

# Impact of Electronic Prescribing System on Prescribing Error Rate at Patients' Transition of Care: An Interventional Study

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## ABSTRACT

**Objective:** To estimate the prevalence of prescribing errors before and after implementing electronic discharge prescription system in the wards of General Surgery in a tertiary care hospital in India. **Methodology:** Patients discharged from General Surgery wards with a prescription containing at least one drug were selected. Discharge prescriptions were collected before and after implementing the electronic prescribing system. Patients' demographic details like age, gender, diagnosis and number days of hospital stay were recorded in the specially designed case record form. Discharge orders were scanned to evaluate the prescribing errors in these orders. **Results:** A total of 1045 handwritten and 1152 electronic discharge summaries were collected, of which 76.7% and 76.2% were of <60 years aged patients, 64.3% and 63.5% of male gender respectively in both the groups. Average number of drugs prescribed per prescription was 3.5 and 4.1 before and after intervention; error rate was 33% and 8.4% of drugs prescribed respectively, 46.3% of prescriptions were of illegible handwriting. The intervention of an electronic prescribing system has reduced 75% of prescribing errors. Handwritten prescriptions had 5.5 higher odds

of having prescribing errors (OR 5.5, 95% CI 4.6-6.1). **Conclusion:** The electronic prescribing system has a high impact in reducing prescribing errors in discharge prescriptions. Handwritten prescriptions had 5.5-times odds of higher risk for prescribing errors. Increase in age, number of drugs prescribed and length of hospital stay were major predictors of prescribing errors.

**Key words:** Prescribing errors, Adverse drug events, Discharge orders, Medication safety, E-prescribing.

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## INTRODUCTION

Medication errors (MEs) may occur at any stage of medication use process,<sup>1</sup> either in hospital or after the discharge which can lead to preventable adverse drug events.<sup>2</sup> MEs during discharge are responsible for one-third of the adverse drug events.<sup>3</sup> Half of the patients had one or more clinically important MEs after discharge from hospital,<sup>4</sup> and these were not reduced by patients health literacy or pharmacist intervention.<sup>5</sup> Patients with complex drug therapy are at high risk for MEs and drug related problems.<sup>6</sup> The best way to reduce the MEs is implementing the computerized provider order entry with clinical decision support system.<sup>7</sup>

MEs during patient discharge can cause harm; this is mainly due to handwritten discharge orders, and usually these will be prepared by the junior doctors.<sup>8,9</sup> Traditionally, discharge summaries are prepared handwritten, but as information systems have developed nowadays, these are prepared in structured electronic discharge summaries.<sup>10</sup> Electronic systems or health information systems reduces the MEs in patients admitted to hospital.<sup>11,12</sup> Post-discharge MEs may occur due to miscommunication between the patient and clinician.<sup>13</sup>

Discharge summaries contain patients' demographic details, diagnosis for admission, treatment during hospital stay, results of laboratory investigations, medication during patient discharge and advice on follow-up.<sup>14</sup> 23% -49% of medical errors occur after discharge of patients from the wards, of which up to 72% were due to MEs. One in five patients experiences adverse events after the discharge from hospital to home.<sup>15</sup> Medication discrepancies found in 56.9% of discharge orders increased cost for medical treatment and re-hospitalization.<sup>16</sup> Medication safety issues can arise due to mistakes and errors in the discharge orders; some

discharge summaries may not have medication to be continued after discharge.<sup>17</sup>

During the patients' in hospital stay there is increased likelihood to prevent errors at any stage of medication use process, i.e. prescribing, transcribing, dispensing and drug administration. Error occurrences during the patients' transition either to home or other hospital setting has a high chance to harm the patient. During the hospital stay, various health professionals will be monitoring the patient so that errors can be detected and prevented but there is less chance to detect errors during the discharge of the patient from the hospital. So it is necessary to evaluate the types and frequency of prescribing errors (PEs) and find possible predictors responsible for errors in discharge prescriptions.

Most of the studies carried out to find MEs are in in-patients and ambulatory patients,<sup>18</sup> but studies were scarce on the evaluation of PEs in discharge orders and impact of an electronic system in reducing PEs in discharge prescriptions. In India, there were no studies on evaluation of the impact of information technology in reducing PEs at the time of patients' transition. In our setting, the impact of an electronic system in reducing PEs in discharge orders were not evaluated earlier, so this study was undertaken to evaluate the baseline PEs and effect of the information system in reducing PEs.

In our study setting, electronic discharge summaries were introduced with the aim to improve the patient safety in the hospital. The patient safety benefits include reducing MEs. With this background, we framed an objective to find the prevalence of PEs before and after implementing electronic discharge order system in the General Surgery wards of a tertiary care hospital in India.

