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Expert Opinion

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Medication errors resulting from the confusion of drug names

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If drug names are similar, errors can occur. Problems arise when different drugs have similar names (whether proprietary or non-proprietary), when formulations with the same brand name contain different drugs, when the same drug is marketed in formulations with different names, and when drug names are abbreviated. The risk of errors could be reduced by some simple precautions at different stages of drug development, prescribing, supply, and administration. Regulatory authorities and manufacturers should maintain their vigilance when naming new drugs and formulations, and should be prepared to change names if errors occur. Before they write an unfamiliar name on a prescription, prescribers should check what they are prescribing and what other medications the patient is taking (patients should be familiar with their medicines), and pharmacists should check patients' medicines. At all times there should be good communication among those who prescribe, supply, and administer medicines, and those who take them.

Keywords: drug names, medication errors

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1. The naming of drugs

'Dear Doctor, Mr Smith has been taking chlorampicillin for some time. I think that he could now stop.' Chlorampicillin doesn't exist; the patient was taking chloram-bucil. Prescribers can just as easily confuse real drug names, many of which look and sound and alike, as this doctor confused the name of a real drug with that of an imaginary one.

Drugs usually have three different names:

- A chemical name, the form of which generally follows the rules issued by the International Union of Pure and Applied Chemistry (IUPAC).
- A non-proprietary name. This is usually the International Non-proprietary Name (INN), either recommended (rINN) or proposed (pINN) by the WHO (World Health Organization). However, it may be a locally approved name – for example, the British Approved Name (BAN) or United States Adopted Name (USAN).
- A proprietary name (brand name or trade name), assigned by a pharmaceutical manufacturer.

For example:

- Chemical name: (*R*)-1-(3,4-dihydroxyphenyl)-2-methylaminoethanol.
- INN: epinephrine.
- BAN: adrenaline.
- Proprietary names (UK): Anapen, Epipen.

Some drugs have no non-proprietary names other than the chemical name (e.g., glyceryl trinitrate, acetylsalicylic acid). In this report, upper case initials are used for brand names and lower case initials are used for non-proprietary names.

2. Incidence of errors as a result of drug names

The incidence of prescribing errors through confusion over the names of drugs and formulations is not known. Of 402 errors in drug administration studied in hospital, none was attributed to confusion over names [1], which could mean an incidence of up to 0.8%. However, 15% of all errors reported to the Medication Errors Reporting Programme of the US Pharmacopoeia (USP) during 1996 – 2000 were due to confusion over drug names [2]. Furthermore, approximately 25% of the 1200 – 1500 reports of serious complications resulting from the use of drugs that the Institute for Safe Medication Practices (ISMP) receives every year are due to confusion over names. Since the ISMP estimates that only 1 – 2% of all events are reported, this implies that approximately 10,000 people in the USA are injured or die each year as a result of confusion over drug names [2]. Since many millions of prescriptions are written every year, errors are probably relatively uncommon, but the morbidity and mortality that they cause are avoidable.

3. Sources of confusion

The possible sources of confusion over drug names [3,4] can be considered under four headings:

- Different drugs with similar names.
- Formulations with the same brand name containing different drugs.
- The same drug marketed in formulations with different names.
- Abbreviated drug names.

3.1 Different drugs with similar names

Comprehensive tables of drugs with similar names have been published in the UK [5,6], Australia [7] and the USA [8,9,101]. Many anecdotes have illustrated errors resulting from confusable drug names.

A 40-year-old man was given Apresoline (hydralazine) in hospital for hypertension. His doctor, inquiring about his progress, was told that he had been given isoprenaline. 'The effects on his blood pressure and mine,' wrote the doctor, 'were the exact opposite' [10].

Confusion between sulfonylureas and other drugs is quite commonly reported [11-16] and often causes hypoglycaemia. A common error is to use acetohexamide (Dimelor or Dymelor) instead of acetazolamide (Diamox). Other errors have included the substitution of chlorpropamide (Diabinese) for chlorpromazine, acetazolamide (Diamox) or aluminium hydroxide (Dialume); glibenclamide (Daonil) for amoxicillin (Amoxil) or De-nol; tolazamide (Tolinase) for tolmetin (Tolectin); and tolbutamide (Orinase) for bromelains (Ananase) or terbutaline.

