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Incorrect drug selection at the point of dispensing: a study of potential predisposing factors

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Abstract

Objective To determine potential predisposing factors to medication errors involving confusion between drug names, strengths and dosage forms.
Methods The study analysed medication errors reported over the period January 2005 to December 2008 from the two main dispensaries of a 1200-bed NHS Foundation Hospital Trust in London. Dispensing incidents considered for analysis included all incidents involving drug name, strength and dosage label and content errors. Statistical analyses were performed using Statistica. Dispensing frequencies of the prescribed and wrongly dispensed drugs were compared by means of Wilcoxon signed-rank test, and the extent of correlation between dispensing frequency and error frequency was assessed using Spearman's rank correlation coefficient.
Key findings The Trust recorded a total of 911 dispensing errors between 2005 and 2008. The most significant category, which accounted for 211 (23.2%) of the reported errors, involved errors in drug selection. Drug-selection errors were not random events because the plot of error frequency against the average yearly dispensing frequency for the 1000 most issued drugs showed little evidence of association ($r = 0.19$, $P(\alpha) = 0.03$). There was, however, an increased likelihood of drug-selection errors occurring when the prescribed drug was dispensed with relatively low frequency and shows a significant orthographic similarity to another drug which has a higher dispensing frequency.
Conclusion The majority of drug-selection errors would seem to be caused by insufficient attention paid to the specified drug strength. Dispensing frequency is an important factor influencing the likelihood of a drug-selection errors occurring, but it is also shown here that a large proportion of the drug-selection errors involved specifications exhibiting high orthographic similarity.

Introduction

Medicines with similar-sounding names, and drug names that look alike, have led to a number of serious errors, and continue to threaten patient safety in spite of error-prevention measures adopted by licensing agencies and various healthcare systems.[1,2] Currently, licensing agencies employ a variety of pre-approval tests to determine the vulnerability of new drugs to similar name confusion. These include conducting computer searches for existing similar names or products, soliciting expert judgements about confusability, performing traditional psycholinguistic tests on memory and perception, and observing error rates during simulated ordering, dispensing and administration.[1,3]

It has been observed that look-alike drug specifications (i.e. drugs with similar alphanumeric spelling of drug name, strength and dosage form) are most likely to be adjacent to each other in drug indexes and on the computer screen menus of healthcare IT systems.[4] As a result, there is a potential risk of pharmacists selecting and supplying the wrong medication. Cognitive psychology has identified errors in visual perception, short-term memory and auditory perception as fundamental human factors that influence name confusion.[5] Name confusion has also been linked to orthographic (spelling) and phonetic (sound) similarity between names and the frequency with which names are encountered in print.[6–9] Studies have shown that words encountered frequently are identified more quickly and accurately than those encountered less frequently.[9,10] Furthermore, quantitative similarity evaluation tests on drug names have led to the basic assumption that similarity increases confusability and so – all other things been equal – a reduction in name similarity between newly registered drugs and existing ones (and ideally also between existing ones) may reduce drug-name confusion errors.[11–14]

Lambert and colleagues[10] investigated visual perception in drug-name similarity errors and concluded that 'pharmacists' visual perception is affected in predictable ways by objectively measurable properties of names, such as; prescribing frequency, neighbourhood density and frequency'. The study investigated the effect of orthographic similarity and prescribing frequency on a pharmacists' ability to identify accurately 'blurry', briefly presented, handwritten and typewritten drug names.[10] The results showed that commonly encountered drug names (e.g. Ventolin and Dyazide) were less likely to be misperceived than less commonly encountered drug names (e.g. Flexeril and Antispas). Although the precise mechanism by which the frequency of word use exerts these effects is not known, Lambert and colleagues suggested that 'presentation of a target word results in the activation of all lexical representations that share features with the target word, i.e. higher frequency word nodes have higher resting activation levels and hence are quicker to exceed a recognition threshold'.[10] If this assertion is true, the consequence would then be that if drugs A and B have similar names, and if drug A is often dispensed, while drug B is rarely dispensed, when drug A is prescribed it is unlikely for it to be the subject of error, but when B is prescribed there is a high probability that drug A would be dispensed instead. Lambert *et al.*'s study[10] was limited in that it involved *simulated* and not real medication-error data. In addition, the researchers disregarded the non-name attributes of drug strength and dosage form in their analyses, despite the fact that similarities between the same drug name but different strengths and/or dosage forms are thought to increase the likelihood of medication error.[15]

In the studies reported here, the aim was to determine whether medication errors involving confusion between drug name, strength and dosage form (a) occur entirely at random, (b) occur such that the erroneously dispensed and prescribed specifications exhibit a pronounced difference in dispensing frequency (with the latter being the more infrequently dispensed) and/or (c) occur such that the erroneously dispensed and prescribed specifications are confused because of their orthographic similarity.