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## METHODS

The study is an interventional and comparative study; it was carried out in the General Surgery wards of a tertiary care hospital in India. Research protocol was approved by the Institute Scientific and Ethics committees before starting the research work. Waiver of consent was obtained for this study from the ethics committee for taking discharge summaries from the study participants' case records. Medical superintendent permission was sought for collecting discharge summaries from the wards. Patients were selected using convenient sampling method from the General Surgery wards. Wards had conventional handwritten prescriptions during their stay, and handwritten discharge summaries were given to the patients while discharging from hospital. The study was carried out from June 2014 to March 2016. During the initial one year of the study period, most of the discharge orders were handwritten. Later on, electronic system for producing electronic discharge summaries was introduced. In the study wards, all doctors had not switched to electronic system at single point of time; it took some time for all to shift to an electronic system. Hospital authorities introduced in-house developed electronic discharge (e-discharge) summaries which had patients' history, diagnosis for admission, treatment, and procedures carried out during hospital admission and discharge orders which are to be continued after patient discharge from the hospital. In the wards, not all patients were given electronic discharge summaries as handwritten summaries were still continued for some. Handwritten discharge summaries were collected before implementing the electronic system. After few months of implementation of the electronic system, e-discharge summaries were collected.

Conveniently selected patients discharge summaries either handwritten or electronic were taken from the patients' file, scanned and kept for the analysis. An inclusion criterion was patients discharged from the wards with age more than 14 years and prescribed with one or more drugs at the time of discharge. Study participants' demographic details like Patients age, gender, diagnosis and number of drugs prescribed were recorded in specially designed case record form (CRF) and those were analyzed for PEs.

Electronic discharge summaries have tabular column for prescribing medicines at discharge, where it has separate space for drug name, strength, route of administration and duration of therapy. It was different from the handwritten discharge summary where it only had a plain space to write orders. Due to the tabular column, there is very less chance for the omission of prescribing information.

In our study, drug advice written in discharge summary was considered as discharge prescription and number of drugs prescribed per prescription was considered as number of orders for analysis of PE rate. PE rate was calculated as frequency. Components of the prescriptions considered for error evaluation were dosage form, drug name, dose of the medicine, route of administrations for parenteral drugs, the frequency of drug administration and duration of therapy.

### Omission error

Considered as an error if any component of the prescription was missing

### Wrong

Any component of the prescription was written wrong

Predictors were analyzed for PEs, like a number of drugs, the length of hospital stay and age of the patients.

In this electronic system, clinicians have to type the prescribed drugs manually and this is different from the automated electronic prescribing system. Automated computerized provider order entry will have the drop down menu of available drugs with dose, dosage form and frequency of administration. Our electronic order entry system did not have any

automated drug information or clinical decision support system. Errors per number of drugs prescribed were taken for calculating the incidence of PE rate and an average number of PEs per prescription was calculated.

## Statistical analysis

Patients age was expressed as mean $\pm$ SD, the number of days of hospital stay expressed as median (IQR). Error rate was given as percentage. An impact of electronic prescribing system on incidence of PEs was checked using chi-square test. Association of PEs with various predictors was done using Pearson correlation analysis. Descriptive statistics done using Microsoft Excel 2010, Chi-square test and Pearson correlation were done using SPSS v20 (SPSS, Inc., Chicago IL, USA).

## RESULTS

A total of 1045 handwritten and 1152 electronic discharge summaries were collected for this study. The majority (76.7% and 76.2%) of the patients belonged to the age group of <60 years and male gender in both the groups. Demographic details of the patients are given in Table 1. An average number of drugs prescribed per prescription were 3.5 and 4.1 in handwritten and electronic respectively (Table 2). The median length of hospital stay in both the groups was 6(IQR3-10) in hand written orders and 7(IQR4-12) in electronic orders. In handwritten 36% of prescriptions and 33.3% of drugs ordered; in electronic 11% of prescriptions and 8.4% drugs ordered had PEs.

Most of the errors were due to the omission of units and duration of therapy to be continued after discharge of patients. Types and frequency of prescribing errors are shown in Table 3. In discharge prescription, the duration of therapy is a vital information to be mentioned but it was not done so in 26.2% and 4.2% of handwritten and electronic prescriptions respectively. Duration of drug administration was mentioned in pharmacy slip, but after dispensing the medications pharmacy slip was retained in pharmacy itself. Patients will only have the discharge summary for their reference or to show a primary care physician. 46.3% (484/1045) prescriptions had one or more drugs illegible (35.9% of prescribed drugs were illegible) in handwritten prescriptions.

