Beyond mixed case lettering: reducing the risk of wrong drug errors requires a multimodal response

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Confusion between drug names that look and sound alike continues to occur and causes harm in all care settings, despite persistent prevention and mitigation efforts by industry, regulators, health systems, clinicians, patients and families. In this issue of *BMJ Quality and Safety*, Lohmeyer *et al* examined the effect of mixed case (often referred to as 'tall man') text enhancement on critical care nurses' ability to correctly identify a specific syringe from an array of similarly labelled syringes.[1] Here, we reflect on their study, summarising its key findings and commenting on its strengths as well as suggesting further developments in this field of research. We then make the case that significant, reliable reduction in drug name confusion errors will require multimodal interventions.

NEW INSIGHTS INTO MIXED CASE TEXT ENHANCEMENT FOR DRUG NAMES

Lohmeyer *et al* tested the effect of mixed case lettering on a syringe selection task with 30 critical care nurses as particpants. They showed that mixed case lettering caused a reduction in selection errors from 5.3% to 0.7%. The study has several strengths. The first has to do with the use of syringe labels realistically formatted using an international standard. The more realistic the labels are, the greater the external generalisability of the findings. A second strength is that it uses practising healthcare professionals as participants. Many previous studies of text enhancement to prevent look-alike/sound-alike (LASA) errors have used laypeople as participants. Use of laypeople as participants is not inherently wrong, since they too can make LASA errors when selecting non-prescription drugs. But the exclusive use of lay participants limits generalisability because drug names are a specialised vocabulary. To understand the effects of text enhancements in clinical settings, it is therefore important to use clinicians as study participants. This is especially true because one of the most powerful effects on word memory and perception is familiarity,[2] and healthcare professionals have much greater familiarity with drug names than laypeople. A third strength concerns the use of eye tracking, an increasingly affordable technology that allows researchers to measure precisely where a participant is looking and for how long. In the context of text enhancement and drug name confusion, eye tracking data provide evidence about the possible mechanisms by which text enhancements might have their effects, for example, by causing people to alter where they look within a name and how long their gaze persists. Continued use of eye tracking in studies of text enhancement could enable progress in understanding whether text enhancement works, and precisely *how* and *why* it works. A more detailed understanding of the mechanism provides a basis for designers to make rational, evidence-based decisions about text enhancement based on the kind of visual attention they want to produce.

OPPORTUNITIES FOR IMPROVEMENT

There are opportunities to make further improvements in the design and execution of experiments such as this. The sample size in the study by Lohmeyer *et al* was small, with only 30 participants. The authors did not describe any power analysis, instead used previous studies to justify their sample size. Although it was a strength to use critical care nurses as participants, all were 45 years old or

younger; future studies should seek to include some older participants, given the visual and cognitive changes that occur in older age.[3] In addition to the small sample size, the actual number of observed errors was low. There were only 9 errors in the entire study, and only 8 of the 30 participants made even 1 error. As a result, 22 of the 30 participants essentially provided no information to the main study end point. Unfortunately, there is no simple remedy for this problem. In situations where naturally occurring errors are relatively rare, experimental psychologists typically manipulate the task to artificially increase the error rate. The most common ways of doing this include distracting participants, shortening exposure durations or response deadlines or adding 'noise' to the stimulus materials to make them harder to perceive. These techniques reliably increase observed error rates in such experiments, and, if done creatively, can also make the tasks more realistic by mirroring the dim lighting, low contrast, small typeface, poor legibility, high noise levels and frequent distractions present in many real clinical environments. The authors of this study erred on the side of a more controlled task, resulting in relatively few errors.

A MULTIMODAL APPROACH TO ELIMINATING WRONG DRUG ERRORS

The study by Lohmeyer *et al* raises a variety of issues regarding how to most effectively reduce the harm caused by wrong-drug errors in general and LASA errors specifically. The first is that we cannot expect either the characteristics of the drug name or the drug label on their own to prevent all wrong drug errors. The drug use process is too complex for any single intervention to be effective across all of the different steps in the process and different contexts of drug prescribing, dispensing and administration. For example, labelling changes may be effective for members of the care team who encounter the physical product in some form of packaging and have a chance to visually inspect the labelling. But physicians and other prescribers often make drug selections using computerised order entry systems where they see dropdown menus or lists of drug names (which may or may not use text enhancement), but never see any labels or packages. Similarly, changes to the user interface of computerised prescriber order entry systems,[4] or the use of clinical decision supports such as indication alerts,[5 6] while beneficial for some, will have no effect on the kinds of errors that nurses, pharmacists or pharmacy technicians might make in selecting products from a shelf or automated dispensing cabinet (ADC).

