Drug errors continue to exact a high cost in modern medical practice in terms of both human suffering and additional costs of healthcare. Drug-related errors cause an estimated 7000 deaths per year in the USA.1 Also in the USA, it has been estimated that adverse drug events cost a single teaching hospital $5.6 million of which $2.8 million was preventable.2 As a speciality, the preparation and administration of drugs is a core clinical activity. Also many of our patients are prescribed a substantial number of concurrent medications for coexisting disease. This topic is therefore of great relevance to anaesthetists. This article will begin with an overview of the incidence and nature of drug error, will then examine the underlying causes from a psychological perspective, and will conclude by examining some possible methods of reducing or even avoiding medication error.

The National Coordinating Council for Medication Errors Reporting and Prevention3 defines a medication error as any preventable event that may cause or lead to inappropriate medication use or patient harm, while the medication is in the control of the health-care professional, patient, or consumer. Such events may be related to professional practice, health-care products, procedures, and systems, including prescribing, order communication, product labelling, packaging and nomenclature, compounding, dispensing, distribution, administration, and education and use.

Although this definition is quite unwieldy, it emphasizes the many stages involved in the preparation and use of drugs and the number of places at which errors may occur. A more workable definition is from the Institute of Medicine,4 which defines an adverse drug event as an injury caused by medical management rather than the underlying condition of the patient. The distinction is, of course, not always clear. An adverse drug event may be caused by an adverse drug reaction. This is defined5 as a response to a drug that is noxious and unintended and occurs at doses normally used in man for the prophylaxis, diagnosis, and therapy of disease or for the modification of physiological function. The following six categories were described.6

(i) Augmented (dose-related)—an abnormal pharmacodynamic response to a drug, for example, sensitivity to an opioid drug resulting in respiratory depression.
(ii) Bizarre (non-dose-related)—anaphylactic or anaphylactoid reactions.
(iii) Chronic (dose-related and time-related)—due to prolonged exposure to a drug, for example, renal failure secondary to methoxyflurane.
(iv) Delayed (time-related)—teratogenesis seen with thalidomide.
(v) End of use (withdrawal)—suppression of the hypothalamic–pituitary–adrenal axis after prolonged steroid therapy.
(vi) Failure (unexpected failure of a therapy)—awareness under general anaesthesia.

An adverse drug event may also be caused by a medication error, which is defined as the failure of a planned action to be completed as intended or the use of a wrong plan to achieve an aim.

Summary. Medication errors are common throughout healthcare and result in significant human and financial cost. Prospective studies suggest that the error rate in anaesthesia is around one error in every 133 anaesthetics. There are several categories of medication error ranging from slips and lapses to fixation errors and deliberate violations. Violations may be more likely in organizations with a tendency to blame front-line workers, a tendency to deny the existence of latent conditions, and a blinkered pursuit of productivity indicators. In these organizations, borderline-tolerated conditions of use may occur which blur the distinction between safe and unsafe practice. Latent conditions will also make the error at the ‘sharp end’ more likely to result in actual patient harm.

Several complementary strategies are proposed which may result in fewer medication errors. At the organizational level, developing a safety culture and promoting robust error reporting systems is key. The individual anaesthetist can play a part in this, setting an example to other members of the team in vigilance for errors, creating a safety climate with psychological safety, and reporting and learning from errors.

Key points
• Drug errors in anaesthesia are common but resulting serious adverse outcomes are rare.
• Active errors and latent conditions in combination are more likely to result in patient harm.
• Incident reporting systems can help to identify latent conditions.
• Consultants, as individuals, have considerable capacity to modify local practice.