Methods

Data (originally procured through routine audits, in line with National Patient Safety Agency (NPSA) recommendations) were obtained on all prevented and unprevented dispensing incidents reported over the period January 2005 to December 2008 from the two main dispensaries of a 1200-bed NHS Foundation Hospital Trust in London. Prescriptions to the pharmacy dispensary were handwritten by doctors in the wards or during outpatient clinics. The subset of these medication errors considered for analysis included all incidents involving drug name, strength and dosage-form label and content errors, with individually dispensed items issued in accordance with inpatient medication charts, discharge prescriptions and outpatient prescriptions. The medication errors excluded from analysis were those that arose during the screening of prescriptions for clinical safety or legal validity, those involving the reconstitution or preparation of extemporaneous products and those involving dispensed items not classified as medicines (e.g. dressings). The computer dispensing system at the study site was designed by JAC Computer Services (subsidiary of Mediware Information).

Medication errors involving mismatches between prescribed and dispensed drug name, strength and dosage form were referred to as error pairs, and the number of times a given error pair appeared in the Trust's incident reports was taken as the frequency of error.

The hospital Trust's dispensary records were used to determine the number of times each drug was dispensed within a year, and the mean of these annual figures was taken as the dispensing frequency for that drug.

The orthographic similarity of error pairs was quantified using the metric of (Levenshtein) Edit distance (computed using an in-house Visual Basic coding of the Wagner–Fischer algorithm[16]). The Edit distance prognostic test compares two strings in terms of their alphanumeric spelling, taking no account of possible phonetic similarities in spoken English; it is defined simply as the number of characters required to be deleted and/inserted to transform one word to another without change of character position. The lower the Edit distance the more similar the spellings of the matched alphanumeric strings.

Statistical analyses were performed using Statistica (version 8; Statsoft Inc., Tulsa, OK, USA). Dispensing frequencies of the wrong drug, strength and dosage forms involved in error pairs were compared by means of Wilcoxon signed-rank test, and the extent of correlation between dispensing frequency and error frequency was presented on a logarithmic-scale graph and and assessed using Spearman rank correlation coefficient.

Results

The Trust recorded a total of 911 dispensing errors between 2005 and 2008. Of these, 211 (23.2%), comprising 139 specific error pairs, were drug-selection errors, with 122 featuring incorrect drug strength, 65 incorrect drug name and 24 incorrect dosage form. Details of these errors, including the error frequencies, the wrong drug name, strength and dosage forms involved, together with their dispensing frequencies and Edit distances, are presented in Tables 1–3.

To test the hypothesis that errors involving mismatched prescribed and dispensed drug selections occur entirely at random (such that the number of errors increases with increasing dispensing frequency), the numbers of errors for given specifications were analysed as a function of dispensing frequency. The plot of error frequency against the average yearly issue frequency for the 1000 most issued drugs dispensed within the study period shows only relatively low association (with $r = 0.19$, $P(\alpha) = 0.03$; Figure 1). It is thus concluded that drug-selection errors are not random events, and dispensing frequency may just be one of several factors that needs to be considered in determining their origin.

To test the assertion that drugs issued frequently are more likely to generate confusion (and result in drug-selection errors) when orthographically similar specifications are prescribed that have significantly lower issue frequencies,[10] the Edit distances for all dispensed and prescribed drugs in the recorded error pairs were computed, and the mean dispensing frequencies for the two sets of drugs compared. We initially considered only those pairs with an Edit distance of 3 or less (the threshold previously used to define orthographic similarity between drug names[10]). Such a comparison shows that there is indeed a significant difference between the mean dispensing frequencies for the prescribed (884.26 ± 85.08) and erroneously dispensed (1309.95 ± 112.52) drugs ($P(\alpha) \leq 0.001$). Inspection of the distribution of drug-selection errors as a function of Edit distance (Figure 2), however, shows that the use of a threshold of 3 to define orthographic similarity is perhaps inappropriate. The majority of drug-selection errors (65%, $n = 137$) have Edit distances in the range 1–4 (with the peak at Edit distance 2). Taking a revised Edit distance threshold of 4 to define orthographic similarity, however, does not alter our conclusion: the mean yearly issue frequencies for the prescribed (841.86 ± 78.44) and erroneously dispensed (1320.58 ± 121.78) drugs are still significantly different ($P(\alpha) = 0.008$).

