**The benefit of targeted, pharmacist-led education for junior doctors in reducing prescription writing errors – a controlled trial.**

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# The benefit of targeted, pharmacist-led education for junior doctors in reducing prescription writing errors – a controlled trial.

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## ABSTRACT

**Background:**

Prescribing errors are common, and a known cause of adverse patient outcomes. Junior doctors are responsible for the majority of prescribing, and may benefit from educational interventions.

**Aim:**

To assess the effect of (1) targeted pharmacist-led feedback and education, and (2) an e-learning prescribing module, on prescription writing error rates by junior doctors in the inpatient medical setting.

**Methods:**

We undertook a cluster randomised trial in 2014 involving 16 prescribers in four general medical units of an Australian tertiary hospital. One unit was randomised to prescribing feedback and targeted education by a clinical pharmacist; another unit was randomised to an e-learning intervention on safe prescribing; and two units were randomised to no intervention. Data were collected via daily audit of paper medication charts. A prescription writing error was deemed to have occurred if patient or prescriber details were incomplete, or if a medication order was illegible, incomplete or incorrect. Statistical analysis was by chi-squared comparison of each unit's error rate pre-intervention to post-intervention.

**Results:**

Prescription writing errors were significantly reduced in the pharmacist education group, from 0.58 errors/total orders pre-intervention to 0.37 errors/total orders post-intervention ($P < 0.001$). Conversely, an increase in the error rate of the control group was observed from 0.49 to 0.59 errors/total orders ($P < 0.001$), and to a lesser extent in the e-learning group from 0.58 to 0.63 errors/total orders ($P = 0.025$).

**Conclusions:**

Regular and targeted pharmacist feedback and education is effective at reducing prescription writing errors, while the effect of e-learning tools remains unclear.

## INTRODUCTION

Prescribing errors are a significant cause of morbidity and mortality in Australian hospitals. Medication related errors cost the Australian healthcare system an estimated $680 million per year.[1] Prevalence of prescribing errors vary widely in the literature. This variation is due to lack of a standardised mechanism of defining a prescribing error, and no common unit as a measure of outcome. Past reviews have found that medication errors affect anywhere between 1-100% of patients admitted to hospital,[2] and prevalence rates of prescribing errors range from 1 in 2 to 1 in 514 medication orders written.[3] Data from the pilot implementation study of the National Inpatient Medication Chart suggested that up to 40% of medication orders in the Australian adult inpatient setting contain prescribing errors.[4]

Prior research which analysed the causes and frequency of prescribing errors has identified a complex interplay of many factors.[5, 6] These include a lack of prescribing knowledge and skills, lack of error awareness, hindering cultural and behavioural prescribing norms, systems failures, and individual pressures such as workload and fatigue.[2, 7, 8] Of particular concern is the lack of a 'safety-culture' reported by many junior doctors, with the task of prescribing often considered to have low relative importance compared to other clinical tasks.[9] Many of the prescribing errors observed in our institution are related to the actual process of writing a prescription or medication order. As such there is a drive to find effective interventions to promote safe prescribing practices and to improve the prescription writing skills of junior doctors, where electronic prescribing is not yet available.

A number of interventions have previously shown benefit in reducing prescription writing errors, including standardised inpatient medication charts,[4] pharmacist participation on ward rounds and electronic prescribing tools.[9] However, these types of interventions can have significant financial and logistical burdens associated with implementation, are not necessarily universally available, and may not improve the skills and knowledge of those responsible for prescribing. Prescriber education or e-learning tools are frequently proposed as potentially cost-effective methods for the prevention of prescribing errors.[2, 8, 10]

A review of the literature relating to educational interventions and prescription writing errors identifies generally positive results. However, the evidence remains incomplete due to a lack of robustly designed trials that examine prescription writing errors in the adult inpatient setting. In some studies, pharmacist-led education of medical staff comprises only one component of a multi-faceted intervention,[11-15] and the benefit of each aspect of the intervention is unclear. One such recent 'mixed-methods' study demonstrated an improvement in prescriber identification, but no change in error rates.[16] In other studies, outcomes have been assessed using tests or quizzes rather than audited clinical prescribing data.[8, 17] Further studies have been uncontrolled,[18, 19] or have occurred in clinical settings such as primary care, paediatrics or intensive care - situations potentially incongruent with the prescribing practices of adult inpatient medicine. One study showed a benefit of an e-learning tool, but again this was based on prescribing tests rather than observed clinical practice.[20]

The aim of our study was to determine the effect of two separate education-based interventions on frequency of prescription writing errors made by junior doctors in the inpatient medical setting. The interventions assessed were: (**1**) pharmacist-directed prescribing feedback and education for junior doctors, and (**2**) completion of the Australian National Prescribing Service's (NPS) online National Inpatient Medication Chart Training Course.[21]

## MATERIALS AND METHODS

### Study design and setting

A cluster randomised trial was undertaken involving the four general medical units of a large tertiary referral centre in Melbourne, Australia. One unit was randomised to regular prescribing feedback and targeted education; another unit was randomised to the intervention whereby junior doctors completed the NPS National Inpatient Medication Chart Training e-learning course;[21] and the two remaining units were randomised to no intervention. Data were collected from paper medication charts of inpatients admitted to the four general medical units.

### Participants

All junior doctors working in the general medical units at the time of the study participated, consisting of 12 interns and four registrars. Each unit had one registrar and three interns. All units were made aware of the study before it began and doctors were informed that they were expected to participate as part of an ongoing quality assurance process. Consultants did not participate in the study.

### Materials

We examined the rates of prescription writing errors made by junior doctors on the paper-based, standardised National Inpatient Medication Chart of general medical inpatients. A prescription writing error was deemed to have occurred if patient or prescriber details were incomplete, or if a medication order was illegible, incomplete or incorrectly written. We did not evaluate any other aspects of the medication provision process such as dispensing or medication administration errors.

We examined all areas of the standardised inpatient medication chart, identifying 25 potential error types. This included general chart factors (legibility, patient identification, prescriber identification, chart numbering, and completion of the adverse drug reaction section), completeness and correctness of each order (date, drug, route, dose, frequency and units), use of generic drug names in accordance with hospital policy, unsafe or error-prone abbreviations, order cessation, use of decimal points, hourly-frequencies and maximum daily doses for 'as required' orders, and appropriate indication of limited duration or modified release preparations. The full list of error types is attached in appendix one. The data collection tool allowed for more than one error to be identified per medication order. Error severity was classified as 'minor', 'significant', 'serious' or 'potentially lethal', based on a stratification tool used by the EQUIP study.[9] This tool balances potential clinical outcomes of a prescription writing error with the likelihood that the error would actually be carried through to the patient. A blinded panel consisting of a clinical pharmacist and senior clinician (clinical pharmacologist) validated this severity stratification by independently assessing the severity of a selection of 100 errors. These comprised a broad selection of 9 serious, 21 significant and 70 minor errors. Examples of all but two categories of error were included in the sample. One error category was omitted (telephone orders not signed by doctor) as this type of error was only identified once, while the other was omitted (incorrect use of decimal point) as it was not identified at all.

**Communication and blinding**

The study took place in 2014, three weeks into the first intern rotation. Clinical pharmacists working with these units were provided a summary of the study. It was emphasised that pharmacists should continue reviewing charts as per standard practice, and they were reminded of the existing hospital policy documents regarding medication chart review protocols in terms of prescription writing error identification.

Clinical pharmacists remained blinded to intervention unit allocation and a rotating ward roster meant that each pharmacist reviewed charts from all four units. All senior medical staff remained blinded to intervention unit allocation and junior medical staff were asked not to discuss the interventions. The investigator responsible for data collection and the intervention pharmacist were unable to be blinded.

