervention(s)** | a. Description of the intervention(s) in sufficient detail that others could reproduce it<br><br>b. Specifics of the team involved in the work<br><br>**Detailed in Planning the Intervention and the Interventions sections** |
| **9. Study of the Intervention(s)** | a. Approach chosen for assessing the impact of the intervention(s)<br><br>b. Approach used to establish whether the observed outcomes were due to the intervention(s)<br><br>**Detailed in Analytic plans and methods section** |
| **10. Measures** | a. Measures chosen for studying processes and outcomes of the intervention(s), including rationale for choosing them, their operational definitions, and their validity and reliability<br><br>b. Description of the approach to the ongoing assessment of contextual elements that contributed to the success, failure, efficiency, and cost |

# Revised Standards for Quality Improvement Reporting Excellence

# SQUIRE 2.0

| | |
|---|---|
| | c. Methods employed for assessing completeness and accuracy of data<br><br>**Available as Table 1 – Process Measures** |
| **11. Analysis** | a. Qualitative and quantitative methods used to draw inferences from the data<br><br>b. Methods for understanding variation within the data, including the effects of time as a variable<br><br>**Detailed in Analytic plans and methods section, including use of SPC** |
| **12. Ethical Considerations** | Ethical aspects of implementing and studying the intervention(s) and how they were addressed, including, but not limited to, formal ethics review and potential conflict(s) of interest<br><br>**Detailed in Ethical approval section, following introductions** |
| **Results** | ***What did you find?*** |
| **13. Results** | a. Initial steps of the intervention(s) and their evolution over time (e.g., time-line diagram, flow chart, or table), including modifications made to the intervention during the project<br><br>b. Details of the process measures and outcome<br><br>c. Contextual elements that interacted with the intervention(s)<br><br>d. Observed associations between outcomes, interventions, and relevant contextual elements<br><br>e. Unintended consequences such as unexpected benefits, problems, failures, or costs associated with the intervention(s).<br><br>f. Details about missing data<br><br>**Detailed in Results section.** |
| **Discussion** | ***What does it mean?*** |
| **14. Summary** | a. Key findings, including relevance to the rationale and specific aims<br><br>b. Particular strengths of the project<br><br>**Given in Lessons learnt section and strengths section of the abstract** |

# Revised Standards for Quality Improvement Reporting Excellence

## SQUIRE 2.0

| | |
|---|---|
| **15. Interpretation** | a. Nature of the association between the intervention(s) and the outcomes<br>b. Comparison of results with findings from other publications<br>c. Impact of the project on people and systems<br>d. Reasons for any differences between observed and anticipated outcomes, including the influence of context<br>e. Costs and strategic trade-offs, including opportunity costs<br>**No costs data were available, discussion addresses other aspects** |
| **16. Limitations** | a. Limits to the generalizability of the work<br>b. Factors that might have limited internal validity such as confounding, bias, or imprecision in the design, methods, measurement, or analysis<br>c. Efforts made to minimize and adjust for limitations<br>**Limitations discussed** |
| **17. Conclusions** | a. Usefulness of the work<br>b. Sustainability<br>c. Potential for spread to other contexts<br>d. Implications for practice and for further study in the field<br>e. Suggested next steps<br>**Sustainability of work noted by a follow up period, recommendations made for others in discussion and conclusion sectiosn** |
| **Other Information** | |
| **18. Funding** | Sources of funding that supported this work. Role, if any, of the funding organization in the design, implementation, interpretation, and reporting<br>**Funding disclaimer is standard as part of our obligations to our funder.** |