Keywords: attitude of health personnel; medical errors; medication errors/prevention and control; medication errors/psychology; risk management/standards

References
Studies of drug errors usually take one of two approaches. The first approach is to review critical incident reports. The second approach is to carry out a prospective study. The first approach has the advantage of identifying serious conditions because these are more likely to be reported in such systems. However, these studies only supply a numerator; the size of the denominator is unknown and, as under-reporting is more likely to occur, these reports cannot give accurate rates of errors. The second approach is intended to provide both a numerator and a denominator because the number of patients or treatments or medication orders had been documented as part of the study. The number of errors or adverse drug reactions can then be identified and an accurate rate was reported. The disadvantage of this type of study is the relatively small population studied because of the associated costs. A study with smaller numbers may not identify the more severe types of reactions but it will give a more accurate account of the rate of error. Both types of study have something to contribute to our understanding of the nature and incidence of adverse drug events.

**Studies of general medical errors**

A large study of the latter kind was reported towards the end of 2009. Errors—Questioning Undergraduate Impact on Prescribing study (EQUIP) was commissioned by the General Medical Council (GMC) but has not yet appeared in a peer-reviewed journal. The study reviewed 124,260 prescriptions in 19 hospitals in North-west England entered over a 7 day period. In addition to this quantitative aspect, interviews were also carried out with doctors to explore some of the underlying reasons behind medication errors. This triangulation process using a combination of qualitative and quantitative methodologies has yielded some very interesting data.

An overall rate of 8.9 errors per 100 medication orders was seen. This varied from 5.9 errors per 100 medication orders for consultants to 10.3 per 100 medication orders for Foundation year 2 doctors. About 1.7% of errors were potentially lethal but were detected and corrected by a combination of other doctors, nurses, and clinical pharmacists.

Matching the drugs associated with errors against the categories in the British National Formulary (BNF) showed that the top five were:

1. Analgesics 9.7%.
2. Antibacterial drugs 6.2%.
3. Bronchodilators 5.7%.
4. Anti-anginal drugs 5.3%.
5. Corticosteroids 5.9%.

General anaesthetics were associated with 0.2%; however, category 15.1 in the BNF also contains benzodiazepine drugs and flumazenil.

When the types of error were analysed, the key findings were:

1. Omission on admission to hospital 29.8%.
2. Under dosage 11.1%.
3. Overdose 8.5%.
4. Significant allergy 0.3%.

The high rate of omission of drugs on admission to hospital could have significance for patients in the perioperative period. The relatively high position on the list of anti-anginal drugs, which may also include some antihypertensive drugs, could put patients with hypertension or ischaemic heart disease at even greater risk of perioperative morbidity or mortality.

**Studies involving anaesthetic adverse drug events**

Catchpole and colleagues reviewed 12,606 reported incidents from January 2004 to February 2006. These incidents came from the National Reporting and Learning System which was set up by the National Patient Safety Agency (NPSA) for prospective collection and analysis of critical incident reports from health-care staff, patients, or the general public. Medication errors accounted for 1120 cases. However, as the authors state, it can be difficult to pin down the actual numbers because some may also be described in other categories; for example, treatment or procedure accounted for 3839 incidents and medical device/equipment accounted for 1664 incidents. Of the 1120 medication errors, only 15 (1.3%) resulted in severe harm or death. These findings support those of other groups that although these errors are quite common, severe errors are uncommon. Many of the errors also appear to be preventable.

A review of incidents reported to the NPSA between August 2006 and February 2007 from intensive care units or high-dependency units identified 2428 medication-associated incidents. Of the 355 different drugs involved, the three most common were morphine (207 incidents), gentamicin (190 incidents), and norepinephrine (133 incidents). However, the drugs most commonly associated with patient harm were norepinephrine (55 incidents) and insulin (48 incidents). The authors do not describe in any further detail what harm meant. In 509 cases, problems with communication between staff were described. This seemed to be particularly important in transfer from theatre and postoperative recovery as 5% of all medication incidents reviewed fell into this classification.

**Prospective studies**

Two fairly recent prospective studies in anaesthesia have been reported. The first reported on incidents gathered from two tertiary teaching hospitals in New Zealand from February 1998 to August 1999. Anaesthetists in these hospitals were asked to return a study form anonymously for every anaesthetic, indicating whether or not a drug administration error or pre-error had occurred. A pre-error was defined as any incident with the potential to become an error.