Further inspection of Figure 2 shows that the number of drug-selection errors is not normally distributed, nor does it decay monotonically from the peak at Edit distance 2; but clearly shows evidence of a second peak around Edit distance 7. In light of these findings, it was thus deemed sensible to abandon the Edit distance threshold altogether, and to compare the issue frequencies for prescribed and erroneously dispensed drugs taking account of *all* recorded drug-selection errors. When we did so, we then found that the mean yearly issue frequencies for the prescribed (670.05 ± 56.03) and erroneously dispensed (1052 ± 97.91) drugs *still* showed a significant difference ($P(\alpha) \leq 0.006$).

Given that orthographically similar drugs will be listed and presented close to one another in the selection menus on

Table 1 Dosage-form error pairs, Edit distance, number of errors and dispensing frequency

Drug name, strength and dosage form		Edit distance	Number of errors	Yearly dispensing frequency	
Prescribed	Dispensed			Prescribed	Dispensed
Beclometasone dipropionate easi-breathe 100 mcg inhaler	Beclometasone dipropionate 100 mcg inhaler	12	1	36	680
Clotrimazole 500 mg pessaries	Clotrimazole 1% cream	13	1	344	709
Co-codamol 30/500 soluble tablets	Co-codamol 30/500 mg tablets	7	1	455	910
Diclofenac sodium 50 mg soluble tablets	Diclofenac sodium 50 mg ec tablets	7	1	101	7422
Dihydrocodeine 10 mg in 5 ml elixir	Dihydrocodeine 30 mg tablets	12	1	115	6845
Epoetin cartridges	Epoetin prefilled syringes	13	1	0	124
Fentanyl 25 mcg patch	Fentanyl 100 mcg/2 ml injection	11	1	226	799
Fluconazole 50 mg/5 ml suspension	Fluconazole 50 mg capsules	14	1	395	775
Fucidin h cream	Fucidin h ointment	7	1	79	58
Hepatitis b vaccine	Hepatitis b immunoglobulin	13	1	93	53
Hydrocortisone 1% ointment	Hydrocortisone 1% cream	7	2	166	328
Itraconazole liquid	Itraconazole capsule	4	1	148	36
Morphine sulphate 10 mg tablets	Morphine sulphate 10 mg sr tablets	2	1	1286	686
Naproxen 250 mg tablets	Naproxen 250 mg ec tablets	2	2	90	29
Prednisolone 5 mg ec tablets	Prednisolone 5 mg tablets	2	3	794	3721
Salbutamol 100 micrograms per metered dose inhaler	Salbutamol easi-breathe 100 mcg inhaler	13	1	2130	145
Serevent 50 mcg accuhaler	Seretide 50 mcg inhaler	10	1	12	14
Sodium chloride 0.9% injection	Sodium chloride 0.9% irrigation	7	1	173	80
Sodium valproate 200 mg chrono tablets	Sodium valproate 200 mg ec tablets	7	1	886	156
Sulfasalazine 500 mg ec tablets	Sulfasalazine 500 mg tablets	2	1	128	48

Table 2 Drug-name error pairs, Edit distance, number of errors and dispensing frequency