Other drugs that have been confused include: aminophylline/amitriptyline [15]; benorylate/Dioralyte [17]; diltiazem/diazepam [18]; hydralazine/hydroxyzine [19]; Inderal (propranolol)/Intal (sodium cromoglicate) [15]; Priadel (lithium)/

Panadol (paracetamol) [20]; Priadel/Pardale (paracetamol, codeine and caffeine) [21]; and Stelazine (trifluoperazine)/selegiline [22]. Reports of confused drug pairings to the USP during October and December 2003 [102] included biperiden/risperidone, Cytosar U/Cytosar, citalopram/escitalopram, dactinomycin/daptomycin, Depo-Medrol/Solu-Medrol, Kaletra/Levitra, Lexepro/loxapine, protamine/Protonix and Zostrix/Zovirax. Epinephrine and ephedrine were yet again confused, justifying the use of the name adrenaline [23].

Sometimes confusion arises when there are confusable indications for drugs with even vaguely similar names. For example, a woman was given Trisequens (hormone replacement therapy) instead of Tripharil (an oral contraceptive); she subsequently became pregnant [15].

Some brand names include numbers or letters, signifying content, dosage, or some other feature. If the number or letter is omitted or misinterpreted, errors can result. Transdermal hyoscine/scopolamine (Transderm V) has been confused with glyceryl trinitrate (Transderm Nitro 5) [24].

3.2 Formulations with the same brand name containing different drugs

Confusion has arisen when a company markets a series of formulations under the same general brand name, each formulation containing different ingredients. This happens with over-the-counter (OTC) formulations [25]. Even if packaging and labelling distinguish the different formulations, such differences may not be clear to the customer.

3.3 The same drug marketed in formulations with different names

Most non-proprietary names are international, although there are exceptions. For instance, some rINNs differ from the names used in the USA (Table 1) [23]. In contrast, there are many differences between proprietary names in different countries, providing room for error when patients travel from one country to another. In addition, a proprietary name used in one country for one drug may be used elsewhere for another. Even in the same country, two different brand names for the same drug can cause confusion. A woman taking Veramax (verapamil) was also given Verasal (verapamil) and developed verapamil toxicity [26]. The large variability in the naming of modified-release formulations, using tags such as MR, XL, LA, SR, and Retard, can lead to confusion between different types of formulation [1].

3.4 Abbreviated drug names

Abbreviations can confuse. For example, ISMN (isosorbide mononitrate) has been misread as Istin (amlodipine) [27]. Some cytotoxic drugs have confusing abbreviations (e.g., CCNU, BiCNU).

4. Avoiding errors

It is clear from these and other stories that no one is immune to error where drug names are concerned –

Table 1. Some USANs that are different from their corresponding rINNs.

USAN	rINN
Glyburide	Glibenclamide
Isoproterenol	Isoprenaline
Moricizine	Moracizine
Metaproterenol	Orciprenaline
Acetaminophen	Paracetamol
Meperidine	Pethidine
Rifampin	Rifampicin
Albuterol	Salbutamol
Torsemide	Torasemide

rINN: Recommended International Non-proprietary Name; USAN: United States Adopted Name.

doctors, pharmacists, nurses and patients. How can the risk of errors be reduced?

4.1 Choosing names

Great care is taken by the WHO over the introduction of new INNs [28,29]. Countries that do not already subscribe to the use of these names should do so; countries in the EU (European Union) already do.

INNs are chosen with regard to pronunciation and spelling, distinguishability from other drug names, and the desirability of choosing names that denote the pharmacological similarity of related compounds [28,29]. This last criterion leads to the use of many common suffixes. For example, -azepam for benzodiazepines, -floxacin for fluoroquinolones, -vastatin for 3-hydroxy-3-methylglutaryl coenzyme A reductase inhibitors and -olol for β -blockers (but beware of stanozolol, an anabolic steroid).