**Data collection**

Data collection was via daily review of medication charts. This occurred after clinical pharmacists had reviewed charts and identified prescription writing errors each day, which occurred as part of their usual ward duties. Using a systematic process, each part of the medication chart was evaluated for errors identified by the pharmacist, conventionally identified at the study hospital by chart annotations in purple ink. Errors that had been identified were noted, stratified by type and rated for severity. Each chart was reviewed for additional orders on a daily basis for the duration of the patient's hospital stay. Baseline data were collected from all units for three weeks, prior to implementation of the interventions. Post-intervention data was collected in the subsequent four weeks, following implementation of the interventions.

**Intervention**

The four general medical units were randomised to two intervention groups (one unit each) and control groups (two units) using a random number generator and a pre-defined sequence of allocation. Medical staff working in the two units assigned to be control groups were not contacted further and did not receive an intervention.

The pharmacist-led targeted feedback and education intervention comprised three ten-minute sessions per week for the duration of the four week intervention period. During these sessions the clinical pharmacist discussed with the interns and registrar the frequency, type and severity of recently observed prescription writing errors. Beginning with the most frequent and most serious error types identified, the pharmacist discussed why the errors were considered incorrect or unsafe, the potential consequences of such errors, and the correct way to prescribe. Any questions or ambiguities were addressed and a handout summarising the content discussed was given to prescribers (see example in Appendix two). Subsequent sessions addressed the next most common and serious errors, usually covering two-to-three error types per session. Realtime chart audit data informed the content of these sessions, using data from the one-to-two days immediately preceding each session. Utilisation of realtime data allowed teaching to be targeted to error-prone aspects of prescribing, and the effectiveness of teaching could be assessed during subsequent daily audits. Throughout the intervention, errors were discussed in a constructive manner and when examples were used, the identification of the prescriber was withheld.

The e-learning intervention was the NPS National Inpatient Medication Chart Training Course.[21] This online course already existed prior to our study, and in the past had formed part of the new intern orientation package at the study hospital. However in the study year the course was only undertaken by the e-learning intervention group. The course comprises seven modules that teach safe and correct prescribing practices, and takes approximately one hour to complete. The course specifically refers to the National Inpatient Medication Chart, the standardised medication chart used widely in Australian hospitals. This was completed in the final few days of the baseline data collection period, after which this intervention group had no further contact with the study authors.

**Analysis**

Each group served as its own control, with comparison of error rates pre- and post-intervention. The error rate was calculated by dividing the total number of errors by the total number of medication orders written. The numerator (total number of errors) included individual prescription-level errors as well as chart-level errors. The method of error rate calculation varies widely in the literature, but the "error per medication order" definition was chosen as it was most commonly used, and provided the greatest fidelity in analysing types and frequency of error. Based on a two-sided alpha value of 0.05 and 80% power to detect a 20% difference in error rate between the two periods (40% vs 32%), we estimated that 589 medication orders were required per study group (a total of 1767). It was elected to collect data for longer than this number required due to the continuous nature of the pharmacist educational intervention.

A chi-squared comparison of each group's error rate pre- and post-intervention was performed without Yate's correction, with expression of 95% confidence intervals (CIs).

**RESULTS**

A total of 9657 medication orders were reviewed across the study period and 5203 prescription writing errors were identified. At baseline, 2198 errors were identified from 4160 medication orders, giving an average prescription writing error rate across all units of 0.53 errors per order (95% CI 0.52 - 0.54). Table 1 provides a stratification of prescription writing error severity at baseline. Table 2 shows the number of errors for each intervention group by error severity pre and post intervention.

**Table 1: Baseline prescription writing error severity across all groups**

**Table 2: Prescription writing errors stratified by severity.**

The error rate decreased significantly in the pharmacist education group, from 0.58 (95% CI 0.58-0.59) errors/order at baseline to 0.37 (95% CI 0.36-0.38) errors/order post-intervention ($P < 0.001$). Conversely, the control group's error rate increased from 0.49 (95% CI 0.48 -0.50) errors/order to 0.59 (95% CI 0.58-0.60) errors/order ($P < 0.001$). The e-learning group's error rate increased slightly from 0.58 (95% CI 0.56-0.60) errors/order to 0.63 (95% CI 0.62-0.65) errors/order ($P = 0.025$). The results are summarised in Figure 1.

**Figure 1: Prescribing error rates by intervention group, pre and post-intervention**

A total of 27 serious errors were identified throughout the study. The types of errors identified as serious are shown in table 3.

**Table 3: Types of serious errors identified throughout the study.**

'Potentially lethal', 'serious' and 'significant' errors were grouped together pre-analysis to compare the effect of each intervention on the more clinically significant errors. As illustrated in Figure 2, there was an absolute reduction of 26% of clinically significant errors in the pharmacist education group. This result was not statistically significant. Clinically significant error rates did not change in the e-learning prescribing module, and increased in the control group. When the independent panel performed severity scoring, greater than 80% of errors were attributed a severity rating equal to or more severe than that attributed by the study authors.

**Figure 2: Rates of clinically significant prescribing errors by intervention group (Potentially lethal, serious and significant errors)**

Errors were clustered into five broad categories to deconstruct the nature of the changes in error types following the intervention. This is shown in Figure 3. In the pharmacist education group, a reduction was observed in the rates of errors concerning patient/prescriber identification, order completeness, chart completeness and order appropriateness, while rate of errors relating to order correctness remained largely unchanged. By contrast, in the control group, the rates of errors relating to order completeness, order correctness and order appropriateness all increased. Similar increases, although to a lesser degree, were observed in in the e-learning group. Error types included in each category of error are shown in Appendix three.

**Figure 3: Changes in rates of categorised prescribing error types.**

## DISCUSSION

Our study shows that regular targeted feedback and education from a clinical pharmacist to small groups of junior doctors reduces prescription writing errors. Our results build upon the existing body of research, providing evidence that a simple, pharmacist-directed feedback and education program can reduce prescription writing errors on adult inpatient wards. Gordon and Bose-Haider conducted a similar study on a paediatric ward, but with feedback delivered by poster display and email summaries to staff.[18] They also showed a significant reduction in prescription writing error rates, although the study was uncontrolled and did not account for potentially confounding temporal changes in prescribing skill.

Both junior doctors and pharmacists were keen to participate in the education and feedback intervention, with attendance rates by the junior doctors almost 100%. Many errors occurred through lack of knowledge or awareness of prescribing rules, rather than deliberate rule-breaking. Reinforcement of the importance of prescriber identification, chart completeness, and appropriate completion of all aspects of a medication order (rate, route, dose, frequency, maximum doses) was particularly effective.

There are considerable potential benefits of a formalised program of pharmacist feedback and education for junior prescribers. Junior doctors across Australia undergo similar training, and the targeted nature of the intervention means it is easily adapted to individual prescribers' strengths and weaknesses. The intervention is simple, requiring only a minimal outlay of clinical pharmacist and junior doctor time, in what is essentially a formalisation of a feedback process that frequently occurs as part of routine clinical care. Reynolds et al[16] recent 'mixed methods' study in which prescriber feedback was a key component demonstrated improved prescriber identification, but didn't reduce the error rate, suggesting that the method of feedback is likely to be important.

Despite the increasing prevalence of e-learning initiatives in medical teaching, there is a lack of definitive research that evaluates their clinical effect. The e-learning unit in our study had a less substantial increase in error rate as compared to the control unit, suggesting a possible benefit. However, the disparity of baseline error rates between the control and e-learning groups made the relative changes in error rates difficult to statistically compare**.** Prior research evaluating an e-learning tool by Gordon et al showed a significant improvement in post-intervention prescribing test scores.[20] Importantly though, this did not assess actual clinical prescribing.

