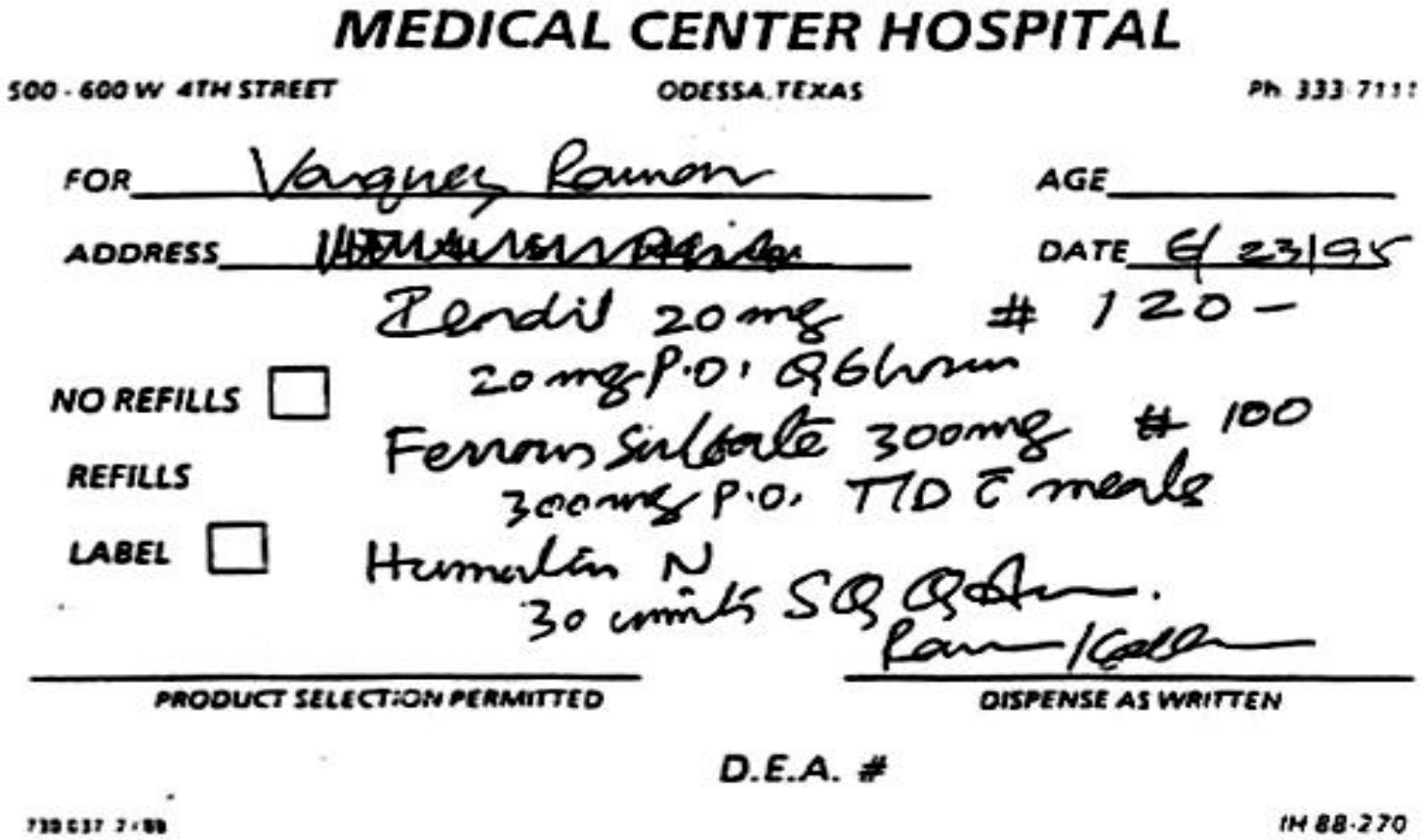
Abstract

Confusions between drug products that look and sound alike continue to be a threat to patient safety in both inpatient and outpatient settings. Although regulatory agencies such as the FDA are attempting to develop better pre-approval screening methods for proposed new drug names, confusing drug names that are already on the market represent an ongoing risk that needs to be minimized. Computerized order entry systems offer several methods (e.g., dose checking) to prevent drug product confusions, but such systems are not yet widely available. We believe a more efficient strategy is to mistake-proof one's formulary by identifying the pairs of products that are most likely to result in clinically significant confusions and then taking action on that small set of targeted products. Specifically, our process is as follows: (a) compile a formulary database consisting of each drug name with its associated strength, dosage form, and route of administration; (b) create two subsets, one of oral solid dosage forms, one of injectable dosage forms; (c) compute similarity scores between all names in each subset; (d) identify all pairs whose name similarities exceed some threshold and whose other attributes are identical; (e) have expert clinicians screen those pairs for severity of consequences of a confusion; and (f) propose, implement, and evaluate interventions to deal with the most problematic pairs. We will illustrate this process using the formulary from Riverside HealthCare in Kankakee, IL.



MEDICAL CENTER HOSPITAL

500 - 600 W 4TH STREET ODESSA, TEXAS Ph. 333-7111

FOR Vasquez Ramon AGE

ADDRESS [redacted] DATE 6/23/95

Zestril 20 mg # 120 -
20 mg P.O. Q6hrs prn

NO REFILLS ☐

Ferrous Sulfate 300 mg # 100
300 mg P.O. TID c meals

REFILLS

LABEL ☐

Humulin N
30 units SQ Q AM.
Ramon Gallegos

PRODUCT SELECTION PERMITTED

DISPENSE AS WRITTEN

D.E.A. #

IH 88-270

http://www.medmal-law.com/illegibl.htm

Plendil or Isordil?

- Isordil® prescribed
- Plendil® dispensed
- Cardiologist found negligent
- $450,000 damage award
- First ever award for bad penmanship!

Drug Name Confusions

- Account for 15-25% of all reported medication errors in the US
- Specifically identified by IOM in their report on medical errors
- Mandated initiatives underway at FDA to address the problem