Drug name, strength and dosage form		Edit distance	Number of errors	Yearly dispensing frequency	
Prescribed	Dispensed			Prescribed	Dispensed
Adcal tablets	Adcal-d3 tablets	3	6	536	2632
Adcal-d3 tablets	Adcal tablets	3	2	2632	536
Adcortyl in orabase	Orabase	10	2	26	25
Allopurinol 100 mg tablets	Amiodarone 100 mg tablets	7	3	355	19
Azithromycin 500 mg tablets	Clarithromycin 500 mg tablets	5	1	37	752
Balneum bath additive	Balneum plus bath additive	4	1	28	11
Calcitriol 0.25 mcg capsules	Alfacalcidol 0.25 mcg capsules	8	1	43	411
Candesartan 16 mg tablets	Ondansetron 16 mg tablets	9	1	163	32
Chloramphenicol 5% ear drops	Chloramphenicol 0.5% eye drops	4	1	6	1361
Clarithromycin 500 mg tablets	Ciprofloxacin 500 mg tablets	8	3	886	3190
Clobazam 10 mg tablets	Clomifene 50 mg tablets	7	3	77	209
Clonidine injection	Clonazepam injection	6	1	13	24
Co-amilofruse 5/40 mg tablets	Co-amilozide 5/50 mg tablets	7	2	495	8
Co-danthramer suspension	Co-danthramer forte suspension	6	1	22	5
Colchicine 500 mcg tablets	Clomifene 50 mg tablets	7	1	270	209
Colestyramine 4 g sachets	Chlorphenamine 4 mg tablets	11	1	18	798
Co-trimoxazole forte 960 mg tablets	Co-trimoxazole 480 mg tablets	8	4	200	242
Cyclophosphamide 50 mg tablets	Ciclosporin 50 mg capsules	14	1	277	152
Doxazosin 4 mg tablets	Candesartan 4 mg tablets	9	1	687	253
Emulsiderm bath additive	Epaderm cream	17	1	90	105
Emulsiderm bath additive	Epaderm ointment	17	1	90	115
Erythromycin 250 mg/5 ml syrup	Clarithromycin 250 mg/5 ml syrup	4	1	102	127
Forceval capsules	Forceval junior capsules	7	1	179	1
Fucibet cream	Fusidic acid 2% cream	12	3	318	166
Gentisone hc ear drops	Gentamicin 0.3% eye/ear drops	13	2	277	67
Hydralazine 25 mg tablets	Hydroxyzine 25 mg tablets	4	3	118	322
Hydroxyzine 25 mg tablets	Hydroxychloroquine 200 mg tablets	11	1	322	407
Melphalan 2 mg tablets	Chlorambucil 2 mg tablets	10	1	32	65
Mercaptopurine 50 mg tablets	Mercaptamine 50 mg capsules	9	1	88	5
Metformin 500 mg tablets	Mefenamic acid 500 mg tablets	10	1	1283	298
Metoprolol 50 mg tablets	Metoclopramide 10 mg tablets	9	1	456	1055
Midazolam 10 mg/2 ml injection	Metoclopramide 10 mg/2 ml injection	10	1	92	34
Ondansetron 4 mg tablets	Granisetron 1 mg tablets	5	1	291	271
Oxycodone 20 mg	Oxycontin 20 mg	4	1	111	104
Potassium chloride 600 mg sr tablets	Potassium bicarbonate 500 mg effervescent tablets	14	1	279	2
Predsol eye drops	Pred forte eye drops	5	1	496	321
Procyclidine 5 mg tablets	Prochlorperazine 5 mg tablets	10	2	1577	422
Promethazine 25 mg tablet	Prochlorperazine 5 mg tablet	11	1	458	422
Tenefovir tablets	Truvada tablets	8	4	135	127

dispensing computer systems, it was elected to determine the distribution of drug-selection errors as a function of the proximity of the confused drug specifications (i.e. drug name, strength and dosage form) on the JAC dispensing computer stock list. The proximity of the specifications on the stock list was quantified simply in terms of the number of intervening specifications, with negative values relating to dispensed specifications that precede the prescribed specification and positive values indicating dispensed specifications that follow the prescribed specification on the list. What we then found was that the percentage of drug-selection errors is normally distributed with respect to the proximity of the drug specifications on the computer stock list (Figure 3). Almost half (45%, $n = 97$) of the drug-selection errors (involving 68 (49%) of the error pairs) had the prescribed and wrongly dispensed drug specifications lying next to each other on the dispensing computer stock list. Of these error pairs, 84% ($n = 57$) had Edit distances of 1–4. It is significant to note too that the wrongly dispensed drug specifications were more or less equally distributed between those preceding and those following the prescribed specifications on the list.

Table 3 Drug-strength error pairs, Edit distance, number of errors and dispensing frequency