The second described a similar study involving three South African tertiary hospitals with anaesthetists being asked to complete a study form for every anaesthetic from
the beginning of April 2005 to the end of September 2005. The term ‘near miss’ was used instead of ‘pre-error’ but was defined in a similar way. The main findings of these studies are summarized in Table 1.

<table>
<thead>
<tr>
<th>Incidence of error or near miss (%)</th>
<th>0.75</th>
<th>0.36</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response rate (%)</td>
<td>72</td>
<td>53</td>
</tr>
<tr>
<td>Number of anaesthetics</td>
<td>10 806</td>
<td>30 412</td>
</tr>
<tr>
<td>Incorrect dose (%)</td>
<td>32</td>
<td>23</td>
</tr>
<tr>
<td>Omission (%)</td>
<td>19</td>
<td>4</td>
</tr>
<tr>
<td>Substitution (%)</td>
<td>27</td>
<td>60</td>
</tr>
<tr>
<td>Repetition (%)</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>Wrong route (actual numbers)</td>
<td>2</td>
<td>7</td>
</tr>
</tbody>
</table>

The main points from both incident type reporting systems and from prospective studies are that medication errors in anaesthesia and critical care are common. This finding is not confined to anaesthetists but applies to all health-care professionals preparing or prescribing drugs. On the basis of the reported rate of one error per 133 anaesthetics, the average anaesthetist would be expected to make seven drug administration errors per year. If 1% of therapeutics, the average anaesthetist would be expected to harm two patients in the course of a 30 yr career in anaesthesia. This may seem a very small number but given the number of anaesthetists, this would be expected to result in injury, then drug error. What is required is a framework that encourages actions such as slips or drug substitutions. Such an important component of anaesthetic practice that actions of people working at the sharp end of the system can be labelled unsafe acts. These are further subdivided into unintentional or intentional acts. Unintentional acts are further divided into slips or lapses. Intentional acts are divided into mistakes and violations.

Slips are due to attentional failures. In the GMC study, slips resulted in foundation doctors writing wrong units such as milligrams instead of micrograms. Factors contributing to slips included a busy workload, multitasking, being tired and not concentrating. These were more likely to happen during on-call days, at the end of shifts, in unfamiliar environments, and in understaffed wards; conditions which may be familiar to the anaesthetist or intensivist.

Lapses are the result of memory failure, specifically prospective memory. Prospective memory is what we use when we want to do something in the future; for example, ‘I must remember to phone the ward to give the third patient her pre-med’. We may forget to do something completely or we may forget a step in a process; such as forgetting to enter all the necessary data while programming an infusion pump for a total i.v. anaesthesia technique. In the GMC study, lapses resulted in activities such as forgetting to write the date or sign the prescription. Predisposing factors were similar to those identified for the category of slips.

Slips and lapses are skill-based errors because they occur during routine activities. The anaesthetist may be on auto-pilot for the current theatre case but may be thinking about other matters—the previous patient in recovery, late laboratory results for patients further down the list, or actions of trainees managing cases in other theatres under distant supervision. Such ‘distractions’ may result in errors such as syringe swaps or drug substitutions.

When we move away from routine activities and have to manage problems or new challenges, then we begin with a rule-based approach. If the patient appears to be ‘too light’ for the level of surgical stimulus, then the rule is increase depth of anaesthesia. In the GMC study, errors in prescribing were seen when the junior doctors had to prescribe drugs as part of the management of new problems arising in patients. Lack of expertise was an important contributing factor. This is much less likely with established anaesthetists acting at a rule-based level. Knowledge of pharmacology is such an important component of anaesthetic practice that...
Drug errors

There are four features associated with these BTCUs. These are known as borderline-tolerated conditions of use (BTCU). From the safe space into the unsafe space. These drifts are from the safe practice to less acceptable practice, where deviations from accepted standards are commonplace and from which position it is easier for some individuals in that system to commit more major deviations.