The increase in prescription writing error rate in the control and e-learning groups was surprising. We had expected the control group's error rate to stay the same or fall slightly across the study period, as interns gained experience and confidence. While there do not appear to be any studies which track error rates throughout the year, the large-scale EQUIP study found the highest rate of errors in second-year trainee doctors.[9] It is possible that with increasing experience and confidence may come a degree of carelessness, or a normalisation of deviance over time. Likewise, as the year proceeds and more responsibility is given to interns the opportunities for error may increase. Alternatively, as suggested by the authors of the EQUIP study, routine violation of prescribing rules is an understandable adaptation to an overly busy working environment, in which prescribing is often not held to be of the highest importance.[9]

Limitations of our study included the small number of participants, incomplete-blinding, and the brief nature of our intervention. The small number of prescribers allows for individual prescriber variation to influence results. Logistical constraints limited us to a single site, but a degree of confidence in our results is conferred by the magnitude of improvement in the pharmacist-led feedback and education group, as well as the large number of medication orders reviewed and the number of errors identified. Follow up was very difficult as all doctors involved in the study rotated on to various other clinical specialties at completion of the intervention period. Blinding of medical and pharmacy staff was attempted, although this was challenging in a single centre study. However, any cross-contamination of interventions between participating doctors is likely to reduce the magnitude of the intervention effect seen. Finally, because a single pharmacist carried out the education intervention there is some potential for the benefit to be variable, based on the teaching skills of an individual. However due to the relatively straightforward nature of the intervention we considered this unlikely to have a major impact.

At baseline, the overall rate of clinically significant errors was 0.055 errors/order. This equates to slightly more than one in twenty medication orders containing a clinically significant error. Some examples of clinically significant errors included not completing the adverse drug reaction section of the chart, prescribing a drug to which a patient had a documented allergy, duplication of medication orders, incorrect doses, and illegible prescriptions. While it is unknown what proportion of errors actually result in adverse events, this frequency of clinically significant errors suggests considerable potential for harm. A reduction in clinically significant errors by the pharmacist intervention unit was observed, although this result wasn't statistically significant, likely due to smaller numbers of clinically significant errors. Importantly, this reduction was roughly paralleled by the reductions in error rates across all error severities. Thus we consider it likely that reduction in error rates through pharmacist-led feedback and education will have a significant clinical effect, although further research needs to be undertaken to quantify this assertion.

E-learning prescribing tools require further investigation through clinical studies, rather than in academic testing scenarios. The type of e-learning tool and the timing of intervention are likely to be important factors in determining the effectiveness of these tools.

## CONCLUSION

Targeted, pharmacist-led education and feedback for junior doctors significantly reduced prescription writing errors. Pharmacist-led education is a safe, inexpensive and easily implemented intervention. The benefit of e-learning tools in reducing prescription writing errors remains uncertain. Further studies involving higher numbers of prescribers need to be undertaken to confirm the benefit of pharmacist-led education and feedback, and to assess e-learning tools.

## DECLARATIONS

Removed from anonymised copy of manuscript.

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**Table 1: Baseline prescription writing error severity across all groups.**

| **Error Severity** | **Definition** | **Baseline Error Frequency** ( n=4160 medication orders) |
|---|---|---|

| | | |
|---|---|---|
| **1** | **Potentially lethal:** potential for critical quantifiable changes to clinical outcomes, including possibility of death. | **0** |
| **2** | **Serious:** potential for major quantifiable changes to clinical outcomes | **15** |
| **3** | **Significant:** potential for some quantifiable changes to clinical outcomes | **201** |
| **4** | **Minor:** unlikely to alter clinical outcomes | **1982** |
| **Total** | **All errors** | **2198** |



**Table 2: Prescription writing errors stratified by severity.**

| | **Education and Feedback** | | **E-Learning** | | **Control (2 Units)** | |
|---|---|---|---|---|---|---|
| | Baseline | Intervention | Baseline | Intervention | Baseline | Intervention |
| **Potentially lethal** | 0 | 0 | 0 | 0 | 0 | 0 |
| **Serious** | 2 | 0 | 7 | 4 | 6 | 7 |
| **Significant** | 68 | 64 | 35 | 79 | 98 | 159 |
| **Minor** | 551 | 429 | 364 | 799 | 1067 | 1464 |
| **Total Errors** | 621 | 493 | 406 | 882 | 1171 | 1630 |
| **Total Medication Orders** | 1074 | 1333 | 697 | 1393 | 2389 | 2771 |

**Table 3: Types of serious errors identified throughout the study.**

| Number of occurrences | Error Code | Explanation |
|---|---|---|
| 17 | E | Mostly due to illegible drug names, some instances of illegible dosing units |
| 5 | K | Use of "U" instead of Units when prescribing insulin - potential 10-fold dosing errors. |
| 4 | Y | Prescription of a drug to a patient with a documented allergy to that drug or a closely related drug with significant chance of cross-reactivity |
| 1 | Y | Prescription of a drug to which a patient has a documented allergy |