Drug name, strength and dosage form		Edit distance	Number of errors	Yearly dispensing frequency	
Prescribed	Dispensed			Prescribed	Dispensed
Alfacaicidiol 0.25 mcg capsules	Alfacaicidiol 1 mcg capsules	4	1	411	142
Alfacaicidiol 1 mcg capsules	Alfacaicidiol 0.25 mcg capsules	4	1	142	411
Aminophylline 450 mg tablets	Aminophylline 225 mg tablets	3	1	39	171
amitriptyline 10 mg tablets	Amitriptyline 25 mg tablets	2	2	832	662
Amitriptyline 25 mg tablets	Amitriptyline 50 mg tablets	2	3	662	593
Amlodipine 10 mg tablets	Amlodipine 5 mg tablets	2	2	1174	1326
Amlodipine 5 mg tablets	Amlodipine 10 mg tablets	2	2	1326	1174
Amoxicillin 250 mg capsules	Amoxicillin 500 mg capsules	2	3	3079	3545
Amoxicillin 250 mg/5 ml sf syrup	Amoxicillin 125 mg/5 ml sf syrup	3	3	335	285
Amoxicillin 500 mg capsules	Amoxicillin 250 mg capsules	2	4	3545	3079
Atenelol 25 mg tablets	Atenelol 50 mg tablets	2	1	650	1027
Atenolol 100 mg tablets	Atenolol 50 mg tablets	2	1	274	1027
Atenolol 50 mg tablets	Atenolol 100 mg tablets	2	1	1027	274
Atorvastatin 10 mg tablets	Atorvastatin 20 mg tablets	1	1	661	615
Beclometasone dipropionate 250 mcg inhaler	Beclometasone dipropionate 100 mcg inhaler	2	1	113	761
Bisoprolol 10 mg tablets	Bisoprolol 5 mg tablets	2	1	192	426
Carbamezapine 200 mg tablets	Carbamezapine 400 mg tablets	1	1	143	51
Ceftazidime 1 g injection	Ceftazidime 2 g injection	1	2	497	251
Ceftazidime 2 g injection	Ceftriaxone 2 g injection	7	1	251	149
Chloramphenicol 1% eye ointment	Chloramphenicol 0.5% eye drops	11	2	1174	1361
Ciclosporin 50 mg capsules	Ciclosporin 25 mg capsules	2	2	323	290
Ciprofloxacin 250 mg tablets	Ciprofloxacin 500 mg tablets	2	7	678	3190
Ciprofloxacin 500 mg tablets	Ciprofloxacin 250 mg tablets	2	1	3190	678
Clarithromycin 250 mg tablets	Clarithromycin 500 mg tablets	2	1	408	886
Clarithromycin 500 mg tablets	Clarithromycin 250 mg tablets	2	3	886	408
Co-amoxiclav 375 mg tablets	Co-amoxiclav 625 mg tablets	2	1	3773	3172
Co-amoxiclav 312.5 mg in 5 ml suspension	Co-amoxiclav 156.5 mg in 5 ml suspension	3	1	631	237
Co-careldopa 25/100 mg mr tablets	Co-careldopa 12.5/50 mg tablets	7	1	24	58
Co-codamol 8/500 mg tablets	Co-codamol 30/500 mg tablets	2	2	2084	910
Dapsone 50 mg tablets	Dapsone 100 mg tablets	2	1	86	39
Dexamethasone 2 mg tablets	Dexamethasone 0.5 mg tablets	3	2	1711	75
Diclofenac sodium 100 mg suppositories	Diclofenac sodium 50 mg suppositories	2	1	595	91
Diclofenac sodium 75 mg mr tablets	Diclofenac sodium 50 mg ec tablets	4	2	921	7422
Diclofenac sodium 75 mg mr tablets	Diclofenac potassium 50 mg tablets	10	1	921	2
Digoxin 125 mcg tablets	Digoxin 250 mcg tablets	2	1	514	183
Dipyridamole 200 mg mr capsules	Dipyridamole 100 mg tablets	9	1	289	6
Enoxaparin 100 mg/1 ml injection	Enoxaparin 40 mg/1 ml injection	2	1	349	1098
Enoxaparin syringes 120 mg/0.8 ml injection	Enoxaparin syringes 150 mg/1 ml injection	4	1	329	132
Erythromycin 250 mg tablets	Erythromycin 500 mg tablets	2	1	821	185
Erythromycin 500 mg tablets	Erythromycin 250 mg tablets	2	2	185	821
Fentanyl 500 mcg in10 ml injection	Fentanyl 100 mg in 2 ml injection	3	1	618	1686
Flucloxacillin 500 mg capsules	Flucloxacillin 250 mg capsules	2	1	2642	322
Fluconazole 150 mg capsules	Fluconazole 200 mg capsules	2	1	271	141
Fluconazole 200 mg capsules	Fluconazole 50 mg capsules	2	2	141	775
Folic acid 400 mcg tablets	Folic acid 5 mg tablets	4	1	220	2031
Gabapentin 300 mg capsules	Gabapentin 100 mg capsules	1	1	941	377
Gabapentin 300 mg capsules	Gabapentin 400 mg capsules	1	1	941	74
Hydrocortisone 0.5% cream	Hydrocortisone 1% cream	3	1	68	328
Ibuprofen 200 mg tablets	Ibuprofen 400 mg tablets	1	1	591	2950
Interferon 30 megaunits	Interferon 60 megaunits	1	1	54	38
Irbesartan 75 mg tablets	Irbesartan 150 mg tablets	2	1	77	141
Lansoprazole 15 mg tablets	Lansoprazole 30 mg tablets	2	2	428	1758
levothyroxine sodium 25 mcg tablets	levothyroxine sodium 100 mcg tablets	3	1	919	620
Lithium 200 mg tablets	Lithium 400 mg tablets	1	1	579	1217

Table 3 (*Continued*)

