REVIEW

The problem of look-alike, sound-alike name errors: Drivers and solutions

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Look-alike or sound-alike (LASA) medication names may be mistaken for each other, e.g. mercaptamine and mercaptopurine. If an error of this sort is not intercepted, it can reach the patient and may result in harm. LASA errors occur because of shared linguistic properties between names (phonetic or orthographic), and potential for error is compounded by similar packaging, tablet appearance, tablet strength, route of administration or therapeutic indication. Estimates of prevalence range from 0.00003 to 0.0022% of all prescriptions, 7% of near misses, and between 6.2 and 14.7% of all medication error events. Solutions to LASA errors can target people or systems, and include reducing interruptions or distractions during medication administration, typographic tweaks, such as selective capitalization (Tall Man letters) or boldface, barcoding, and computerized physician order entry.

KEYWORDS
look-alike, medication error, nomenclature, similarity, sound-alike

1 | INTRODUCTION

In this review we introduce the problem of look-alike, sound-alike (LASA) name errors; give an overview of the landscape of medication nomenclature; outline the scope, importance and prevalence of LASA name errors; and explore solutions. This paper is to be complemented by a systematic review in a forthcoming issue. We adopted a step-wise approach to exploring the literature. After identifying papers that are central to the problem of LASA name errors, we handsearched forward citations (paper that cited it after publication) and backward citations (key papers they cited), and identified further relevant literature.

2 | MEDICATION ERRORS INVOLVING LASA NAMES

Of all events that are reported to cause patient harm in the UK, medication errors are the most common. Between January and March 2018 they accounted for 10.7% of incidents (206 485 medication

incidents out of a total of 1 936 812 incidents), and 63 deaths.[1] Medication errors can occur when medications have similar-looking or similar-sounding names, and/or shared features of product packaging. These *wrong drug* errors are so-called LASA errors.[2] LASA errors make up a high proportion of all medication errors; estimates range from 6.2[3] to 14.7%,[4] representing a significant threat to patient safety.[5,6] They can occur during prescribing, dispensing or administration of medicines, and can lead to administration of the wrong medication. LASA errors can result in overdosing, under-dosing, or inappropriate dosing.[7] Confusion can occur between: generic–generic names (e.g. penicillin–penicillamine); brand–brand names (e.g. Prozac–Provera); brand–generic names (e.g. Soriatane–sertraline); or generic–brand names (e.g. methadone–Metadate); these examples are taken from error reports.[8] Most LASA pairs are reciprocal, i.e. each has been mistaken for its counterpart, revealing the influence of inherent pairwise similarity, rather than external environmental factors.

This review is primarily concerned with errors that are caused by look-alike names and sound-alike names, and interventions to reduce their prevalence. A systematic review in a forthcoming issue explores

interventions to reduce the prevalence of LASA errors. Given the wide variation in definitions of a medication error, it is difficult to quantify the proportion of medical errors that concern medications: for example, the authors of 1 review found 26 definitions of a medication error in 45 medication error studies, but no association between definitions of error and prevalence.[9] Under the *5 rights* framework, a LASA error is typically a *wrong drug* error, which may be due to a LASA name (e.g. morphine *vs* hydromorphone[10]) or LASA packaging (e.g. acebutolol *vs* amiodarone packaged in identical drug blisters[11]), with or without a similar name.

LASA errors occur because of shared linguistic properties between 2 or more names, and lead to incorrect substitution of 1 medicinal product for another. If not interrupted, this results in erroneous drug administration. The cause of the error may lie in similarities in orthography (the written forms) or phonology (the spoken forms), and several similarity measures have been proposed.[12,13] The potential for LASA errors may also be compounded by similarities in product packaging, dosage form, or strength. LASA errors often involve selection of the wrong medication from a shelf or from an electronic list.[5]

There is no universally agreed definition of a LASA error—Table 1 illustrates the range of published usages of the term. These examples show that (i) the property LASA is usually applied to medication name pairs, rather than the error itself; and (ii) LASA names are viewed as the cause of medication errors. This is important—LASA name pairs are present in the nomenclature as potential errors, regardless of whether an error has occurred. For the sake of brevity, we shall use the term *LASA error* in this review.[5,13,14]