Prefixes pose more of a problem. Errors of confusion are more likely with drugs that have common prefixes (e.g., am- or amino- for drugs that contain an amino group, cef- or cep- for cephalosporins, chlor- or clo- for drugs that contain a chlorine atom) than with those that have similar suffixes, as many of the examples quoted here show. The tendency for confusion may be worsened when prefixes are used for both non-proprietary and proprietary names (e.g., Ceporex and Cefizox, proprietary names for cephalosporins). Following confusion between amiodarone and amrinone, renaming was proposed [30]. The USP Nomenclature Committee and the United States Adopted Names (USAN) Council subsequently renamed amrinone inamrinone [103]; however, the rINN of amrinone has not been changed. Unilateral action by one country was regrettable; if the change was justifiable, it should have been international.

Proprietary names are chosen by pharmaceutical companies after extensive market research and computerised searching of existing names, including structural and phonetic analysis in a number of languages [31]. Large databases are available for these purposes [32,33]. Furthermore, the choices made by

pharmaceutical companies are subject to external controls. For example, in the UK, the Medicines Act 1968 empowers the Licensing Authority to refuse a licence if the proprietary name is unacceptable, although I suspect that this sanction is rarely, if ever, invoked; the Trade Marks Act 1938 and the Consumer Protection Act 1987 add extra incentive, as do the European Product Liability Directive (85/374/EEC) and the Directive on General Product Safety (92/59/EEC). However, no matter how much care is taken, problems of confusion with new names can still occur, since the number of pre-existing names is large (there are more than half a million pharmaceutical trade marks registered worldwide). For example, Losec (omeprazole) was confused with Lasix (furosemide) [34], with at least one fatal outcome [35]; the manufacturers changed the name of Losec to Prilosec, although not in all countries – in the UK, for example, Losec and Lasix are still available.

Names for formulations of drugs that are out of patent can pose problems. In October 1982, four generic products with names beginning with Al- were introduced in the UK; two differed by only one letter – Aluline (allopurinol) and Aluzine (furosemide) [36]; Aluzyme (folic acid plus B vitamins) was already on the market. Although proprietary names are usually registered trade marks, the brand names of generic products are often not registered. Companies that produce generic formulations should name their products using the non-proprietary name with, if they wish, the company's name suffixed.

OTC formulations pose similar problems. Manufacturers sometimes give a series of OTC formulations the same general name, even if they contain different compounds; this should be discouraged [25]. Packaging should emphasise the non-proprietary name and de-emphasise the brand name or manufacturer's name. The danger of failing to emphasise the non-proprietary name on packaging has been illustrated by two fatal cases of potassium poisoning when potassium chloride was given instead of Kayexalate (sodium polystyrene sulfonate) because the bottles containing the two drugs looked very similar and because the name Kayexalate is reminiscent of some brand names for potassium salts (e.g., Kay-Cee-L and Kay-Ciel) [37].

Table 2. Actions that could be taken to reduce the risk of errors through confusion of drug names.

Group	Recommended actions
Regulatory agencies	<ul style="list-style-type: none"> • INNs should be used internationally • Licensing authorities should exercise more control over the naming of new proprietary formulations • New proprietary names should be internationalised • Commonly used prefixes in names should be avoided if possible • Computerised databases should be used in comparing proposed names with existing names; the Levenshtein distance provides a simple method of predicting possible conflicts
Pharmaceutical manufacturers	<ul style="list-style-type: none"> • Manufacturers should play their part in ensuring that new names are carefully chosen and internationalised • They should use a single standard tag to indicate modified-release formulations • Tags used in OTC formulations (e.g., 'Plus', 'Extra') should have a uniform meaning from one manufacturer to another; a standard glossary should be used • They should test potential new names on patients and prescribers • They should be prepared to change brand names if necessary, and to do so worldwide • Generic formulations for prescription should be marketed under their non-proprietary names, not under new proprietary names • OTC formulations should be given unique brand names • Packaging and package inserts should emphasise the non-proprietary name of the drug above the brand name
Prescribers	<ul style="list-style-type: none"> • Prescribers should inform patients about the nature and risks of their therapy • They should issue computer-printed prescriptions if possible, and in handwritten prescriptions use clearly penned upper case letters • They should always check unfamiliar names of medicines that patients are taking • In most cases they should use INNs when prescribing • They should never abbreviate drug names • They should inspect patients' medicines, especially when adverse events occur • They should report errors to their regulatory authority
Pharmacists	<ul style="list-style-type: none"> • Pharmacists should discuss the nature and risks of patients' therapy with them and check that they recognise the medicines they are taking • Pharmacists should ask patients to hand in their old medicine containers when they fill a new prescription • In hospital, clinical pharmacists should check prescriptions and liaise with prescribers, advising on correct therapy • They should report errors to their regulatory authority
Patients	<ul style="list-style-type: none"> • Patients should educate themselves about the medicines they are taking and tell each new prescriber about them • They should bring their medicines with them when they go to consult a prescriber or pharmacist