When the repertoire of rules is exhausted, then new solutions have to be devised. This is cognitively intense work and especially in situations where the operator is under time pressure, the brain’s tendency is to select a rule that approximates to the situation facing the operator.16 These are known as fixation errors because the tendency is to go down one path and ignore evidence to the contrary. An example from anaesthetic practice is a clinical situation where an anaesthetist is presented with unexpectedly high airway pressure and a slight fall in oxygen saturation levels in an intubated anaesthetist patient. If this is due to a foreign body in the catheter mount connecting the tracheal tube to the breathing system but interpreted by the anaesthetist as bronchospasm then that fixation error may result in harm to the patient as more powerful bronchodilators are administered. Knowledge-based errors often cause problems not due to lack of specific facts or concepts but due to misapplication of existing knowledge during the management of fixation errors. The GMC study17 highlighted the lack of knowledge of not only pharmacology, especially drug interactions, but also lack of knowledge of prescribing systems and how to use them. As with rule-based mistakes, this is much less likely with experienced anaesthetists but the administration of ‘wrong drugs’ during the management of a crisis as part of a fixation error could result in serious patient harm.

The next category of intentional unsafe acts is violations. A violation is a deliberate deviation from standard instruction.18 Vulnerable system syndrome19 describes an organization in which a cluster of organizational pathologies renders that system more liable to errors and violations and so to accidents and adverse events. Features seen in such systems are a tendency to blame front-line workers, a tendency to deny the existence of latent conditions, and a blinkered pursuit of productivity indicators. A three-phase model of violations has been described.18 The first phase relates to a safe and legal workspace. This is easier to define in an organization where the distinction between acceptable practice and unacceptable practice is obvious and clearly demarcated. However, in many organizations, the distinction is not always so clear and so actions drift from the safe space into the unsafe space. These drifts are known as borderline-tolerated conditions of use (BTCU). There are four features associated with these BTCUs.

(i) They are first seen as benefits and not as risks.
(ii) They enhance the performance of the system in the short term or provide advantage for the individual operator.
(iii) They are tolerated by management (indeed, they may be required by management).
(iv) They are associated with a variety of informal safety measures.

As these BTCUs become more tolerated, Phase 2 is entered and now the distinction between safe and unsafe practice becomes blurred and deviations from normal practice become more acceptable. Although these may not lead to many episodes of severe harm, they make it easier for some individuals to enter the third phase. This can be thought of as the space in which extreme disregard for safety occurs. Now dangerous actions, albeit on the part of a minority, can take place. The three-phase model describes a creep from safe practice to less acceptable practice, where deviations from accepted standards are commonplace and from which position it is easier for some individuals in that system to commit more major deviations.

An example of a major deviation relates to the rate of deaths of patients undergoing liposuction in Florida.18 In office-based practice, the rate was one death in 5000 cases compared with a rate of one death in 200 000 cases in hospital-based practice. The deaths were due to local anaesthetic toxicity. The BTCUs were an increasing disregard for the accepted amount of drug administered to patients. As these limits were breached, the operators initially ‘got away with it’ and so may have become more tempted to try even more extensive procedures in their own office settings. Although financial profit may have been a motive, the desire to provide treatment at a more convenient setting and even lower cost for the patient may also have been factors. The same disregard to maximum dosages may have taken place in hospital but at least the backup resuscitation expertise would be more readily available. This leads onto latent conditions.

Latent conditions

Latent conditions predispose active errors to harmful outcomes. Many slips, lapses, mistakes, and violations do not result in severe harm, as we have seen. This is often because defence mechanisms prevent serious adverse drug events. The GMC study17 revealed that 1.7% of medication errors were potentially lethal but were detected by other health-care workers before they were put into action. Removal of some of these lines of defence, for example, reducing the number of clinical pharmacists on the wards, serves as an example of a latent condition. It would not be noticed until an unsafe medication order was prescribed and then, unchecked, carried out.

