# Ethnographic study of incidence and severity of intravenous drug errors

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## Abstract

**Objectives** To determine the incidence and clinical importance of errors in the preparation and administration of intravenous drugs and the stages of the process in which errors occur.
**Design** Prospective ethnographic study using disguised observation.
**Participants** Nurses who prepared and administered intravenous drugs.
**Setting** 10 wards in a teaching and non-teaching hospital in the United Kingdom.
**Main outcome measures** Number, type, and clinical importance of errors.
**Results** 249 errors were identified. At least one error occurred in 212 out of 430 intravenous drug doses (49%, 95% confidence interval 45% to 54%). Three doses (1%) had potentially severe errors, 126 (29%) potentially moderate errors, and 83 (19%) potentially minor errors. Most errors occurred when giving bolus doses or making up drugs that required multiple step preparation.
**Conclusions** The rate of intravenous drug errors was high. Although most errors would cause only short term adverse effects, a few could have been serious. A combination of reducing the amount of preparation on the ward, training, and technology to administer slow bolus doses would probably have the greatest effect on error rates.


## Introduction

Intravenous therapy is a complex healthcare technology. In the United Kingdom, as in most other European countries, nurses generally prepare and administer intravenous drugs prescribed by doctors. Administration of intravenous therapy is associated with considerable risk—for example, patients have died when cytotoxic drugs have been given intrathecally instead of intravenously.[1] The UK Department of Health has made this particular type of error one of its prime targets in increasing patient safety.[2] Similar initiatives have been proposed in the United States.[3]

Little prospective research has been done into the incidence, causes, and severity of intravenous drug errors. Single site studies carried out on one or two wards have reported errors in preparing and administering intravenous drugs of 13%-84%,[4–7] but the studies used different definitions and did not assess the severity of errors. Epidemiological studies using retrospective record review have shown that adverse drug events are common but have not provided detailed analysis of the type of errors.[8–11] We therefore conducted an ethnographic prospective study using defined measures to determine the incidence of errors in preparing and administering intravenous drugs, to identify the stages in the process in which errors occur, and to evaluate their clinical importance.


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## Participants and methods

We used a purposive sampling strategy to select study hospitals and study wards, with the aim of exploring the preparation and administration of intravenous drugs in a range of settings. We selected a university teaching hospital and a non-teaching general hospital of similar size (about 20 wards and 400 beds). We did a pilot study to determine the frequency of use of intravenous drugs on each ward and then selected a total of 10 wards with high, medium, and low usage.

Both hospitals operated a typical British ward pharmacy service. Doctors recorded prescriptions on formatted inpatient drug charts, and nurses used the charts to determine the doses due and record the administration of drugs. Ward pharmacists ordered drugs that were not stored on the ward and reviewed the appropriateness of prescribed drugs every weekday. Nurses usually prepared and administered intravenous drugs on the wards, but cytotoxic drugs were prepared centrally by the pharmacy department. Nurses had to attend a one day training course before they were allowed to give intravenous drugs. A guide to preparation and administration of intravenous drugs was available on each ward.

### Identification of errors

We defined an intravenous drug error as a deviation in preparation or administration of a drug from a doctor's prescription, the hospital's intravenous policy, or the manufacturer's instructions. The clinical appropriateness of the prescription was not assessed. All errors had to have the potential to adversely affect the patient, so deviations from hospital procedures, such as not checking name bands or not labelling infusions, were not considered as errors if the correct drug was given to the patient. Deviations from prescribed administration time were not considered errors. We excluded errors if they were corrected by a member of

staff or the patient before administration. Errors were related to particular actions; multiple errors could occur in each case of preparation and administration.

We chose a prospective ethnographic research method to collect data. A trained and experienced observer (KT) accompanied nurses during intravenous drug rounds. She recorded the preparation and administration of each drug on a standard form. Information came from observation and talking informally to staff. The researcher intervened in a discreet and non-judgmental manner when she became aware of a potentially serious error; these incidents were still included as an error. Ward staff were told that we were investigating common problems of preparing and administering intravenous drugs; this disguised observation method has been shown to be valid.[12] The researcher avoided the word error to prevent the study from appearing threatening to staff. Each nurse gave permission for observation.