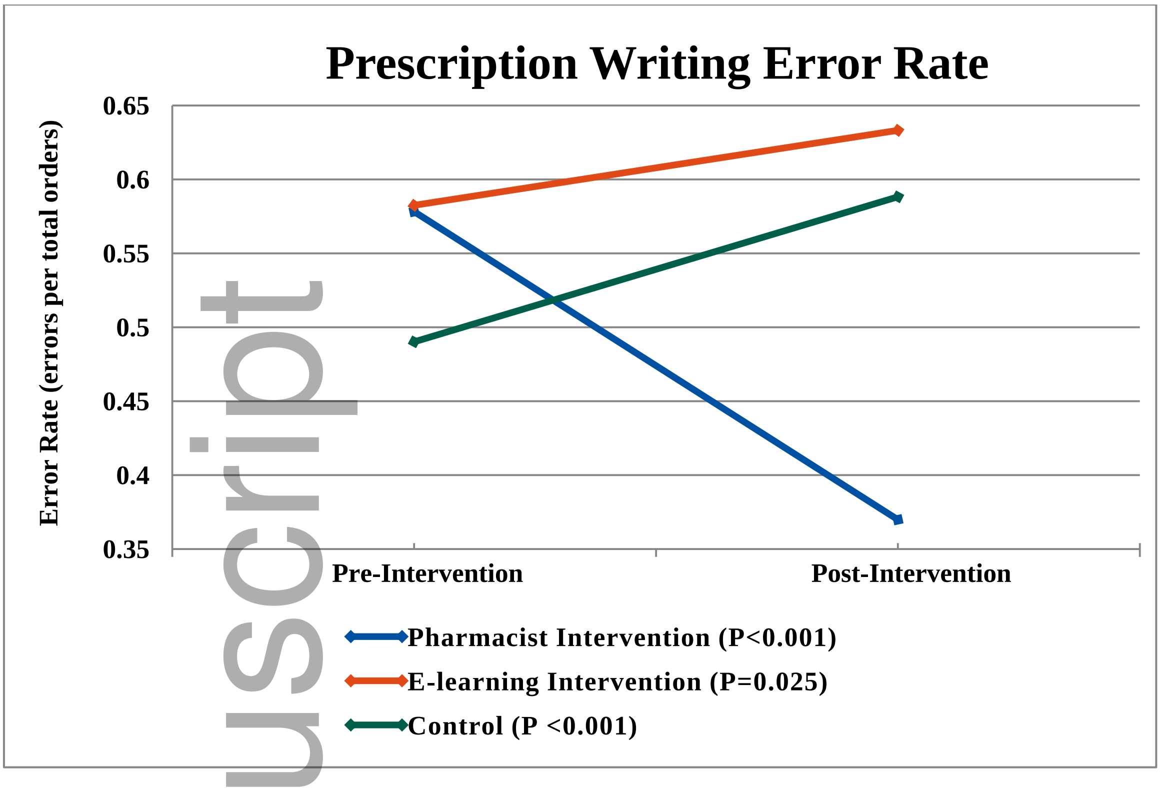



**Figure 1: Prescribing error rates by intervention group, pre and post-intervention**

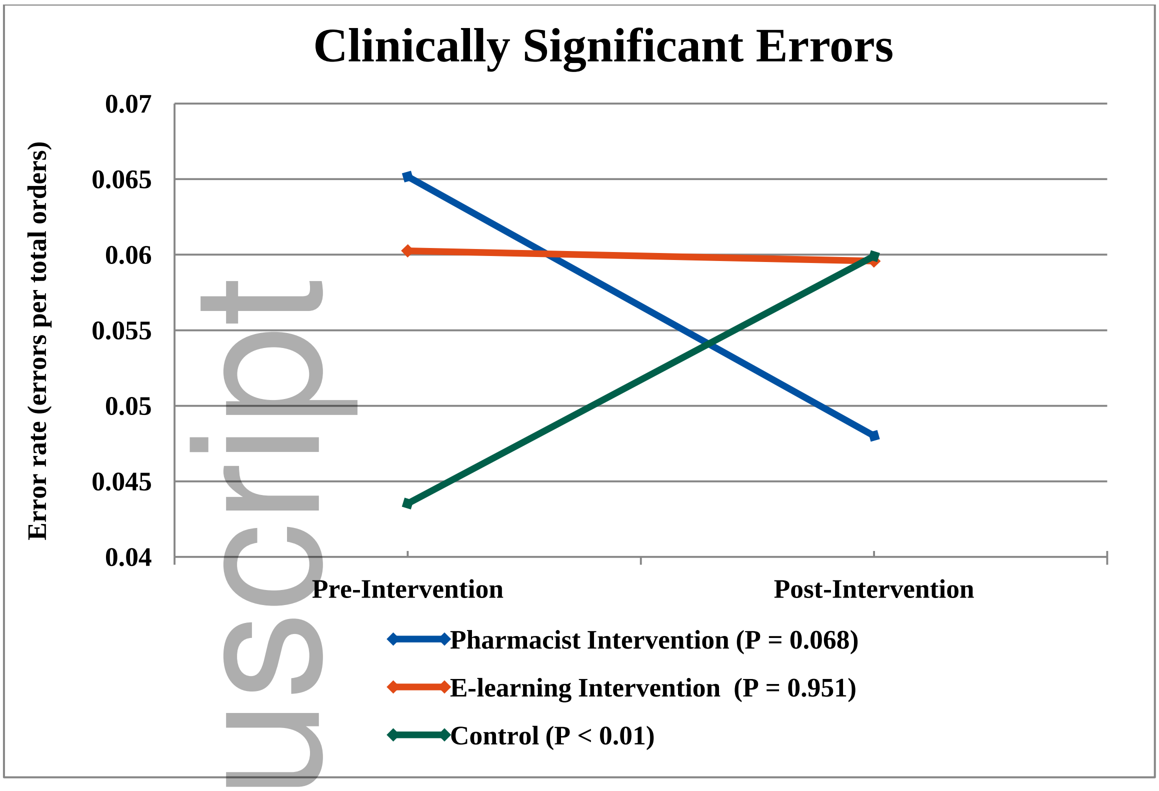



**Figure 2: Rates of clinically significant prescribing errors by intervention group (Potentially lethal, serious and significant errors)**