3 | MEDICATION NOMENCLATURE— NAMES AS MEANINGFUL LINGUISTIC ITEMS

Medications have at least 3 names. The first is the chemical name, published by the International Union of Pure and Applied Chemistry (IUPAC). The chemical name (e.g. N-acetyl-para-aminophenol) is based upon the chemical formula of the substance. Secondly, a medication will have at least 1 brand name, chosen by each manufacturer (e.g. Tylenol, Panadol). The name is commercially motivated, with an upper-case initial, and may be followed by the registered trademark symbol. Legally the name is required not to imply any therapeutic benefit; it is typically laconic and euphonious. Once out of patent (up to 20 years in the EU), a substance can be marketed and sold by competitors and will be given more brand names. Thirdly, in each country in which the medication is licensed to be marketed, it will be assigned a national generic name (such as a British Approved Name, BAN, in the UK; a United States Adopted Name, USAN, in the USA; or a Denominazione Comune Italiana, DCIt, in Italy). It will also be assigned a global generic name—an International Nonproprietary Name (INN) by the World Health Organization (WHO). Examples include paracetamol (INN, BAN), acetaminophen (USAN), and paracetamolo (DCIt).

There are multiple strata in the nomenclature of generic names: they are formed on international, regional and national levels, and are published multilingually. INNs are the most commonly used generic names, with over 8000 already designated; INNs are used by default in both the UK and the EU, with only a few notable exceptions (such as adrenaline in the UK, see[26]). These names are formally placed in the public domain to promote consistency of global communications between manufacturers, clinicians, prescribers, and patients. The nomenclature is published in 7 languages: English, Spanish, French, Chinese, Arabic, Russian and Latin.[27]

Historically, the classical languages Latin and Greek were used to form terms in medicine. However, throughout the 19th century medicine was transformed into an applied science and started to move away from publication in Latin.[28] Nevertheless, Latin and Greek live on in word formation processes in English, in particular for terms in specialist domains such as medicine. Neoclassical word formation is a process in which a morph (a word part) is borrowed from a classical language and combined with other morphs to form a word with a new meaning that did not exist in the classical language. An analogy would be using parts from a classic car to create a new, modern car. This is helpful to users of the specialist language, as the terms formed are readily understandable by speakers of various European languages, sharing as they do lexical roots. For example, *neuroblastoma* comprises neuro- (Greek νευρο-, nerve), blast (Greek βλαστός, embryo) -oma (Greek -ωμα, tumour)[29]; and *antimicrobial* comes from anti- (Latin, against), micro- (Greek μικρός, small) and -bial Greek βίος, life).

Medication names are artificial terms, created by official bodies such as the WHO. They are morphologically complex and can be analysed into base components, or stems. The stems are determined by the naming body (WHO 2009), and they are formed from neoclassical roots or other methods. Stems may be acronyms (e.g. -mab for monoclonal antibody) or abbreviations (such as -vir for antivirals or -ast for antiasthmatics). They are often indirectly formed from neoclassical compounds. For example, the suffix stem -kin is an abbreviation of interleukin, which in turn is a neoclassical combining form of the morphs inter- (Latin, between) and -leuk- (Greek λευκο-, white and κύτος, cell), plus the suffix -in.

We have previously identified multiple problems with WHO naming guidelines for INNs,[2,30] in that they are sometimes vague and unquantifiable, and expose a tension between the 2 primary goals of the INN programme: on 1 hand, to reduce the risk of confusion, and on the other hand, to ensure that names are easy to use, remember, and understand and are clearly related to chemical composition, pharmacological action, and/or therapeutic use. Almost half of the INNs we analysed use pharmacological stems inconsistently, and a fifth of them are distinguishable from other names by just a single letter, creating the potential for confusion.[2]

4 | SCOPE AND IMPORTANCE

The impact of a LASA error can vary, depending on the medicinal product administered, the dose or route of administration, and the condition of the patient. LASA errors may be spotted before the wrong medicinal product reaches the patient, or they may be