Data were collected on 6-10 consecutive days on each ward between June 1999 and December 1999. To be representative, the study included weekends and all times of drug rounds on each ward. The researcher attended two to three drug rounds out of the four that took place each day.

### Importance of errors

We used a validated scale to assess the clinical importance of intravenous drug errors.[13] Briefly, four experienced healthcare professionals (one doctor, one nurse, and two pharmacists) scored the potential clinical importance of each drug error on a visual analogue scale between zero (labelled as no harm) and 10 (death). The mean score was calculated for each drug error. Mean scores below 3 suggested a minor outcome, scores of 3-7 a moderate outcome, and scores above 7 a severe outcome.

### Analysis of data

The data on the incidence of intravenous drug errors is expressed in two ways: errors per dose and errors per process stage (boxes 1 and 2). KT classified the errors and NB checked them. We calculated proportions and 95% confidence intervals using standard methods.[14]

## Results

A total of 113 nurses and one doctor were observed over 76 days (table 1). Table 2 shows the number of observations on each ward. All the nurses agreed to participate. On three occasions ward managers asked the researcher not to observe a particular drug round as the general workload on the ward was high. Altogether 1042 doses of intravenous drugs, representing 35 different drugs, were prescribed for 106 patients during the study. Our observations were representative for the study period: 41% (430) of all intravenous drug doses prescribed were observed; administrations of 91% (32) of the prescribed drugs was observed at least once; and 92% (98) of patients who were prescribed regular intravenous drugs were observed at least once. The researcher intervened in 12 cases to prevent an error reaching the patient.

One or more errors occurred in the preparation and administration of 212 out of 430 intravenous drug doses (error rate 49%, 95% confidence interval 45% to

**Box 1: Classification of intravenous drug errors according to stage of occurrence (categories are mutually exclusive)**

**Preparation stage**
Identification of prescription
Preparation process:
- Ready for administration
- One step preparation, eg measuring a drug solution
- Multiple step preparations, eg measuring and diluting a drug solution, reconstitution of a drug

**Administration stage**
Identification of the patient
Administration process:
- Bolus dose injection, usually 3 to 5 min
- Intermittent infusion
- Continuous infusion

**Box 2: Classification of type of intravenous drug errors (categories are mutually exclusive)**

**Preparation errors**
Preparation of wrong drug
Preparation of an unauthorised drug
Errors in solvent/diluent (use of wrong solvent/diluent or wrong volume)
Preparation of wrong dose
Omission of prescribed drug
Other

**Administration errors**
Administration to wrong patient
Fast administration of bolus dose through a peripheral line
Fast administration of bolus dose through a central line
Incompatibility errors
Other

**Table 1** Position of staff included in the study

| Staff grade | No of observations |
|---|---|
| Staff nurse | 280 |
| Ward manager/sister | 73 |
| Bank/agency nurse | 62 |
| Student nurse | 11 |
| Doctor | 4 |
| Total | 430 |

**Table 2** Number of observations by type of ward

| Type of ward | No of observations |
|---|---|
| University teaching hospital: | |
| General medical ward | 41 |
| Renal ward | 41 |
| Cardiothoracic surgical ward | 42 |
| Coronary intensive care unit | 67 |
| Neonatal ward | 29 |
| Oncology ward | 33 |
| Non-teaching hospital*: | |
| General surgical ward | 64 |
| General medical ward | 58 |
| Intensive care unit | 39 |
| Paediatric ward | 16 |
| Total | 430 |

*Former district general hospital.

54%). A total of 249 errors were identified. Preparation errors occurred in 32 intravenous doses (7%), administration errors in 155 doses (36%), and both types of error in 25 doses (6%). Errors were potentially severe in three doses (1%), potentially moderate in 126 (29%), and potentially minor in 83 (19%). Box 3 describes the three severe errors and typical examples of moderate and minor errors.

The figure shows the incidence of errors at each stage of drug preparation and administration. Most preparation errors were associated with multiple step preparations—for example, drugs that required reconstitution with a solvent and addition of a diluent. Typical errors were preparing the wrong dose or selecting the wrong solvent. All three severe errors occurred at this stage. A few errors occurred in identifying prescriptions—for example, not seeing a drug order. Most errors occurred when giving bolus doses, with errors in 172/235 (73%) doses. In most of these cases (163, 95%) the dose was given faster than recommended, which is usually three to five minutes; more than half of these errors (85, 52%) were considered to be of potential moderate severity. Table 3 gives a more detailed analysis of the type and severity of the errors.