- Several ongoing ‘disasters’ involving high-profile products

Why Do These Errors Happen

- Similarity- and frequency-based errors in cognitive processing
- Memory (recall and recognition)
- Perception (visual and auditory)
- Motor control (picking wrong drug from drop-down menu)
- Poorly designed systems (e.g., handwritten orders, oral orders, no CPOE, etc.)

Examples (from USP-MERP)

- Lamisil® vs. Lamicel®
- Accupril® vs. Accutane®
- Celebrex® vs. Celexa®
- Cisplatin vs. carboplatin
- Hydroxyzine vs. Hydralazine
- Zosyn® vs. Zofran®
- Prilosec® vs. Prozac®
- Pediapred® vs. Pediaprofen®
- Prepridil® vs. Bepridil®

Objective Measures of Name Similarity

- N-gram measures of spelling similarity (e.g., bigram, trigram)
- Edit distance
- Phonetic measures (e.g., editex)
- Phonological measures
- Multiple attribute measures
- These measures have been validated in several peer-reviewed publications

Overview of Method

- Clean and prep formulary database
- Create two subsets
  - Oral solid dosage forms
  - Injectable dosage forms
- Compute similarity scores between all name pairs
- Identify all pairs whose name similarities exceed some threshold and that match on other attributes
- Screen selected pairs for severity of consequences of a confusion
- Propose, implement, and evaluate interventions to deal with the most problematic pairs

Drug Product Attributes

- Brand name
- Generic name
- Strength
- Dosage form
- Route of administration
- Pharmacologic category

Analysis Plan and Organization of Results

- Select pairs that exceed threshold of similarity or distance
- Sort in ascending order of distance
- Link to known error pairs and indicate which pairs have been previously reported as confusing
- Tally total number of pairs and number of previously reported pairs

Increasing Levels of Similarity

1. Name similarity only (distance<=8)
2. Similar name and identical strength
3. Name, strength, and one member of pair must be in “high alert” category (e.g., opiates, antineoplastics)
4. Name, strength, route of administration

Injectables: Name Similarity Only

3; **LIPID 10% INJ**; 0.1; LIPID; CALORIC AGENTS; IV PIGGYBACK;
LIPID 20% INJ; 0.2; LIPID; CALORIC AGENTS; IV PIGGYBACK;
Unreported

5; **EPOGEN**; ; EPOETIN; HEMATOPOLETIC AGENTS; SUBCUTANEOUS;
NEUPOGEN; ; FILGRASTIM; UNCLASSIFIED THERAPEUTIC AGENTS; SUBCUTANEOUS;
Reported