INN: International Non-proprietary Name; OTC: Over-the-counter.

There are various methods for comparing two drug names to determine whether or not they are likely to be confused, of which the Levenshtein distance may be the best [38]. Those who are involved in naming new drugs should use such a method to check for potential confusables.

4.2 Prescription writing

A doctor told a 55-year-old man to use Remotic (triamcinolone and halquinol) eardrops. Instead, the patient swallowed the Rivotril (clonazepam) tablets that his chemist dispensed and became unfit to drive. Another doctor commented, 'That a supposedly intelligent patient, having been told to use capsules of Remotic in the ear, should then eat tablets of Rivotril will surprise no one with 30 years in general practice' [39]. That a doctor's handwriting may be so bad is equally unsurprising [40].

A psychiatrist prescribed Concordin (protriptyline). The pharmacist dispensed Coumadin (warfarin). The patient suffered multiple haemorrhages [41]. In a similar case, procyclidine (Kemadrin) was confused with Coumadin [42].

Careful prescription writing is important. Increasingly, prescriptions are being computer-printed; the use of a large, bold font will help pharmacists to avoid misreadings. Hand-written prescriptions should be penned carefully, with drug names in block capitals. In one case, illegible handwriting led to the dispensing of lorazepam instead of Magnapen, and the patient crashed his car; in another case, Daonil (glibenclamide) was dispensed instead of Amoxil, and the patient suffered irreversible brain damage [15]. Other errors have involved hydroxyzine/hydralazine and DesOwen (desonide) ointment/Dovonex (calcipotriene) ointment [40]. If pharmacists have doubts about poorly legible drug names they should contact

the prescriber. In hospitals, clinical pharmacists should check prescriptions and liaise with prescribers.

Prescribing by non-proprietary names probably reduces the risk of confusion. Most of the reported examples of confusion have been with proprietary names and there are more proprietary than non-proprietary names in the confusable pairs listed in comprehensive tables. Abbreviations of drug names should never be used.

4.3 Communication

Informing the patient about drug therapy and its possible adverse consequences should help in avoiding errors of confusion. This includes giving patients information leaflets and carefully labelling containers. When patients were given written information about their drug therapy upon leaving hospital, 86% of them knew the names of their drugs 12 weeks later, compared with 47% of those who had not been given information [43]. Good communication between different prescribers and with pharmacists also helps. Patients should be encouraged to bring their medications with them when consulting a prescriber, to enable errors to be detected [44].

Pharmacists are well aware of the problems and generally take care to avoid them. They should ask patients to return

old medicine containers, in order to identify previous therapy and check that patients know what therapy they are currently taking. They should be especially careful with sulfonylureas, which have often been implicated in medication errors, and keep them in a separate section in the dispensary, in order to highlight the problem. These and other recommendations are summarised in Table 2.

5. Conclusions

Future developments in this field will include the discovery of better ways of avoiding errors, based on methods of classification [45,46], and improvements in methods for predicting confusable names; for example, the Levenshtein distance method could probably be improved by taking into account the lengths of the words.

Conflict of interest

Dr JK Aronson is a member of the British Pharmacopoeia Commission's Panel of Experts on Drug Nomenclature. However, the views expressed in this editorial do not necessarily reflect those of the Commission or of other members of the panel.

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