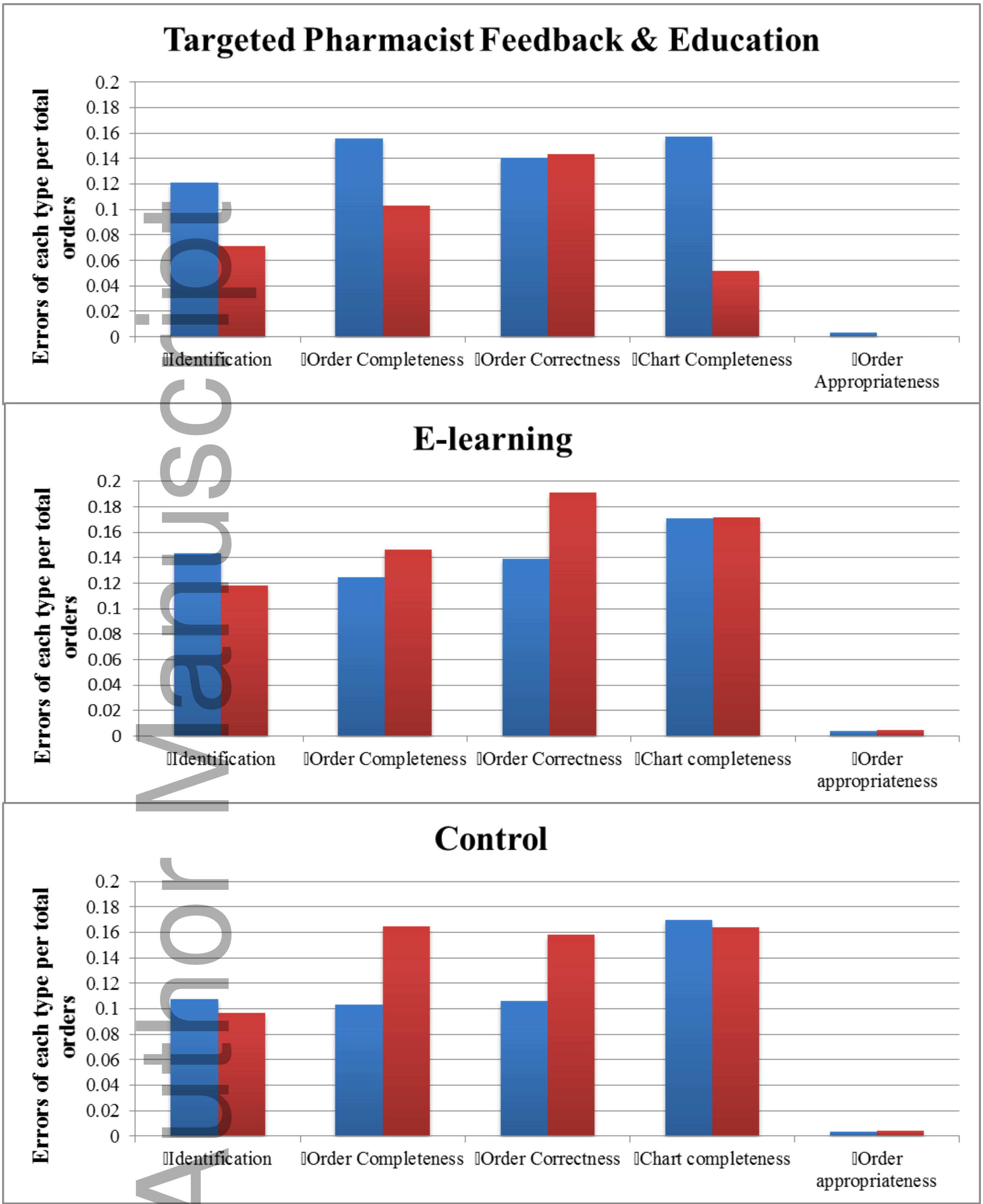



**Figure 3: Changes in rates of categorised prescribing error types.**

**Appendix 1: Prescription writing error types**

| Error Code | Error Type | Extra details |
|---|---|---|
| A | Patient details incomplete | Need 3 approved identifiers (patient idenfitifation number, name, birthdate) AND 1st prescriber to write patient name on chart. |
| B | Prescriber name NOT identifiable at least once on chart | Should also include contact details/pager number at least once |
| C | ADR (Adverse drug reaction) section incomplete | ADR box to be complete or 'no known allergies' ticked, WITH Sign AND Date. |
| D | Medication Chart not numbered | each chart should be numbered: _ / _ |
| E | Prescription illegible or written inappropriately | eg illegible handwriting, written in pencil/fountain pen (water soluble ink) |
| F | Date of prescription not completed | An individual medication order is not dated. |
| G | Non-generic drug name used | Exceptions include insulins and oral opiates. Potentially dangerous as can cause confusion with similar-sounding wrong drug administered, or missed identification of an allergy to the drug (especially with penicillins) |
| H | Abbreviated drug name or chemical symbol | e.g. GTN (Glyceryl trinitrate), KCL (potassium chloride) |
| I | Route | e.g. wrong route abbreviation used (eg S/C instead of subcut) or wrong route prescribed |
| J | Incorrect dose | Clinically inappropriate dose - eg prescribing of 50mg instead of 500mg - severity depends on magnitude of error and drug |
| K | Dose units | unclear / error-prone abbreviations. eg. Mcg instead of microg, "U" instead of "units" (potiental 10-fold insulin dose) |
| L | Incorrect use of a decimal point | e.g. trailing zero (1.0mg), no leading zero (.1mg) |
| M | Frequency - unclear, not properly annotated | Non-accepted abbreviations, non-hourly frequency used on **PRN** (as required) chart |
| N | Frequency - incorrect | Clinically inappropriate frequency e.g. daily dosing where twice-daily dosing required. |
| O | Dose administration times incomplete | eg 0800/2000. |
| P | Duplicate order | If unintentional - eg duplicate order on two charts, or orders in regular and PRN sections which exceed maximum allowed doses. |
| Q | Prescription not signed | individual medication order not signed. |
| R | PRN order - max dose not specified. | No max dose/24hrs for PRN order |
| S | Modified release preparations not documented completely | |
| T | Warfarin section not filled out completely | Refers only to aspects of warfarin prescription not applicable to other error codes - e.g. brand name not specified, omission of target INR (international normalised ratio) or indication. |
| U | Orders ceased incorrectly | Must not obliterate the order - should have line through order, with date, reason ceased (or "ceased"), and signature. |
| V | Telephone order not signed by doctor | |
| W | Omission | Key section of order not completed - eg Route, dose, frequency, strength,, units |
| X | Limited duration medicines | Should have days beyond this period blocked out with 'X'. Eg 3 days: _ _ _ X X X X |
| Y | ADR to prescribed medication | Documented allergic/anaphylactic reaction (in ADR section) to prescibed drug |



**Appendix 2: Example of the pharmacist-led feedback and education session handout.**

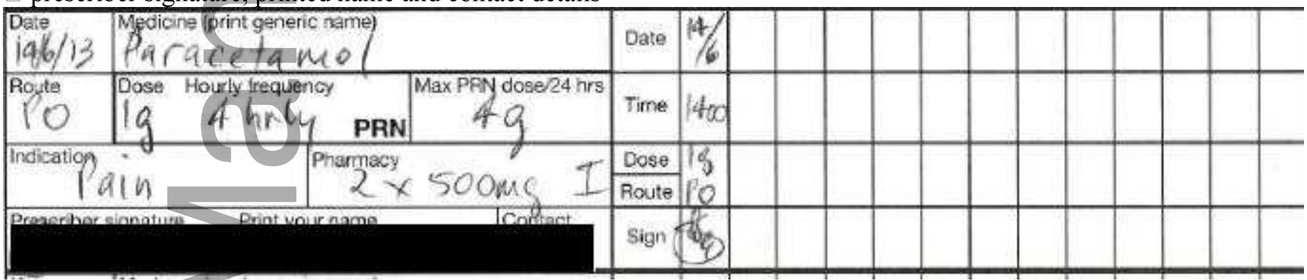
**GEN MED PRESCRIBING ERRORS – Summary 24th Feb**

- 2198 errors identified in total
- 4137 medication orders reviewed → errors : orders =~ 53%
- Almost all "minor errors"- unlikely to cause harm to patient
- 201 "significant errors" – some quantifiable potential change to patient outcomes/length of stay/level of care/Ix required
- 15 "serious errors" – significant quantifiable potential for change to patient outcomes/length of stay/level of care/Ix required
- 0 "potentially lethal errors"

**Common errors**

**PRN orders:**
- **non-hourly frequency** used – 205 instances
- **Max PRN dose** omitted – 213 instances

Document the following for each medicine prescription:
☐ dose and hourly frequency. (PRN (pre-printed) alone is not sufficient.)
☐ route
☐ dose
☐ hourly frequency
☐ maximum daily dose (maximum PRN dose in 24 hours)
  - e.g.Paracetamol 4g
☐ indication
☐ prescriber signature, printed name and contact details




**Significant errors**

Use of non-generic drug names (excepting insulins/oral opiates)
- **188** instances over last 3 weeks.
- **Common examples:**
  - piperacillin / tazobactam
  - amoxycillin/clavulanate
  - codeine-containing drugs
  - magnesium/potassium/sodium
  - enoxaparin

**Most Common (already discussed last session)**
- **orders ceased inappropriately (548 occurrences) -** (must include date, reason ceased, signature)
- **patient details incomplete (269)** - Need 3 approved identifiers (UR, name, DOB) AND 1st prescriber to write patient name ON BOTH SIDES
- **prescriber identification (211) -** Prescriber name NOT identifiable at least once on chart - should also include contact details/pager number at least once

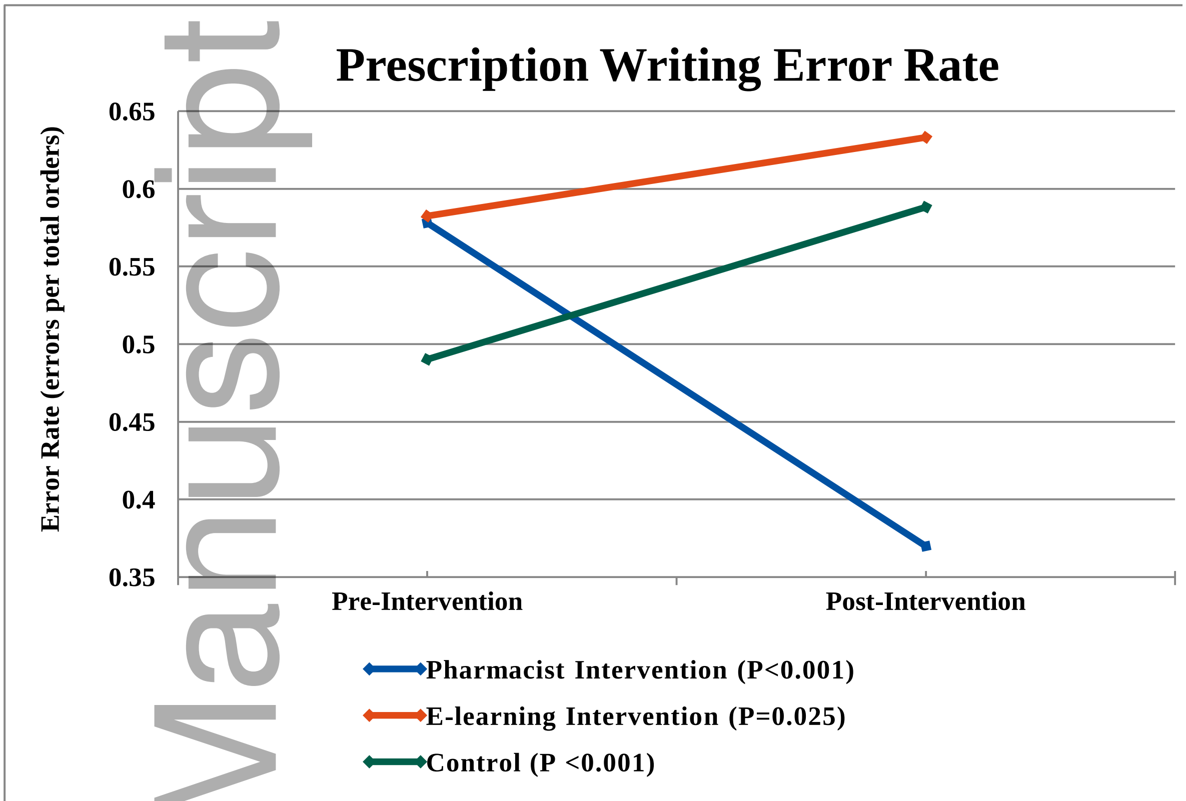
**Most serious (already discussed)**
→ Two types of serious errors during baseline data collection period
- **"U" instead of "UNITS"** – prescribing insulin.
  - Should always write UNITS in full – "U" is a 'never event'
- Ceftriaxone prescribed to patient with anaphylactic penicillin reaction
  - ~10% cross-reaction between cephalosporins and penicillin allergies