TABLE 1 Usage of the terms LASA and look-alike, sound-alike

Citation	Relationship between LASA names and medication errors (ME)	Reference
"Around 1 in 4 medication errors has been attributed to orthographic (look-alike) and phonetic (sound-alike) similarity between drug names and/or look-alike or confusable packaging."	LASA as a cause of ME.	5
"One of every 4 medication errors reported in the United States is a name-confusion error."	LASA as a hyponym of ME.	13
"Many hundreds of drugs have names that either look or sound so much alike that doctors, nurses and pharmacists can get them confused, dispensing the wrong one in errors that can injure or even kill patients."	LASA as a cause of error.	14
"Some of the more common sources of medication errors are confusion between sound-alike medication names or look-alike medication names, and confusion due to similar appearances for medication packages, or similar labels for different medications."	LASA as a risk factor of ME.	15
"Medication names that look-alike [or] sound-alike (LASA) are the most common cause contributing to medication errors [sic]."	LASA as a cause of ME.	16
"Medication errors commonly involve drug names that look or sound alike." "Similar-looking commercial labelling and packaging are common causes of medication error, often from the use of nearly identical packaging for 2 separate items."	LASA as a cause of ME.	17
"Confusions between drug names that look and sound alike are common, costly, harmful, and difficult to prevent."	The event is the confusion. LASA as a hyponym of ME.	18
"Confusions between drug names that look and sound alike account for between 15 and 25% of reported medication errors."	Confusion (LASA) as a hyponym of ME.	19
"Similarity between drug names can cause errors in short-term memory as well as in visual and auditory perception."	Similarity as a cause of error.	19
"Patients sometimes receive the wrong drug because similarity in the spelling and/or pronunciation of drug names leads to errors in prescribing, dispensing and administration."	Similarity as a cause of error.	20
"The term LASA (look-alike sound-alike) delineates a confusion of medication due to the similar labelling and packaging of different drugs, or similar labelling and packaging of the same drug containing different strengths."	Similarity as a cause of error.	21
"The potential for drug name similarity to cause medication errors is widely	Similarity as a cause of error.	22

(Continues)

TABLE 1 (Continued)

Citation	Relationship between LASA names and medication errors (ME)	Reference
acknowledged by health care professionals." "It is approximated that 1/4 of medication-related incidents voluntarily reported in the United States are caused by drug name confusion".		
"Look-alike, sound-alike medication errors occur when the names of 2 drugs have orthographic similarity […], or phonetic similarity […], forming a look-alike, sound-alike pair."	LASA as a hyponym of ME.	[23]
"Considerable research on medication error has focused on the provision of an incorrect drug to a patient caused by confusion between orthographically similar drug names or similar drug packaging."	LASA as a cause of ME.	[24]
"Wrong-drug errors, thought to be caused primarily by drug names that look and/or sound alike, occur at a rate of about 1 error per thousand dispensed prescriptions in the outpatient setting and 1 per thousand orders in the inpatient setting."	LASA as a cause of ME.	[25]

recognized only much later. There have been many case reports of LASA errors. A few indicative examples are described here. Often, the outcome is not reported, so it is difficult to assess intensity and seriousness accurately. These examples show the range of events that can arise from LASA errors.

4.1 | Example 1: Mercaptopurine INSTEAD OF mercaptamine[31]

In 2010 the MHRA reported that an infant with nephropathic cystinosis was given mercaptopurine instead of mercaptamine. After taking the wrong medicinal product for 1 month, the infant developed pancytopenia but made a full recovery after the error was noticed and rectified.

4.2 | Example 2: Hydromorphone INSTEAD OF morphine[10]

In 2005 it was reported that in a US emergency department a nurse gave oral hydromorphone 10 mg (standard dose 1.3 mg 4 hourly) instead of oral morphine 10 mg (standard dose 5–10 mg 4 hourly) to an elderly man, a 3–5-fold overdose. She had been distracted by another patient. When she returned, she forgot to fill in the medicines reconciliation record for the cupboard. Also, hydromorphone was not usually stored in that cupboard, so she was not primed to be prepared

for the confusion. The patient was discharged before the error was noticed and suffered a fatal respiratory arrest on his way home.