Drug name, strength and dosage form		Edit distance	Number of errors	Yearly dispensing frequency	
Prescribed	Dispensed			Prescribed	Dispensed
Losartan potassium 25 mg tablets	Losartan potassium 50 mg tablets	2	1	131	506
Metformin 500 mg tablets	Metformin 850 mg tablets	2	1	1283	285
Metronidazole 200 mg tablets	Metronidazole 400 mg tablets	1	3	1113	3487
Metronidazole 400 mg tablets	Metronidazole 200 mg tablets	1	1	3487	1113
Mirtazepine 15 mg tablets	Mirtazepine 30 mg tablets	2	1	217	391
Morphine sulphate 20 mg tablets	Morphine sulphate 10 mg tablets	1	3	465	1286
Nicorandil 20 mg tablets	Nicorandil 10 mg tablets	1	1	221	366
Nitrofurantoin 50 mg capsules	Nitrofurantoin 100 mg tablets	7	1	137	55
Octreotide 25 mcg in 1 ml injection	Octreotide 50 mcg in 1 ml injection	2	1	21	72
Omeprazole 10 mg capsule	Omeprazole 20 mg capsule	1	1	158	6340
Oxynorm 10 mg capsules	Oxynorm 5 mg capsules	2	1	426	624
Peg interferon 100 mcg	Peg interferon 150 mcg	1	1	81	116
Prednisolone 2.5 mg ec tablets	Prednisolone 5 mg ec tablets	2	1	228	794
Pregabalin 25 mg capsules	Pregabalin 75 mg capsules	1	3	232	260
Quetiapine 25 mg tablets	Quetiapine 200 mg tablets	2	1	322	486
Quetiapine 25 mg tablets	Quetiapine 100 mg tablets	3	1	322	178
Ramipril 2.5 mg capsules	Ramipril 5 mg capsules	2	1	303	254
Salbutamol 5 mg in 2.5 ml respirator solution	Salbutamol 2.5 mg in 2.5 ml respirator solution	2	1	122	422
Simvastatin 10 mg tablets	Simvastatin 20 mg tablets	1	1	303	1289
Simvastatin 40 mg tablets	Simvastatin 20 mg tablets	1	2	2695	1289
Solifenacin 10 mg tablets	Solifenacin 5 mg tablets	2	1	262	606
Solifenacin 5 mg tablets	Solifenacin 10 mg tablets	2	1	606	262
Temazepam 20 mg tablets	Temazepam 10 mg tablets	1	1	92	919
Trimethoprim 100 mg tablets	Trimethoprim 200 mg tablets	1	2	156	913
Zopiclone 3.75 mg tablets	Zopiclone 7.5 mg tablets	2	6	851	2093
Zopiclone 7.5 mg tablets	Zopiclone 3.75 mg tablets	2	1	2093	851

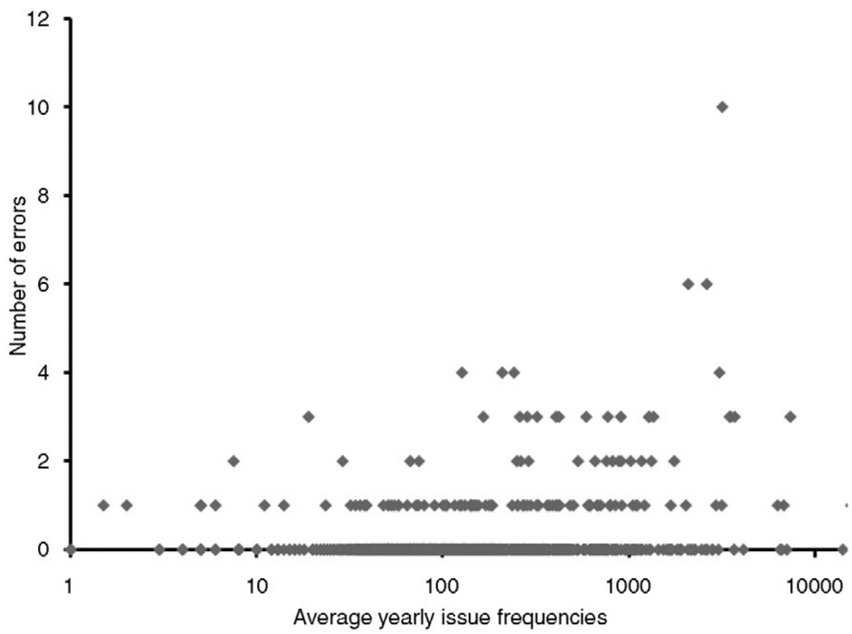

Figure 1 Distribution of drug-specification errors as a function of issue frequency, for the top 1000 drug issues at the study site between 2005 and 2008. Correlation coefficient (r) = 0.19.