## Appendix 3: Error code groupings

| Grouping | Error Codes Included |
|---|---|
| Identification (Patient or Prescriber) | A, B, Q, V |
| Order Incomplete | E, F, O, R, S, T, W, X |
| Order incorrect | G, H, I , J, K , L, M , N |
| Chart incomplete/incorrect | C, D, U |
| Inappropriate orders | Y, P. |

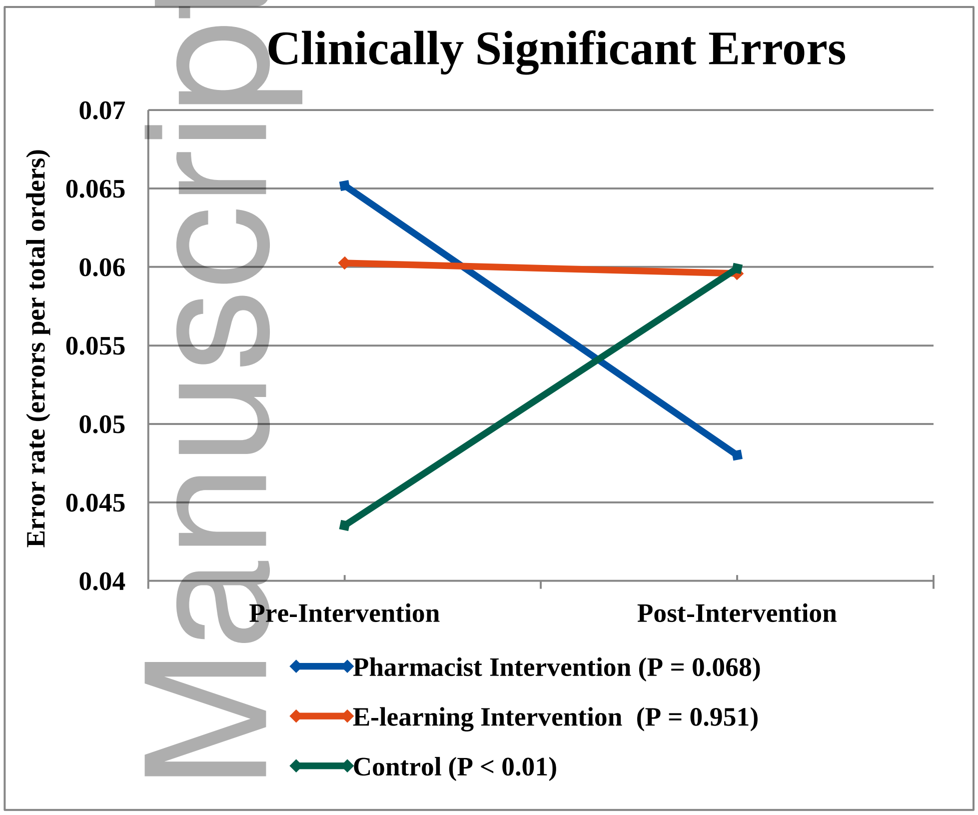
Note: Refer to Appendix 1 for error code definitions.

| Error rates (as % of total orders) | Pharmacy group | E-learning |
|---|---|---|
| Baseline | 0.578212291 | 0.582496413 |
| Intervention | 0.369842461 | 0.633165829 |