4.3 | Example 3: Cisatracurium INSTEAD OF vecuronium[32]

In 2010 it was reported that cisatracurium had been dispensed instead of vecuronium and administered to a 1-week-old neonate. The error was realized immediately and no changes in vital signs were observed. This error occurred due to similarity of the loaded syringes, despite different labels.

4.4 | Example 4: Sufentanil INSTEAD OF fentanyl[33]

In 2000 sufentanil instead of fentanyl was administered to a 15-year-old boy and a 45-year-old man (who were admitted to the same ward on the same day). Both developed apnoea, cyanosis, flaccidity and vital signs far below baseline (e.g. oximetry as low as 60%), but both made a full recovery. This was an approximately 6-fold overdose. For the 15-year-old, 20 μg of intravenous fentanyl was prescribed, and supposedly administered—in actuality this was sufentanil in the same dose. For the 45-year-old, 100 μg of intravenous fentanyl was prescribed, but 50 μg was supposedly administered—in actuality this was sufentanil (the same dose). Owing to similar names and packaging and

TABLE 2 Summary of the results of studies of the prevalence of look-alike, sound-alike (LASA) errors

Reference	% (n/N)	Details
[3]	6.2% of paediatric medication events (37/597)	Based on incident reports collected in 18 emergency departments in the USA; paediatric medication events accounted for 19% of 597 events; 6.2% (37) were due to LASA errors
[4]	14.7% (89/607)	This was an analysis of 607 error reports to US MEDMARX between 2003 and 2006; errors can be categorized under 1 or more different types; 105 of 607 reports pertained to a *wrong vaccine* error, of which 89 (14.7%) were errors within LASA groups (as defined by the authors), such as td, Tdap, DTaP, and DT.
[23]	0.00003% of all prescriptions (395/1,420,091).	A database rather than clinical outcomes; this US study identified 0.28 alerts to potential LASA errors per 1000 prescriptions; all the errors arose from 22 LASA name pairs prescribed over 6 months in South Carolina.
[34]	0.0022% of all prescriptions (244/113,346)	This was the proportion of errors attributed to brand name confusion in a general hospital in Delhi.
[35]	11.4% of medication errors due to similar names, both brand and generic (79/2103)	Evaluation of prescribing errors in a 631-bed teaching hospital in the US, and causes attributed; the figure of 11.4% includes 'wrong drug' errors due to similar names, wrong dosages, and wrong abbreviations, and so this is an upper estimate
[36]	7% of medication near misses (143/2,044)	A systematic evaluation of 2044 near miss prescribing events; 7% were due to sound-alike names.
[37]	22% of errors reported; absolute numbers not available as we have not retrieved the paper; numerators and denominators not stated	Multiple papers cite this report from the US Pharmacopoeia Medication Errors Reporting Program (date unknown but published in 1996); it reports that similarity in appearance or sound of medicinal product names played a key roles in the commission of 22% of errors. The original paper cannot be retrieved, but it is pertinent to include here as it is cited by so many other papers.

the same manufacturer, they were put into the wrong medication drawer. The ampoules contained the same concentration.

5 | PREVALENCE

There is a dearth of quantitative evidence about the prevalence of LASA errors, and wide variations have been reported. A summary of the prevalence of LASA errors is given in Table 2.

LASA errors occur in up to 0.0022% of all prescriptions.[17,23,34,38] Since over 1 billion prescriptions are issued in the UK each year (1.1 billion in England in 2017[39]), we can extrapolate this error incidence to 2.2 million such errors each year. It is often stated that they account for up to 25% of medication errors,[13,15,22,40] although this seems to be a rather shaky upper ceiling, as the sources cited in these papers are not original studies (e.g.[41] a list of suggested LASA pairs cited by[13]), or are anecdotal case reports (e.g.[42] a commentary and case study, cited by[13]), or are studies finding a lower prevalence (e.g. on average 11.4% of medication errors committed in a hospital were due to similar names,[35] cited by[15]). A lower prevalence is suggested by other original studies, such as 6.2% of reported medication events (37 of 597 event reports[3]), 7% of medication near misses (143 or 2044 near miss reports[36]) and 15% of vaccine errors (89 of 607 error reports[4]). Searches aiming to ascertain the prevalence of LASA errors indicate little evidence and a problematic reliance on secondary citations.