Implementation of an electronic prescribing system, reduced PE rate by 75% when compared to handwritten prescriptions and handwritten prescriptions were at higher risk for PEs at  $p < 0.001$  OR 5.5 (95% CI 4.6- 6.1). In electronic prescriptions 11.1% (129) prescriptions had PE with a total of 400 errors at a range from 1-10 per prescription and in handwritten prescriptions 36% (377) of prescriptions had PE with a total of 1241 PE in the range of 1-11 per prescription. Average number of PEs in handwritten prescriptions was 1.1 and in electronic prescription it was 0.3 per prescription. Association of prescribing errors with predictors are given in Table 4.

## DISCUSSION

In our study, the implementation of an electronic system eradicated the illegibility problem of prescriptions and reduced the prevalence of PEs. The majority of the errors were due to the omission of the duration of therapy, in handwritten it was 78.8%, followed by units for drug dose (13%). Similarly in electronic orders 50.4% of PEs were due to the omission of the duration of therapy, 21.3% omission of units and 19.4% omission of the route of parenteral drug administrations. In omission of the route of administration, the majority were associated with insulin. Our study has found (75%) a significant reduction in the PEs in electronic discharge orders compared to handwritten orders. This is similar to another study where they had compared handwritten and electronic prescriptions in the wards and shown to have a significant reduction of PEs by implementing the electronic prescribing method.<sup>19</sup> A meta-analysis

**Table 1: Demographic details of patients with handwritten and electronic discharge prescriptions (Original)**

| Age (Years) | Handwritten prescriptions |            |             | Electronic prescriptions |            |             |
|-------------|---------------------------|------------|-------------|--------------------------|------------|-------------|
|             | No. of Patients (n)       | Number (%) | Age Mean±SD | No. of patients (n)      | Number     | Age Mean±SD |
| <60         | Total                     | 802 (76.7) | 38.8±12.3   | Total                    | 874 (76.2) | 40.0±12.0   |
| ≥60         | (1045)                    | 243 (23.2) | 66.2±5.7    | (1152)                   | 278 (24.1) | 66.7±6.2    |
| <60         | Female                    | 291 (27.8) | 39.2±11.9   | Female                   | 334 (28.9) | 40.5±11.8   |
| ≥60         | (373)                     | 82 (7.8)   | 65.9±5.3    | (420)                    | 86 (7.4)   | 65.6±5.8    |
| <60         | Male (672)                | 511 (48.8) | 36.6±12.5   | Male                     | 540 (46.8) | 39.7±12.1   |
| ≥60         |                           | 161 (15.4) | 66.3±5.9    | (732)                    | 192 (16.6) | 67.2±6.3    |

**Table 2: Number of discharge prescriptions observed (Original)**

|        | Handwritten prescriptions |                                |       | Electronic prescriptions       |                                |       |
|--------|---------------------------|--------------------------------|-------|--------------------------------|--------------------------------|-------|
|        | Number of drugs ordered   | Drugs per prescription Mean±SD | Range | Number of drugs ordered (4763) | Drugs per prescription Mean±SD | Range |
| Female | 1301                      | 3.4±1.8                        | 1-12  | 1718                           | 4.1±2.1                        | 1-12  |
| Male   | 2425                      | 3.6±1.8                        | 1-14  | 3045                           | 4.1±2.3                        | 1-15  |
| Total  | 3726                      | 3.5±1.8                        | 1-14  | 4763                           | 4.1±2.2                        | 1-15  |

**Table 3: Types and frequency of prescribing errors in discharge prescriptions (Original)**

| Variable                            | Handwritten prescriptions (%) | Electronic prescriptions (%) |
|-------------------------------------|-------------------------------|------------------------------|
| Number of drugs prescribed          | 3726                          | 4763                         |
| Total number of errors              | 1241 (33.3)                   | 400 (8.3) *                  |
| Omission of strength                | 34 (2.7)                      | 11 (2.7)                     |
| Omission of units                   | 162 (13.0)                    | 86 (21.3)                    |
| Omission of route of administration | 40 (3.2)                      | 78 (19.4)                    |
| Omission of frequency               | 15 (1.2)                      | 2 (0.4)                      |
| Omission of duration                | 978 (78.8)                    | 203 (50.4)                   |
| Omission of dosage form             | 2 (0.1)                       | 3 (0.7)                      |
| Wrong strength                      | 8 (0.6)                       | 18 (4.4)                     |
| Wrong units                         | 1 (0.08)                      | 1 (0.2)                      |
| Wrong dosage form                   | 1 (0.08)                      | 0                            |

\*P value, OR (95% CI) P<0.001, 5.5 (4.6-6.1); P value calculated by Chi-square test SPSS V20.