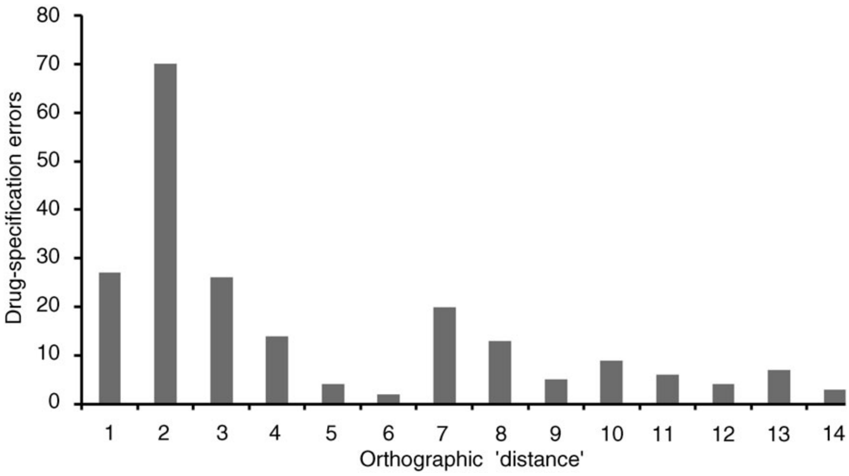

Figure 2 The distribution of drug-specification errors as a function of the Edit distance/orthographic similarity of the prescribed and dispensed drug specifications.

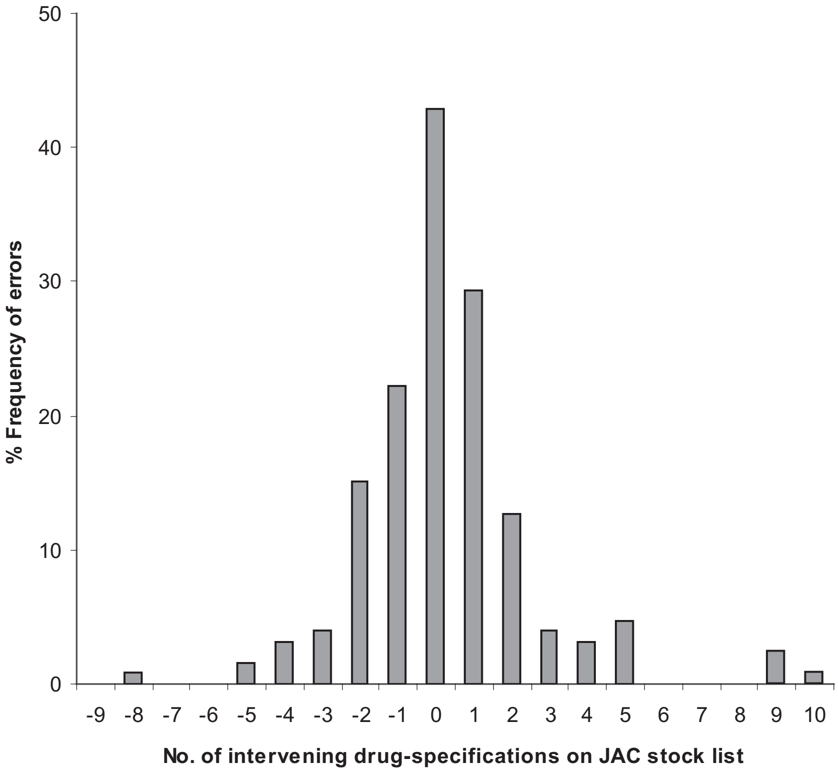

Figure 3 Percentage frequency of drug-specification errors as a function of the proximity of the prescribed and dispensed drug specifications on the JAC stock list.

Discussion

Main findings

At the study site, the observed drug-selection errors were shown not to be random, were more likely to occur when drugs with a low yearly dispensing frequency were prescribed. Dispensing frequency is thus shown to be an important factor influencing the likelihood of a drug-selection error occurring, but it is also shown here that a large proportion of the drug-selection errors involved specifications exhibiting high orthographic similarity, as quantified using the metric of

(Levenshtein) Edit distance. The explanation of the observed error distribution (Figure 2) was ultimately shown to arise because the prescribed and erroneously selected drug specifications were listed close to one another on the JAC stock list and would thus be displayed in close proximity on the dispensary computer menus. It is proposed therefore that the majority of the reported drug-selection errors occurred because the pharmacy staff scrolled through the menu list of available specifications, eventually alighting at and selecting a specification close to the one required; a specification that, in most cases therefore would show a significant orthographic similarity to the prescribed specification and/or appear close to it in the menu list on the dispensary computer.

Confusion between drug *names* is shown not to be as important as previously supposed,[11,13,17] given that the error set analysed here shows that confusion between similar drug specifications (drug name, strength and dosage form) arises primarily because of confusion over *non-name* attributes,[15] with only 31% of the recorded drug-selection errors involving confusion over drug name. Moreover, the distribution of drug-selection errors (Figure 2) shows two peaks, at Edit distances of 2 and 7, and inspection of the errors (Tables 1–3) reveals that the former generally correspond to specifications that differ as regards drug strength (e.g. 'Amlodipine 5 mg tablets' and 'Amlodipine 10 mg tablets') whereas the latter very often correspond to specifications with differences in dosage form (e.g. 'Hydrocortisone 1 mg cream' and 'Hydrocorisone 1 mg ointment').