6 | SOLUTIONS

Unlike other forms of medication error (such as wrong patient or wrong route of administration), the onus does not squarely fall on the healthcare professionals who prescribe, dispense, or administer the medication. More broadly, the problem of LASA name confusion should also be considered to be the responsibility of the manufacturer, regulators and naming bodies.[43] There is little focus in the error literature on manufacturers and regulators, and indeed there is a clear incentive for pharmaceutical companies to avoid error reduction activities, for fear of exposure to liability, regulatory interference, and loss of competitive advantage.[44] Furthermore, naming bodies, such as the WHO and the British Pharmacopoeia Commission, have a central responsibility to work against the designation of highly confusable pairs, but our previous research demonstrates vague and unquantifiable guidelines, which are applied very inconsistently.[2]

If LASA pairs were identified at the pre-marketing stage, the errors would not have occurred, because the names would not exist, and several similarity measures between proposed names and existing names have been created.[19,45] In 2002 the Food and Drug Administration, in collaboration with academics, developed the phonetic and orthographic computer analysis (POCA) tool, an algorithm that measures the phonetic and orthographic similarities of a proposed brand name against multiple datasets of both brand and generic names.[46,47] The software was made publicly available, and industry manufacturers are encouraged to use it when proposing new brand names. An INN report in 2016 briefly mentioned the POCA scores between 2 proposed generic names, so they appear to be making use of the software in the name approval process, but to an unknown extent. Use of software such as POCA should reduce LASA errors involving new names, but of course it cannot be used retroactively, and an INN, once recommended, has never been amended. The accuracy of the similarity score and ability to predict error is also heavily reliant on the exact method of the algorithm.

However, LASA pairs may only become apparent after errors or near misses are reported, and several strategies to reduce the risks have been proposed. Reviews focusing on risk reduction commonly separate interventions into *person* and *system* approaches[5,40]; this dichotomy originates in James Reason's theory of human error.[48] The person approach commonly apportions blame by focusing on the role of the practitioner in the error, implying negligence, carelessness, inattention, incompetence, deficiencies/lack of knowledge or inadequate professional preparation.[40,49] It also considers the potentially chaotic circumstances in which medications are prescribed, dispensed or administered, which may include interruptions and distractions,[50] especially in high intensity environments, such as emergency departments.[10] The system approach assumes that to err is human and that the root causes of error lie in nonhuman factors present in the system.[48,49] The system approach thus attempts to reduce errors by identifying and addressing *latent conditions*[48] in the system that prime the risk of errors. It is generally accepted that system-based approaches to preventing errors have greater success.[5,10,48] Elucidating external causative factors encourages practitioners to report errors and near misses, which may otherwise be underreported, owing to fear of reprisal, blame and reputation damage.[51]

In recent years, there has been a growing body of research on LASA errors, and various interventions have been proposed.[5] Below we introduce 4 key interventions: (i) reducing interruptions and distractions in relation to LASA errors; (ii) typographic adaptation; (iii) barcoding; and (iv) computerized physician order entry.

6.1 | Reducing interruptions and distractions.

This intervention falls squarely into the person approach, by aiming to reduce variability in human behaviour. Since a LASA error may occur in writing or speaking a name (language production) or in reading or hearing a name (language reception), it has been recommended that health care professionals say and/or spell the name out loud (presumably before typing or handwriting or administering it), to ensure correct understanding and to solidify the name in the working memory.[5] Furthermore, a suite of measures to reduce distractions and interruptions during prescribing/prescription, dispensing, and administration have been proposed, such as "Do not disturb" tabards to be worn during drug rounds and "no interruption" zones, with varying degrees of success.[50,52]