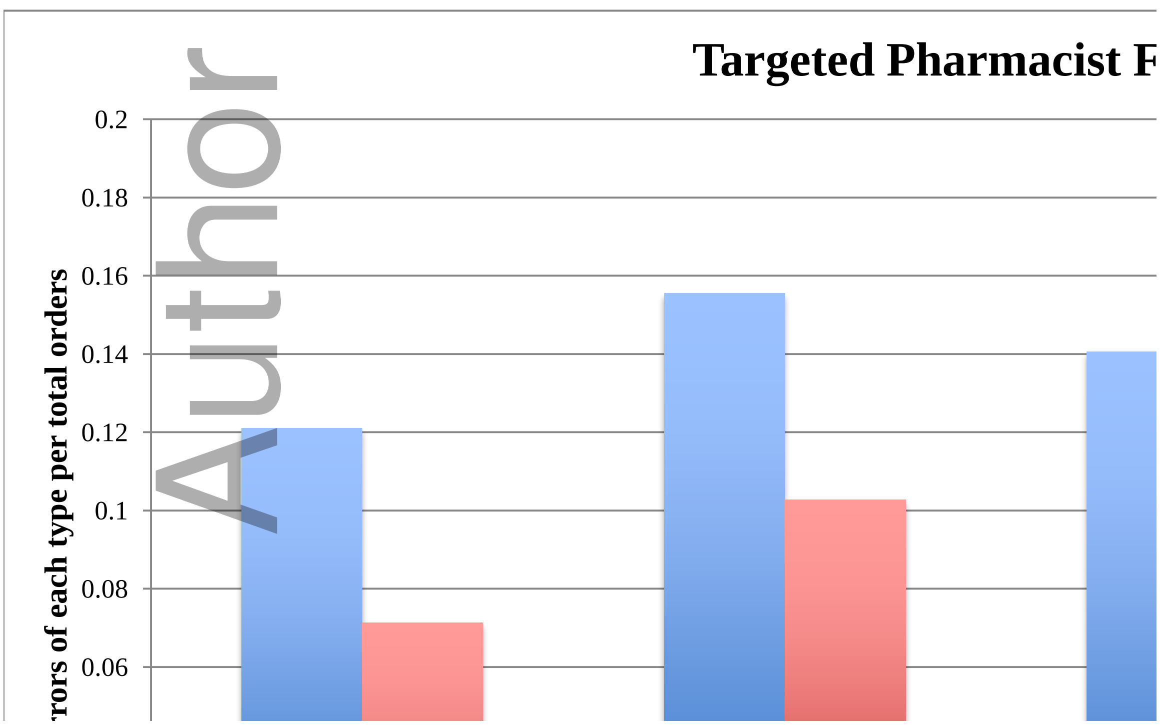


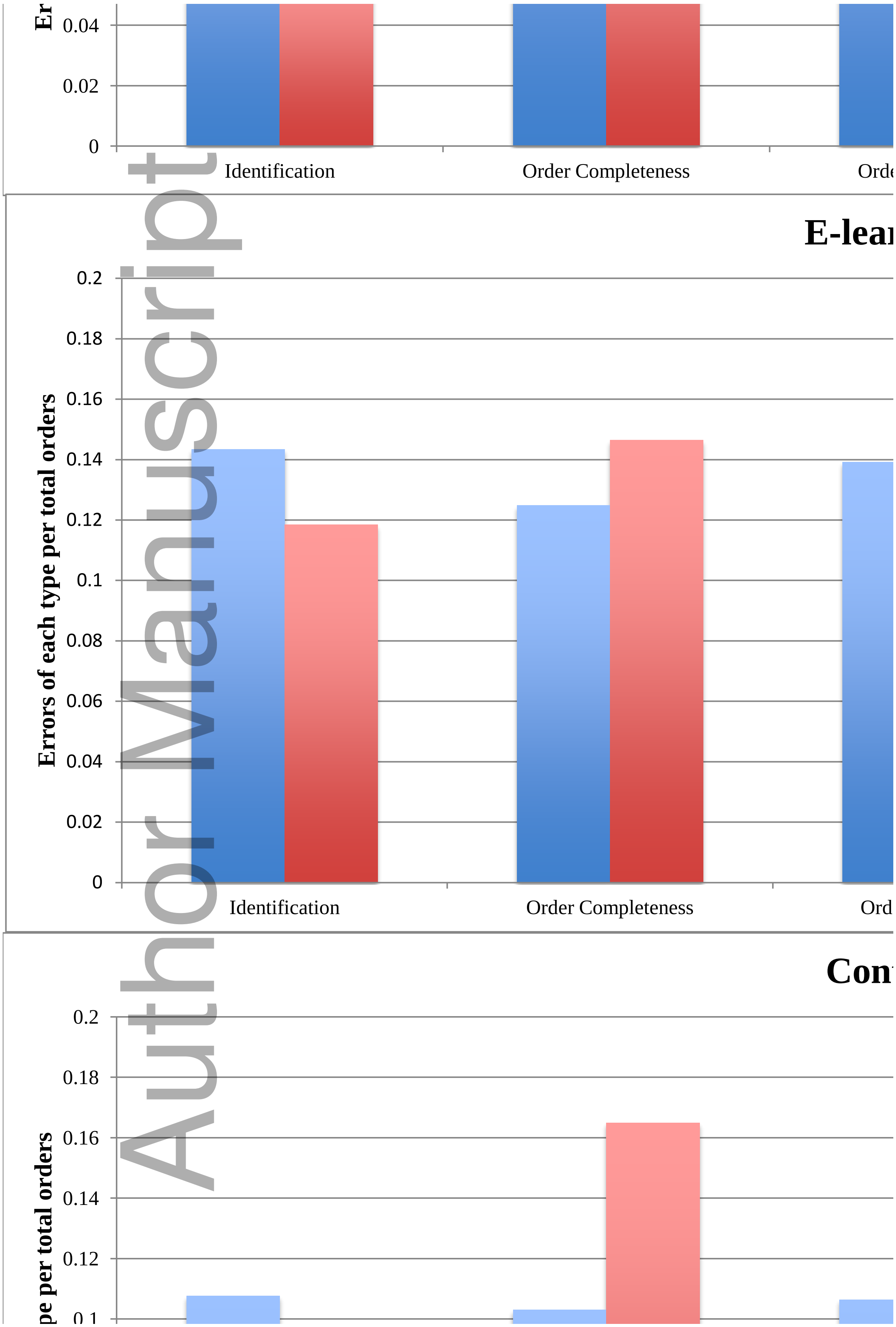
| Control |
| --- |
| 0.490163248 |
| 0.588235294 |

| | Pre-Intervention | Post-Intervention |
|---|---|---|
| Pharmacist Intervention (P = 0.068) | 0.065176909 | 0.048012003 |
| E-learning Intervention (P = 0.951) | 0.06025825 | 0.059583632 |
| Control (P < 0.01) | 0.043532859 | 0.059906171 |

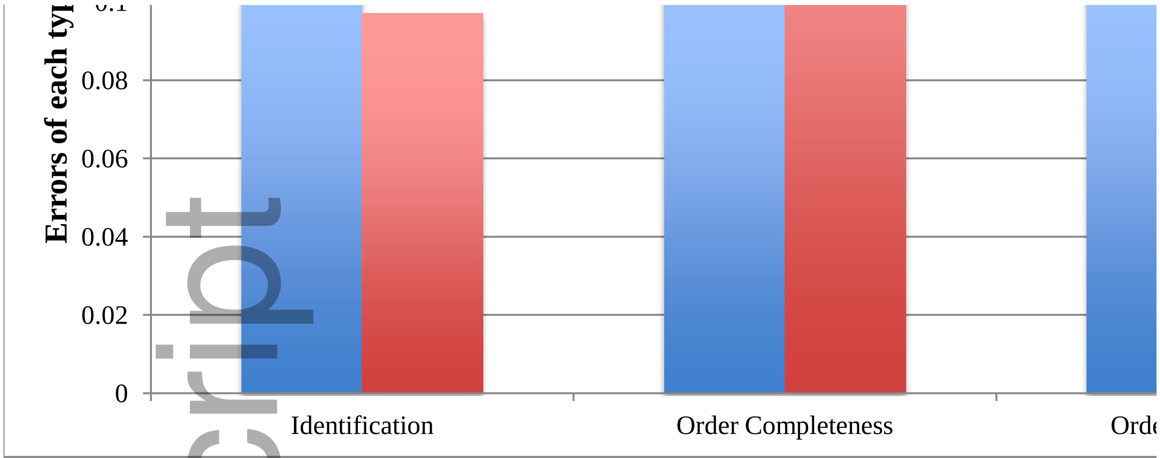


| | | Pre-Intervention |
|---|---|---|
| **Control** | Identification | 0.107576392 |
| | Order Completeness | 0.102971955 |
| | Order Correctness | 0.106320636 |
| | Chart completeness | 0.169945584 |
| | Order appropriateness | 0.003348681 |
| **E-learning** | Identification | 0.143472023 |
| | Order Completeness | 0.12482066 |
| | Order Correctness | 0.139167862 |
| | Chart completeness | 0.170731707 |
| | Order appropriateness | 0.004304161 |
| **Pharmacy Education** | Identification | 0.121042831 |
| | Order Completeness | 0.155493482 |
| | Order Correctness | 0.140595903 |
| | Chart Completeness | 0.15735568 |
| | Order Appropriateness | 0.003724395 |