## Discussion

We found a high incidence of errors in the preparation and administration of intravenous drugs. Although most were unlikely to cause lasting harm, some were serious. The sample was taken from two types of hospital and included a range of patients, nurses, drugs, drug administration times, ward specialties, and frequency of drug administration on the ward. We have used explicit methods, definitions, and tools that we hope others can use elsewhere for research and audit.

Although the proportion of serious errors is small, the number of patients and intravenous doses in a hospital means that errors may be more common than expected. A point prevalence study we carried out in the university teaching hospital (400 beds) showed that about 112 (28%) of inpatients received intravenous drugs, resulting in more than 300 doses a day. Although we cannot extrapolate with any precision, our data suggest that at least one patient will experience a potentially serious intravenous drug error every day in a hospital of that size. Hence, intravenous drug errors are a potential source of serious harm for patients and risk reduction strategies should be developed accordingly.

### Reducing the risks

Our analysis shows that the two weak stages in the system are drugs that require multiple step preparation and administration of doses as a bolus. Several strategies could be used to reduce multiple step preparation errors. Centralised preparation of intravenous drugs by the pharmacy department was suggested in the 1970s in the United Kingdom but was rarely adopted.[15] Centralised preparation of intravenous drugs is common in the United States[16] but not in Europe, apart from in specialised areas such as oncology.[17] The evidence for centralised services is currently weak, and it is unclear whether they are cost effective or improve the quality of the service.[18–21] An alternative strategy would be to purchase ready prepared intravenous drugs from pharmaceutical companies.

The effect of the above changes would have to be assessed carefully. New types of errors could be

**Box 3: Examples of intravenous drug errors**

**Potentially severe errors**

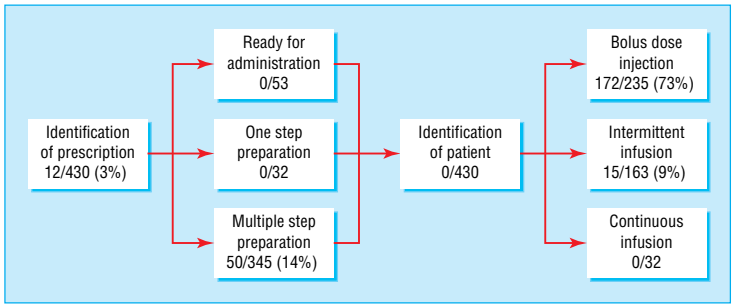
- The whole content of a vial containing 125 000 international units of heparin was prepared as a continuous infusion, resulting in a five times overdose (severity score 8.4; general medical ward, teaching hospital). *Comment*: Haemorrhage is one of the serious, potentially life threatening complication of an overdose of heparin.
- A nurse injected 750 mg vancomycin into an infusion bag of 0.9% sodium chloride (already connected to the patient's cannula) without mixing the solution. The patient is likely to have initially received a concentrated solution of vancomycin as a bolus (severity score 7.3; renal ward, teaching hospital). *Comment*: Rapid infusions of vancomycin carry the risk of reactions such as severe hypotension (including shock and cardiac arrest) and flushing of the upper body.
- A patient's continuous infusion of adrenaline (epinephrine) was interrupted for about 10 minutes as the new infusion had not been prepared in advance (severity score 7.5; intensive care unit, non-teaching hospital). *Comment*: This patient's blood pressure decreased to about 50/30 mm Hg. A bolus dose of adrenaline and midazolam was given to stabilise him until the adrenaline infusion was restarted.

**Potentially moderate errors**

- A nurse measured 0.2 mg metoclopramide using a 1 ml syringe and then drew up 0.9% sodium chloride into the same syringe. This was administered as a bolus dose. Using this preparation technique, the metoclopramide contained in the dead space of the syringe (hub and needle) was also administered to the patient, resulting in a two to three times overdose (severity score 7.0; neonatal ward, teaching hospital). *Comment*: Side effects include extrapyramidal effects, which are more likely in children. There are also reports of cardiac conduction abnormalities.
- A patient's lunchtime dose of 750 mg cefuroxime was omitted because of his transfer to another ward at lunchtime (severity score 4.1; cardiothoracic surgical ward, teaching hospital). *Comment*: Successful anti-infective therapy depends on achieving effective levels.
- Administration of 80 mg furosemide (frusemide) over 45 seconds through a peripheral vein (severity score 6.1; general surgical ward, non-teaching hospital). *Comment*: The recommended duration of administration was 20 min (4 mg/min). Tinnitus and deafness are among the side effects reported after rapid administration.