5; **TOBRAMYCIN**; ; TOBRAMYCIN; AMINOGLYCOSIDES; IV PIGGYBACK;
VIBRAMYCIN; ; DOXYCYCLINE HYCLATE; TETRACYCLINES; IV PIGGYBACK;
Unreported

5; **PREMARIN**; ; CONJUGATED ESTROGENS; ESTROGENS; INTRAVENOUS;
PRIMAXIN; ; IMIPENEM-CILASTATIN; MISCELLANEOUS B-LACTAM ANTIBIOTICS; IV PIGGYBACK;
Reported

5; **LINCOMYCIN**; ; LINCOCIN; MISCELLANEOUS ANTIBIOTICS; INTRAMUSCULAR;
VANCOMYCIN; ; VANCOMYCIN; MISCELLANEOUS ANTIBIOTICS; IV PIGGYBACK;
Unreported

Injectables: Name, Strength, One Antineoplastic

6; **MITHRAMYCIN**; ; PLICAMYCIN INJ; ANTINEOPLASTIC AGENTS; IV PIGGYBACK;
MITOMYCIN; ; MUTAMYCIN; ANTINEOPLASTIC AGENTS; SYRINGE;
Reported

6; **MITHRAMYCIN**; ; PLICAMYCIN INJ; ANTINEOPLASTIC AGENTS; IV PIGGYBACK;
MUTAMYCIN; ; MITOMYCIN; ANTINEOPLASTIC AGENTS; SYRINGE;
Unreported

6; **STADOL**; ; BUTORPHANOL INJ; OPIATE PARTIAL; INTRAVENOUS;
TAXOL; ; PACLITAXEL; ANTINEOPLASTIC AGENTS; IV PIGGYBACK;
Unreported

7; **IDAMYCIN**; ; IDARUBICIN; ANTINEOPLASTIC AGENTS; SYRINGE;
MITOMYCIN; ; MUTAMYCIN; ANTINEOPLASTIC AGENTS; SYRINGE;
Unreported

7; **IDAMYCIN**; ; IDARUBICIN; ANTINEOPLASTIC AGENTS; SYRINGE;
MUTAMYCIN; ; MITOMYCIN; ANTINEOPLASTIC AGENTS; SYRINGE;
Unreported

Injectables: Name, Strength, One Antineoplastic, Route

7; **IDAMYCIN**; ; IDARUBICIN; ANTINEOPLASTIC AGENTS; SYRINGE;
MITOMYCIN; ; MUTAMYCIN; ANTINEOPLASTIC AGENTS; SYRINGE;
Unreported

7; **IDAMYCIN**; ; IDARUBICIN; ANTINEOPLASTIC AGENTS; SYRINGE;
MUTAMYCIN; ; MITOMYCIN; ANTINEOPLASTIC AGENTS; SYRINGE;
Unreported

8; **ADRIAMYCIN**; ; DOXORUBICIN; ANTINEOPLASTIC AGENTS; SYRINGE;
IDAMYCIN; ; IDARUBICIN; ANTINEOPLASTIC AGENTS; SYRINGE;
Reported

8; **ETOPOSIDE**; ; VEPESID; ANTINEOPLASTIC AGENTS; IV PIGGYBACK;
TENIPOSIDE; ; VUMON; ANTINEOPLASTIC AGENTS; IV PIGGYBACK;
Unreported

8; **MITHRAMYCIN**; ; PLICAMYCIN INJ; ANTINEOPLASTIC AGENTS; IV PIGGYBACK;
VIBRAMYCIN; ; DOXYCYCLINE HYCLATE; TETRACYCLINES; IV PIGGYBACK;
Unreported

Oral Solids: Name Similarity Only

2; **VITAMIN A**; 10,000 UNIT; VITAMIN A; VITAMIN A; ORAL;
VITAMIN E; 100UN; VITAMIN E; VITAMIN E; ORAL;
Unreported

3; **THYROLAR-2**; 25mcg/100mcg; LEVOTHYROXINE-LIOTHYRONINE; THYROID AGENTS; ORAL;
THYROLAR-3; 37mcg/150mcg; LEVOTHYROXINE-LIOTHYRONINE; THYROID AGENTS; ORAL;
Unreported