Latent conditions can be described in terms of six ‘Ps’.20

Providers

Reducing the number of clinical pharmacists in the wards serves as an example of an action that a Trust or Health Board may take that as a latent condition.
Procedures
The same day admission of patients for theatres may provide latent conditions if beds are not available in the morning, patients arrive late, or at late notice without pre-assessment or advice regarding regular medication.

Products
The similarity of drug ampoules may lead to drug substitutions.

Peripherals
Infusion lines, connectors, pressure devices, and filling systems for vaporizers all have the potential to add to errors, especially when new equipment appears.

Patients
Not all patients will remember drug allergies, many will not remember all of the drugs that they take, and some may not even regard inhalers, creams, or patches as drugs. Some may not be truthful about recreational substances that may have an impact on anaesthetic management—amount of alcohol consumed, the number of cigarettes smoked.

Policy
A recent example was described in which anaesthetists were ‘banned’ from taking food or hot drinks into anaesthetic rooms. The impact of tiredness, fatigue, and hunger on slips and lapses were noted in the critical incident studies and the GMC study.8

The importance of latent conditions is that if they are not dealt with, then the same pattern of errors may be seen and the chances of a serious incident resulting in patient harm become greater. Detection of latent conditions leads into the next section.

Reduction and avoidance of errors
Two approaches have been described: those specifically addressing drug errors in anaesthesia and those looking at ways of reducing critical incidents in general. The two are not mutually exclusive. Jensen and colleagues22 studied the evidence relating to various recommendations to reduce drug errors. They used this to devise a list of actions matched to the strength of the evidence. These are summarized in Table 2.

Many of these efforts are intended to reduce substitutions and so help the anaesthetist administer the intended drug. A new infusion syringe label system designed to reduce task complexity during drug preparation demonstrated no drug errors with the use of this system compared with seven errors when using a more conventional approach.23 However, other workers24 25 have shown that although technology can be helpful, its widespread use and application is not a panacea to all of the causes of adverse drug reactions.

General measures
The NPSA published a guide entitled Seven steps to patient safety. These steps are as follows.

(i) Step 1: Build a safety culture.
(ii) Step 2: Lead and support your staff.
(iii) Step 3: Integrate your risk management activity.
(iv) Step 4: Promote reporting.
(v) Step 5: Involve and communicate with patients and the public.
(vi) Step 6: Learn and share safety lessons.
(vii) Step 7: Implement solutions to prevent harm.

It is worth exploring some of these points in greater depth.

Safety culture
Although no single definition exists, a safety culture is characterized by the following.

| Table 2 Specific recommendations related to the avoidance of drug error in drug administration in order of strength (after Jensen and colleagues)22 |
|---|---|
| Action | Strength of evidence |
| The label on any drug or ampoule or syringe should be carefully read before a drug is drawn up or injected | Strongly recommended |
| Legibility and contents of labels on ampoules and syringes should be optimized according to agreed standards. | Strongly recommended |
| Syringes should be labelled (always or almost always) | Strongly recommended |
| Formal organization of drug drawers and workspace should be used | Strongly recommended |
| Labels should be checked specifically with a second person or device before a drug is drawn up or administered | Recommended |
| Errors in i.v. drug administration during anaesthesia should be reported and reviewed | Recommended |
| Management of the drug inventory should focus on minimizing the risk of drug error | Recommended |
| Similar packaging and presentation of drugs should be avoided where possible | Recommended |
| Drugs should be presented in prefilled syringes rather than ampoules | Possibly recommended |
| Drugs should be drawn up and labelled by the anaesthetist who will administer them | Possibly recommended |
| Colour coding by class of drug according to an agreed national or international standard should be used | Possibly recommended |
| Coding by syringe position or by the needle on the syringe should be used | Unclear |
(i) A culture where staff have a constant and active awareness of the potential for things to go wrong.
(ii) A culture that is open and fair.
(iii) A culture that encourages people to speak up about mistakes.
(iv) Patient safety is at the forefront of everyone’s minds whether delivering healthcare, developing procedures or redesigning clinical areas.