**Potentially minor errors**

- Preparation of 1.2 g co-amoxiclav using 10 ml instead of 20 ml water for injection (severity score 2.3; general surgical ward, non-teaching hospital). *Comment*: The drug may not dissolve completely when insufficient solvent is used. Concentrated solutions may also increase the risk of thrombophlebitis.
- Administration of 500 mg amoxycillin/10 ml of water by injection over 2.5 minutes rather than through a peripheral vein over 3-5 minutes (severity score 2.9; general medical ward, teaching hospital). *Comment*: More rapid administration may damage the blood vessels but is unlikely in this case.




Stages and errors in preparation and administration of intravenous drugs (numbers of errors/number of observations of each stage)

**Table 3** Type and clinical importance of errors in preparation and administration of intravenous drugs. Values are numbers (percentages) of errors in 430 observations

| Type of error* | Importance of error | | | Total |
|---|---|---|---|---|
| | Minor | Moderate | Severe | |
| Preparation errors: | | | | |
| Errors in solvent/diluent | 20 (5) | 16 (4) | 0 | 36 (8) |
| Wrong dose | 0 | 11 (3) | 1 (0.2) | 12 (3) |
| Omission | 0 | 12 (3) | 0 | 12 (3) |
| Other | 0 | 0 | 2 (0.5) | 2 (0.5) |
| Administration errors: | | | | |
| Fast bolus dose (peripheral line) | 64 (15) | 63 (15) | 0 | 127 (30) |
| Fast bolus dose (central line) | 14 (3) | 22 (5) | 0 | 36 (8) |
| Incompatibilities | 1 (0.2) | 11 (3) | 0 | 12 (3) |
| Other | 3 (7) | 9 (2) | 0 | 12 (3) |

*No errors were observed in the categories of preparing the wrong drug, using an unauthorised drug, or administration to the wrong patient.

introduced, such as transmission errors from the ward to the preparation department.[22] Furthermore, nurses who are no longer used to preparing intravenous drugs may make serious errors if they have to prepare drugs in an emergency.

Technical solutions could reduce the frequent errors from rapid bolus injections—for example, a pump that prevents fast administration of bolus doses. Staff training could improve awareness of drugs that have a high risk of adverse effects when given too fast. A warning could also be put on the drugs by the pharmacy.

### Validity of study

The effect of the observer on the observed is often discussed as a possible limitation of ethnographic observation methods.[23] The error rate may be even higher in the absence of the researcher. However, a previous observation based study using a similar method showed that the drug error rate is unlikely to be affected by the observer, even if the observer occasionally intervenes.[12] Modification of behaviour is minimal once the researcher is an accepted member of the group and part of the social context.[24] The researcher seemed to have been accepted in our study, and some initial activities by nurses, such as wearing gloves to make up the doses, were soon abandoned. Using an observation based approach allowed us to explore drugs errors that would not have been documented and therefore missed by studies relying on review of hospital records.[8 9 11]

### Conclusions

Our study shows that errors in the preparation and administration of intravenous drugs remain a concern in the United Kingdom, 25 years after the problem was first highlighted. Steps to ensure the correct administration of bolus doses and to reduce mistakes in making up drugs that require multiple step preparation will have the greatest effect on error rates.

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Contributors: KT and NB designed the study and wrote the paper. KT collected the data and was responsible for data analysis. KT and NB are guarantors.

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## What is already known on this topic

Errors in preparing and administering intravenous drugs can cause considerable harm to patients

Reduction of drug errors is a government health target in the United Kingdom and the United States

## What this study adds

Errors occurred in about half of the intravenous drug doses observed

Errors were potentially harmful in about a third of cases

The most common errors were giving bolus doses too quickly and mistakes in preparing drugs that required multiple steps

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