4; **MOTRIN**; 400MG; IBUPROFEN; NONSTEROIDAL ANTI-INFLAMMATORY AGENTS; ORAL;
MIDRIN; ; ISOMETHEPTENE-DICHLPHEN-APAP; MISCELLANEOUS ANALGESIC AND ANTIPYRETICS; ORAL;
Unreported

4; **NAPROSYN EC**; 375MG; NAPROXEN EC; NONSTEROIDAL ANTI-INFLAMMATORY AGENTS; ORAL;
NAPROXEN EC; 500MG; NAPROSYN EC; NONSTEROIDAL ANTI-INFLAMMATORY AGENTS; ORAL;
Unreported

4; **SOMA**; 350MG; CARISOPRODOL; SKELETAL MUSLE RELAXANTS; ORAL;
SENNA; ; SENOKOT; CATHARTICS AND LAXATIVES; ORAL;
Unreported

4; **PERMAX**; 0.05MG; PERGOLIDE; UNCLASSIFIED THERAPEUTIC AGENTS; ORAL;
VERMOX; 100MG; MEBENDAZOLE; ANTHELMINTICS; ORAL;
Unreported

Oral Solids: Name and Strength

5; **NIMODIPINE**; 30MG; NIMOTOP; UNCLASSIFIED THERAPEUTIC AGENTS; ORAL;
NIFEDIPINE; 30MG; PROCARDIA XL; CARDIAC DRUGS; ORAL;
Reported

5; **CLOZAPINE**; 25MG; CLOZARIL; ANTIDEPRESSANTS; ORAL;
LOXAPINE; 25MG; LOXITANE; TRANQUILIZERS; ORAL;
Unreported

5; **ADDERALL**; 10MG; AMPHETAMINE/DEXTROAMPHETAMINE; RESPIRATORY AND CEREBRAL STIMULANTS; ORAL;
INDERAL; 10MG; PROPRANOLOL; CARDIAC DRUGS; ORAL;
Reported

5; **RIMANTADINE**; 100MG; FLUMADINE; ANTIVIRALS; ORAL;
AMANTADINE; 100MG; SYMMETREL; UNCLASSIFIED THERAPEUTIC AGENTS; ORAL;
Reported

6; **ELAVIL**; 75MG; AMITRIPTYLINE; ANTIDEPRESSANTS; ORAL;
PLAVIX; 75MG; CLOPIDOGREL BISULFATE; UNCLASSIFIED THERAPEUTIC AGENTS; ORAL;
Reported

Oral Solids: Name, Strength, One Opiate

7; **DEMEROL**; 50MG; MEPERIDINE; OPIATE AGENTS; ORAL;
DESYREL; 50MG; TRAZODONE; ANTIDEPRESSANTS; ORAL;
Reported

7; **CARDENE**; 30MG; NICARDIPINE; CARDIAC DRUGS; ORAL;
CODEINE; 30MG; CODEINE; OPIATE AGENTS; ORAL;
Reported

8; **FOLTX**; ; FOLIC ACID/VIT B6/VIT B12; MULTIVITAMIN b
PREPARATIONS; ORAL;
TYLOX; ; ACETAMINOPHEN-OXYCODONE; OPIATE AGENTS;
ORAL;
Unreported

Oral Solids: Name, Strength, One Cardiac

5; **NIMODIPINE**; 30MG; NIMOTOP; UNCLASSIFIED THERAPEUTIC AGENTS; ORAL;
NIFEDIPINE; 30MG; PROCARDIA XL; CARDIAC DRUGS; ORAL;
Reported

5; **ADDERALL**; 10MG; AMPHETAMINE/DEXTROAMPHETAMINE; RESPIRATORY AND CEREBRAL STIMULANTS; ORAL;
INDERAL; 10MG; PROPRANOLOL; CARDIAC DRUGS; ORAL;
Reported

6; **AMLODIPINE**; 5MG; NORVASC; CARDIAC DRUGS; ORAL;
FELODIPINE; 5MG; PLENDIL; CARDIAC DRUGS; ORAL;
Unreported

6; **QUINIDINE SULFATE**; 200MG; QUINIDINE SULFATE; CARDIAC DRUGS; ORAL;
QUININE SULFATE; 200MG; QUININE SULFATE; ANTIMALARIAL AGENTS; ORAL;
Unreported