This study has implications outside the pharmacy: at the point of prescription writing, transcription and medicines administration. Computer Physician Order Entrys have pull-down menus of drug specifications identical to those found on dispensing computers. This means that the selection of medicines during the prescribing process could be compromised by the similarity/proximity phenomena identified in this study. From NPSA reports, drug-selection confusion errors which occur at the point of medicine administration have a high potential to harm patients.[18–20]

Study limitations

A limitation of the current study was that the incident data included a mixture of both prevented and unprevented dispensing incidents, and so the adverse drug event potential of the incidents was assumed. It could also be argued that errors were treated as if they occurred in an abstract environment, whereas in reality they occurred within complex organisational environments. Thus, the causative factors of the incidents analysed in this study may be more complex than considered here. The data analysed in this study were self-reported dispensing incidents, which may not be a true reflection of the actual number of incidents that occurred within the study period. This is because self-reporting of incidents has been found to be less effective than direct observation.[21] It should also be noted here that the data involved exclusively generic drug names, which are the names preferred for prescribing in the UK. However, the conclusions from this study are likely to be just as relevant for dispensaries (e.g. those in other countries) where computer drug lists are employed that involve branded drug names.

In its recent report, *Safety in Doses: Improving the Use of Medicines in the NHS*, the NPSA identified the threat that drug-name confusion poses to patient safety.[18] In consequence, the report recommended that strategies for the purchase and storage of high-risk medicines should take account of potential name confusion. The present studies were designed to explore the origins of medication errors involving confusion over drug *specification*, and including errors involving confusion of drug strength and form as well those involving confusion of drug name. Previous related studies[10,11,13,17] were limited in that they did not consider the strengths and dosage forms, while only focusing on drug brand. In the studies reported here therefore the aim was to conduct analyses using real incident data with drug (generic) specification (name, strength and dosage form) confusion errors as the unit of analysis. The studies focused on the relationship between the frequency of drug-selection errors and dispensing frequency, and the relevance of the orthographic similarity of confused drug specifications. The Edit distance prognostic test[22] was used to compute the orthographic similarity of drug specifications because previous studies have shown it to be more useful than other prognostic tests, such as the bigram and trigram.[12]

Preventive strategies

In line with NPSA recommendations, managers at the study sites had measures in place to address some drug-selection confusion errors. The overriding concern of patient safety advocates is to prevent harm that may result when a patient receives the wrong drug. In recommending strategies for preventing drug name, strength and dosage form confusion therefore emphasis should be on medications that have the potential to harm patients if wrongly administered. Based on the findings from this study, the following recommendations could help in reducing drug-selection errors.

- All drugs that are easily confused should be kept separate; that is, if one is kept in the Automated Dispensing System the other should be kept on shelves.
- 'Tallman' lettering and coloured lettering should be used to highlight unique aspects of a drug specification on packages and computer menus.[23,24] The NPSA, in conjunction with the Medicines Health Product Regulatory Agency (MHRA), have released a new labelling protocol for cephalosporins using Tallman lettering and colour lettering to

highlight unique aspects of the drug name (e.g. ceFIXime, cefALEXin) to reduce mis-selection.[25] This could be extended to other drugs that have been identified as prone to drug-selection confusion and have a high potential for adverse drug events.

- Most dispensaries have alerts on shelves to warn staff of the possibility of confusing one drug with another. However, this could be extended to dispensing computer screen menus where one could be required to go through additional steps to select a specific drug, strength and form which has a high confusion potential. Drug-selection screen menus could be modified to have different fields for drug name, strength and form, identical to Computer Physician Order Entrys. Other strategies could include programming alerts into the computer software to highlight drug specifications with similar spelling, using different typefaces and colours to emphasise different forms and strengths of the same drug.[26]

Conclusions

It has been confirmed that the majority of drug-selection errors are related to confusion between different strengths of the same drug. Therefore, restricting look-alike/sound-alike prevention strategies only to drug names may fail to address the problem. The use of enhanced text such as Tallman lettering may highlight sections of the drug specification (drug name, strength and dosage form) which offer a potential source of confusion. Other error-prevention measures suggested are the use of different fields for the drug name, strength and dosage form on the dispensing computer menu to prevent selection errors. There may, however, be a need for user testing to determine the error-prevention potential and drug-selection efficiency of such measures.

Declarations

Conflict of interest

The Author(s) declare(s) that they have no conflicts of interest to disclose.

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