6.2 | Storage strategies

It is recommended that LASA drugs are stored physically apart from 1 another to reduce the risk of selection, or *picking*, errors. In terms of psychology, selection of a medicinal product encompasses 2 distinct processes—choosing the correct item and rejecting distractors.[53] Strategically organized shelves and storage areas can separate items with orthographically similar names, and this reduces the number of similar names (distractors) in the health care professional's visual field. Strategic storage will inevitably be an improvement on alphabetical ordering, since names that share the initial 2 or 3 letter sequences are more likely to be confused.[54]

6.3 | Typographic intervention, e.g. Tall Man lettering

Printed and digital names can be presented in various ways to maximize their readability and distinctiveness, by changing font colour, weight, kerning, and capitalization. Tall Man lettering is a popular way of changing the typography of medicinal product names; it has been endorsed by the US Food and Drug Administration since 2001,[55] and is used in many hospital pharmacies in the UK (personal communication, ABMU pharmacist). Tall Man lettering uses selective capitalization of LASA name pairs to highlight characters that distinguish them from each other, for example, DOBUTamine and DOPamine, or

hydrALAzine and hydrOXYzine.[17,22] Tall Man lettering has the potential to reduce LASA errors in written/typed, but not spoken, communications, and it differentiates look-alike packaging. Moreover, it is relatively easy to implement, both on physical packaging and electronically. According to cognitive theory of visual searching, similarity between the desired selection (*target*) and other items (*nontargets*) increases the difficulty of the search.[24,56,57] It is thus beneficial to enhance certain properties of the target that distinguish it from non-targets, so-called feature-based processing,[58] such as changes to typography. Examples are bolding, italicizing, colour contrast, or use of uppercase lettering. In the forthcoming systematic review (by the same authors) of the efficacy of Tall Man lettering, we found that Tall Man is a marginally effective intervention to reduce LASA error, with a number of caveats. We presented a *Tall Man placebo effect*, whereby users derive more benefit from the intervention when they are aware of its purpose, and found a ceiling of efficacy, beyond which in certain high-risk situations the risk of confusion cannot be mitigated by typography alone.

6.4 | Barcoding

Some studies have estimated that a third of all errors take place during administration, and are therefore more likely to reach the patient and to cause harm.[59] Barcode medication administration technology was developed to reduce medication errors during administration, by confirming at the bedside that the *5 rights* of medication are in place: right drug, dose, time, route and patient. Patients are given a barcode wristband on admission, and this is scanned before any medication is administered. Barcode scanning may also be integrated into dispensing and is used to correlate physical selection of the medicinal product with selection on the screen. This is used to varying degrees and is especially popular in Australia owing to financial incentives.[5,10] A key disadvantage to barcode scanning is that it risks reproducing errors that were made before dispensing, as these are then less likely to be spotted if manual checks are also not performed as a result.

6.5 | Computerized physician order entry

Computerized alerts can be introduced into dispensing software to alert the user to potential LASA medication pairs and to intercept LASA errors. For example, an alert may read: "This medicinal product is typically used for hypothyroidism. No such problem appears on the problem list of this patient. [Cancel/Ignore/Add diagnosis]" (taken from[38]). Computerized alerts are used in various forms to varying degrees.[5] They can reduce errors[38] and contribute to lists of problem names, jog attention and inform about specific properties of LASA pairs, such as names that share the initial 3 letters, which are more likely to be confused. However, professionals can over-ride computerized warnings and there is associated alert fatigue.[60]

7 | SUMMARY

LASA errors between similar medication names pose a complex problem, with the potential to cause fatal or devastating harm to patients. Estimates of prevalence are wide-ranging, and are based on multiple, competing definitions. Several solutions are available, some of which focus on reducing variability in human behaviour (person approaches, such as limiting work interruptions) and others, which seek to identify risk factors or weaknesses in the nomenclature system and create safeguards (system approaches, such as Tall Man lettering).

COMPETING INTERESTS
R.B., A.W. and S.J. have no conflicts of interest to declare. J.K.A. has published papers on adverse drug reactions and medical linguistics and has edited textbooks on adverse drug reactions; he has acted as an expert witness in cases related to adverse drug reactions; he chairs an expert working group on nomenclature for the British Pharmacopoeia Commission and is an Associate Editor of BMJ Evidence Based Medicine and President Emeritus of the British Pharmacological Society.

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