Many organizations, such as those providing and delivering healthcare, need to adapt and improve as a result of changing conditions. Those that are effective adapt by seeking feedback, sharing information, asking for help, and talking about errors and experimenting. However, activities such as asking for help or confessing to errors carry a potential psychological threat. If people fear the potential for threat or embarrassment, then they will not carry out the above activities and so group learning is less likely to occur. The way to counteract this is to create a climate that instils in the members of the team a sense of confidence that they will not be rejected, punished, or embarrassed by the team when speaking up. This is psychological safety. It does not happen by itself nor does it happen overnight but occurs when team leaders make concerns explicit and lead by example.

One can think of the safety culture in terms of how easy or difficult it is for people to act in the ways described above. Two factors will influence how an individual will act; the level of commitment felt by that individual and the prevailing circumstances. Let us imagine a health-care worker who feels that the right thing to do is to work for the patients and if speaking up about mistakes will help patients, then this health-care worker will probably want to speak out. However, the health-care worker will feel as strongly, or even more strongly, about other matters such as self-esteem and the desire to remain in gainful employment. If the perceived response to speaking out about mistakes is to be shunned by others in the group involved in that mistake, or to receive disciplinary action in the form of suspension from work or dismissal from work, then even a strong commitment to speak out will be overcome. The vulnerable system syndrome described earlier is one in which only those with exceptional commitment to speaking up about mistakes are likely to do so. In contrast, a system with a good safety culture, with a strong sense of psychological safety, will make it easier for workers to speak up about mistakes because such an action will generate approval from leaders and colleagues.

**Error reporting**

This is related to speaking up. If the system confers a degree of anonymity upon the person reporting the error, then some of the psychological safety issues can be bypassed but people will only continue to report errors if certain conditions hold. Doctors are less likely to report errors if they feel that they get little for the investment. If the process takes time, if there is no feedback, or if the feedback is not helpful, then reporting is less likely to take place. A review of contributory factors to medication errors in nursing practice found that nurses view medication errors in different ways which include:

(i) If it is not my fault then it is not an error.
(ii) If everybody knows then it is not an error.
(iii) If you can put it right then it is not an error.
(iv) If a patient has needs that are more urgent than the accurate administration of medication, then it is not an error.
(v) If it is a clerical error, then it is not an error.
(vi) If an irregularity is carried out to prevent something worse, then it is not an error.

The interpretation of what constitutes an error therefore impacts on the reporting of medication errors to the detriment of organizational learning. Without reporting there can be no analysis and without analysis latent conditions will remain undiscovered and able to exert a malign influence on future occasions.

Maximization of the opportunities to learn from errors requires an integrated framework. The two key features of this system are, first, an information and incident management system based on a universal patient safety classification and, secondly, quadruple learning. Quadruple learning means using feedback to learn local lessons and make local changes (at the level of the individual practitioner or team), using that information to also make changes at employer level (Trust or Health Board), while simultaneously feeding the reports into a national system and being able to share the national information at international level.

**What can the individual anaesthetist do?**

The first and most important step is to develop an awareness of the ubiquity of medical error and the potential capacity to inflict severe harm or death on patients. Reason uses the term ‘feral vigilance’ to describe the ever present watchfulness and alertness required to prevent errors, whether slips, lapses, or mistakes.

Secondly, consultant anaesthetists have great capacity to influence what goes on in the operating theatres in which they work. A safety climate with psychological safety is more likely to take place when those in a position of responsibility and leadership make explicit what they are doing and lead by example. The actions of individuals in turn influence the climate of an anaesthetic department.

Thirdly, by reporting errors and by encouraging the local feedback of the analysis of such errors or near misses, the more likely other members of the team are to do so. Evidence has shown that as more incidents are reported, the number of serious adverse events decreases.

Furthermore, the act of reporting can help the reporter reflect upon the nature of the error and the factors that may have contributed.

We should not underestimate our power to influence such processes by our actions as individuals.

**Conflict of interest**

None declared.
References