**Table 4: Association of prescribing errors with predictors (Original)**

| Predictors of prescribing errors   | Handwritten prescriptions     |         | Electronic prescriptions      |         |
|------------------------------------|-------------------------------|---------|-------------------------------|---------|
|                                    | Pearson correlation value (r) | P value | Pearson correlation value (r) | P value |
| Age vs. PEs                        | 0.04                          | 0.17    | 0.06                          | 0.02    |
| Number of drugs vs. PEs            | 0.2                           | <0.001  | 0.2                           | <0.001  |
| Length of stay vs. PEs             | 0.1                           | <0.001  | 0.1                           | <0.001  |
| Age vs. number of drugs prescribed | 0.09                          | <0.001  | 0.2                           | <0.001  |

had shown that reduction in 12.5% of prevalence of PEs due to the adoption of the electronic prescribing system in in-patients.<sup>11</sup> The electronic system reduced the duration of therapy errors and omission of units, but the omission of the route of administration errors increased in the electronic prescriptions. Our study has shown 75% reduction of PE rate after implementing the electronic system which is higher than other studies.<sup>20</sup> Our study results are similar to another study, where they reported a reduction in 86% of error rate after implementing the electronic system in inpatient service.<sup>21</sup> Electronic prescribing had shown 92% reduction in PE rate and 17.5% decrease in administration error rate in in-patients.<sup>22</sup>

Handwritten orders had five times higher risk for errors in comparison to electronic discharge orders (p<0.001, OR 5.5 (95% CI 4.6-6.1)).

The lowest frequency of PEs reported in the discharge prescriptions were 20%, 17% and 6.3%,<sup>10,23-25</sup> which are lower than our study reported (33.3%). Our study results are different from Callen *et al.* where they reported that electronic discharge summaries have no impact on reducing MEs, according to them handwritten and electronic summaries have a similar rate of PEs which are contrary to our study as we have reported a reduction in incidence of PEs by using the electronic system.<sup>8</sup> Similarities found in both the studies were that most of the errors were due to omissions in prescriptions.

Due to the predesigned format for the prescribing orders in discharge summaries, it led to decrease in the omission errors. Most of the errors in electronic orders were due to the omission of the route of administration for anti-diabetic injections, i.e., insulin. Most of the time, clinicians assume that patients are already on insulin, so they are aware of the route of administration. It is essential to mention the route of administration for all parenteral drugs. In electronic system, there is no alarm mechanism if any column is missed, so there is still a chance for the omission of any one part of the prescription. The electronic system has shown significant reduction of PEs. This is similar to other studies where they have reported in inpatients and ambulatory patients. In our study, omission of the duration of therapy and route of administration were seen in higher percentage. When compared with another study among in-patients it was observed that omission of route of administration error rate was high.<sup>22</sup>

Electronic system was also studied in reducing reconcilable errors in Surgery patients, which had shown decrease in unintended medication use.<sup>26</sup> Clinical decision support system also help in reducing errors similar to electronic prescribing system. It notifies wherever it finds the omission of a specific group of drugs for a particular disease in a patient, if any allergies are recorded and also if contraindicating drugs are prescribed.<sup>12</sup> Smart electronic discharge summary system also reminds the clinician to prescribe if any drug is omitted.

Number of drugs and length of hospital stay were the major predictors for PEs.<sup>27</sup> Age was a significant predictor for PEs in electronic prescriptions but not in the handwritten prescriptions. This is similar to another study where they have also reported that age and number of drugs are major contributor factors for errors.<sup>28</sup> Error rate may increase with age, multiple co-morbid conditions and when prescribed with multiple drugs. The increase in the number of drugs has high chance of increase in PE rate.

Pearson correlation had shown that PEs were positively correlated, with an increase in the number of drugs per prescription. This is similar to the study where they reported polypharmacy is a major contributor for MEs.<sup>29</sup> Increased length of stay and age of the patients also positively correlated with incidence of PEs. Number of drugs per prescription increased with age, it may be due to the fact that as age progress, number of co-morbid conditions also increases.

## CONCLUSION

This study mainly highlights the importance and impact of an electronic system in reducing the PEs in discharge prescriptions. Our study had demonstrated 75% reduction in PE rate after implementing the electronic discharge prescribing system which is very important for patient safety. Our study suggests, an electronic system is a better tool to reduce PEs and improve the quality of medication management. Electronic system prevented illegibility of prescriptions. Patients with increase in age, prescribed with multiple drugs and longer length of hospital stay were at more risk of PEs.

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## CONFLICTS OF INTEREST

Nil

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Nil

## ABBREVIATION USED

ME: Medication error; PE: Prescribing error.

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