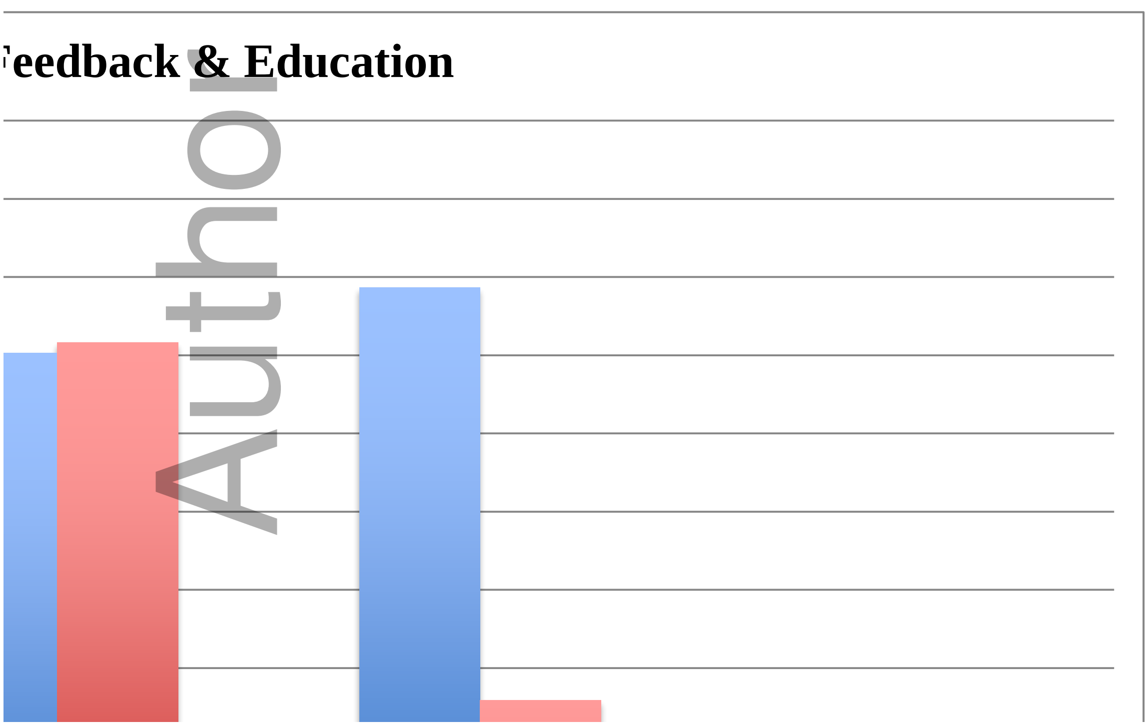


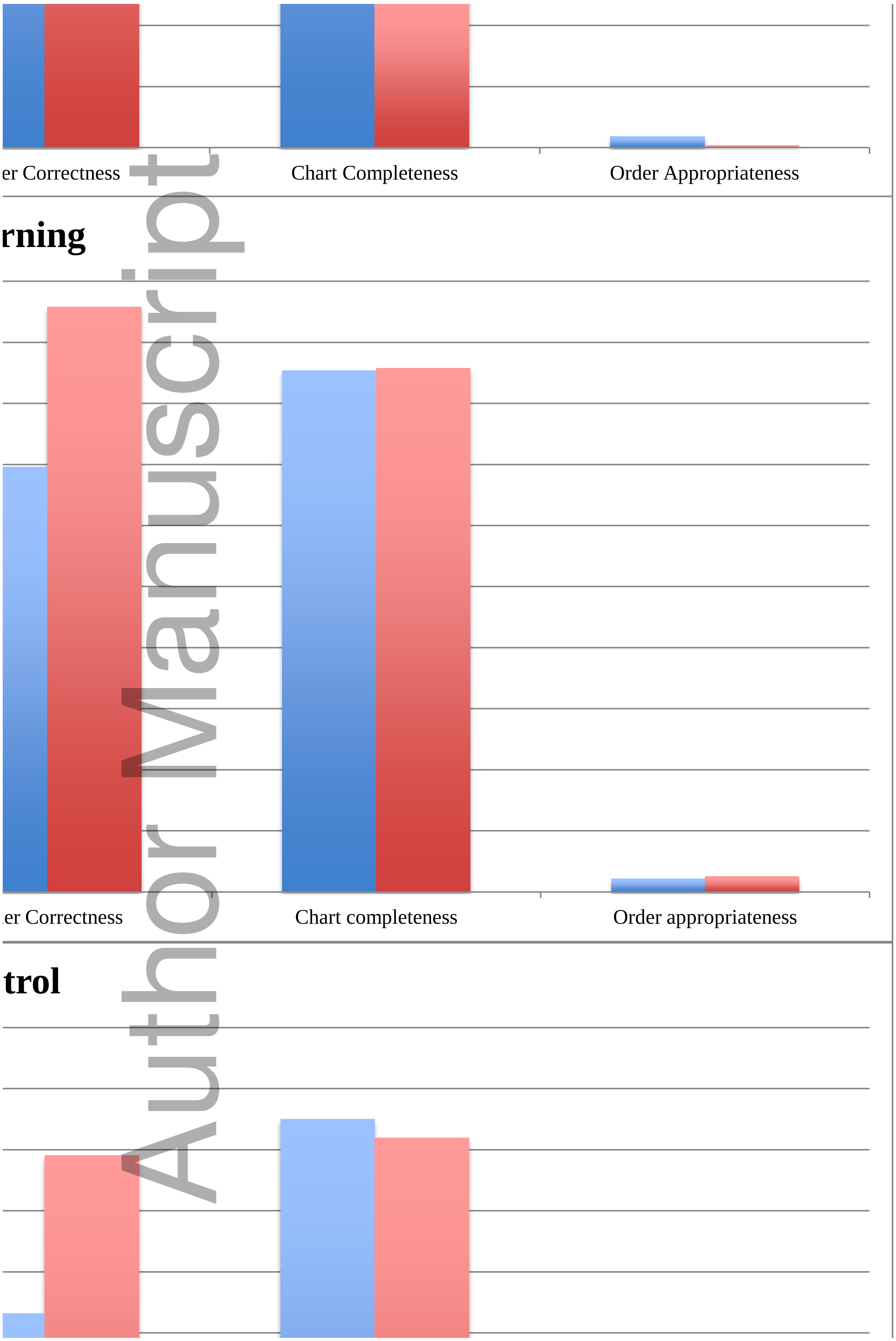


0.04
0.02
0
Identification
Order Completeness
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Errors of each type per total orders
Identification
Order Completeness
0.2
0.18
0.16
0.14
0.12
0.1


Errors of each ty
0.08
0.06
0.04
0.02
0
Identification
Order Completeness

| Post-Intervention |
| --- |
| 0.097076868 |
| 0.164922411 |
| 0.15806568 |
| 0.163839769 |
| 0.004330567 |
| 0.11844939 |
| 0.146446518 |
| 0.191672649 |
| 0.171572146 |
| 0.005025126 |
| 0.071267817 |
| 0.102775694 |
| 0.143285822 |
| 0.051762941 |
| 0.000750188 |




er Correctness
Chart Completeness
Order Appropriateness
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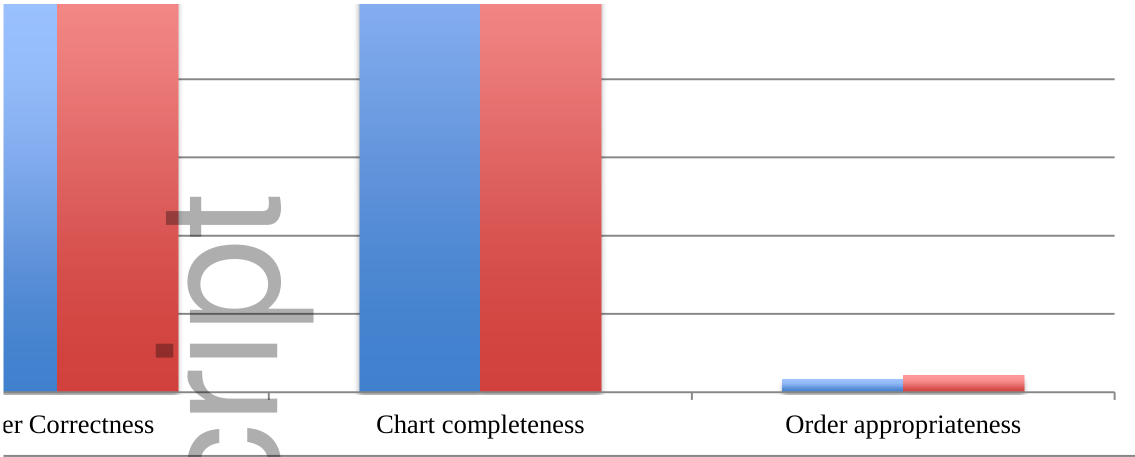
er Correctness
Chart completeness
Order appropriateness
trol


er Correctness
Chart completeness
Order appropriateness