7; **CARDENE**; 30MG; NICARDIPINE; CARDIAC DRUGS; ORAL;
CODEINE; 30MG; CODEINE; OPIATE AGENTS; ORAL;
Reported

Oral Solids: Name, Strength, One Antineoplastic

8; **CAPOTEN**; 50MG; CAPTOPRIL; HYPOTENSIVE AGENTS;
CASODEX; 50MG; BICALUTAMIDE; ANTINEOPLASTIC AGENTS;
Unreported

8; **ALKERAN**; 2MG; MELPHALAN; ANTINEOPLASTIC AGENTS;
MYLERAN; 2MG; BUSULFAN; ANTINEOPLASTIC AGENTS;
Unreported

8; **ALKERAN**; 2MG; MELPHALAN; ANTINEOPLASTIC AGENTS;
LEUKERAN; 2MG; CHLORAMBUCIL; ANTINEOPLASTIC AGENTS;
Reported

Summary of Yield: Injectables

- Name only
  - 100 pairs, 18 previously reported
- Name, strength, one antineoplastic
  - 18 pairs, 3 previously reported
- Name, strength, route, one antineoplastic
  - 5 pairs, 1 previously reported

Summary of Yield: Oral Solids

- Name only
  - 405 pairs, 52 previously reported
- Name, strength
  - 66 pairs, 21 previously reported
- Name, strength, one opiate
  - 3 pairs, 2 previously reported
- Name, strength, one cardiac
  - 12 pairs, 6 previously reported
- Name, strength, one antineoplastic
  - 3 pairs, 1 previously reported

Rating Severity of Harm (In Progress)

- Harm=Probability of error X num. opportunities for error X severity of each error X probability of not detecting
- Depends on direction of error
- Depends on duration of exposure
- Depends on patient clinical status
- Exposure to wrong drug vs. failure to receive right drug

Strategies for Prevention

- Pre-approval screening
- Post-event labeling changes (e.g., Lamictal, cisplatin)
- CPOE-based solutions
- Safe prescribing practices
- Doctor-patient interaction
- Dispensing and administration fixes

Pre-Approval Screening

- FDA and manufacturer's joint responsibility
- Should use validated measures
- Should search on multiple attributes
- Criteria for acceptance/rejection of new names should be rational and explicit
- Companies soon mandated to submit pre-approval info about name confusion

Labeling Changes

CPOE-based Solutions

- Warnings on known confusing names
- Dose checking
- Indication checking
- Non-alphabetical presentation on menus
- Querying for distinguishing attributes
- “Tall man” lettering

ISMP Safe Medication Practices

- Specify form, strength, and directions.
- Include indication on outpatient Rxs and on inpatient *prn* orders.
- With problem pairs, use both brand and generic name.
- Limit spoken and telephone orders. Repeat back all orders, spell product name, state indication.
- Use magnifying lenses and copyholders under good lighting
- Change the appearance of look-alike product names on computer screens, shelf labels and bins (including automated dispensing cabinets), product labels, and medication administration records by highlighting, through bold face, color, and/or tall man letters, the parts of the names that are different (e.g., hydr**OXY**zine, hydr**ALA**zine).
- Affix “name alert” stickers to areas where look or sound-alike products are stored (available from pharmacy label manufacturers).
- Store products with look or sound-alike names in different locations. Avoid storing both products in the fast-mover area. Use a shelf sticker to help locate the product that is moved.

Additional System Solutions

- Focus prevention efforts on small set of “high alert” medications
- Make errors visible, local, personal
- Print names (not cursive)
- Short feedback loops (via nurses)
- Check meds each visit
- Restrict or filter personal and organizational formulary
- Write Rx “out loud” when patient present
- Minimize switching/use of new drugs
- Use pre-printed prescription forms
- Establish universal pill imprint codes to ease product identification
- Use bar codes
- Organize drug lists by indication or pharmacologic category, not alphabetically

Limitations

- Need to include prescribing frequency information
- Name similarity measures can be improved
- No information on schedule (e.g., BID)
- Prevention strategies unclear, largely untested
- Must limit false positives (2-3 warnings/day)
- Need valid, reliable method for severity/harm assessment