We should also be realistic about the magnitude of error reduction that might be possible as a result of text enhancement or other label redesigns. To illustrate with a related example, Salmasian *et al* added photographs of patients to the electronic medical record in an effort to reduce patient identification errors.[7] This intervention reduced the rate of wrong patient order entry errors by about 35% (from 474 to 310 retract and reorder events per 100 000 orders). Adelman *et al* used distinctive baby names to reduce the relative risk of wrong patient errors in a neonatal intensive care unit by 36% (from 60 to 38 retract and reorder events per 100 000 orders).[8] These interventions produced impressive and clinically significant reductions in the error rate, but in both cases, more than half of the errors remained. No doubt Lohmeyer *et al*, and the readers of this editorial, would be thrilled if it were shown that some type of text enhancement reduced wrong drug error rates by 30%–40%, but our work would still not be done.

To be sure, we should continue to try to find text enhancements and label designs that facilitate correct identification of drug products. At the same time, we should be pursuing multimodal interventions that include, among other things, standardising and simplifying formularies to eliminate confusing or infrequently used products, using barcode or machine-readable scanning,[9] indication alerts, indication-based prescribing to differentiate similar products[10 11] and special strategies for high-alert drugs with potential to cause the most serious harm.[12] We next comment briefly on other opportunities for wrong drug error reduction.

INCREASE THE AVAILABILITY OF BARCODE SCANNING

The use of barcode scanners during medication dispensing and administration produces relative risk reductions of 50% or more in medication error rates.[9] Any multimodal intervention to minimise wrong drug errors should include widespread adoption and thorough implementation of barcode scanning wherever possible, recognising that this may not be possible in hospitals without electronic health records or in low resource environments. A recent fatal medication error at Vanderbilt Medical Center (involving mistaken withdrawal of vecuronium instead of Versed (midazolam) from an ADC) demonstrated that, even in hospitals that have adopted barcoding technology, implementation can be incomplete.[13] In this case, the patient was in radiology, where barcode scanners for medication administration had not been installed. Even in the USA, where most hospitals have well-developed IT systems, an industry group reported in 2018 that only 34.5% of surveyed hospitals met all four of their criteria for successful implementation of barcoding technology.[14] The American Society of Health-System Pharmacy's 2020 survey of pharmacy practice showed that only a third of pharmacies use barcodes to verify doses during dispensing and 80% when filling ADCs.[15] Even when barcoding is present in a given care setting, it may not be used at every

step (such as stocking shelves), and the omitted steps remain vulnerable to error.[16]

REDESIGN AND OPTIMISE DRUG SELECTION INTERFACES

The introduction of computers into the medication use process has improved safety, but the design, layout and functionality of user interfaces for order entry, order verification and drug selection are suboptimal and continue to lead to errors. Again the tragic case above is a telling example, where the interface permitted the user to search for a drug with only a two-letter search string ('*Ve*'), creating the hazard where vecuronium was offered as a search result when Versed (midazolam) was intended.[17] That error led to a nationwide effort in the USA to require at least the first five letters be entered before an ADC will produce search results.[18] The Institute for Safe Medication Practices also recommends that ADCs be configured to allow simultaneous searching by brand and generic names. Had the ADC been configured to allow brand name searching, then Versed (midazolam) would have been retrieved after the first search, eliminating the need for the second search that then returned vecuronium.[19]

Interface design problems are also common in computerised prescriber order entry systems. Schiff *et al* documented substantial variability in how drug names are represented on order entry screens, including inconsistency in display of brand and generic names, availability of clinical decision support for generic but not brand names, inability to search for combination products by individual ingredient names, truncation of drug names and inclusion of non-drug name information (such as indication) in drug name fields.[4] Initiating the ordering session with the indication (so-called indication-based prescribing) is an interface redesign technique that would all but eliminate wrong drug errors that were for different indications. In indication-based prescribing, the prescriber first inputs the indication and only then searches for a drug product, with search results only being drawn from drugs used for the specified indication.[10]

STUDY TEXT ENHANCEMENTS OTHER THAN MIXED CASE LETTERING

It would also be useful to understand the effects of other types of text enhancement such as bolding, italics, colour or enhanced contrast. Recent reviews and meta-analyses of experiments on text enhancement for drug names call for more rigorous study of text enhancements other than mixed case lettering.[20] Outside of work on LASA errors, mixed case lettering has been argued in some psycholinguistic circles to disrupt the typical reading process. As Lohmeyer *et al* note, this disruption could be part of the mechanism behind any benefits of mixed case lettering. It could also unnecessarily slow drug name recognition, among other possible concerns. Other text enhancements, such as using a coloured font instead of capital letters, could direct visual attention to the disambiguating letters, possibly without the same disruption to the reading process, and with the additional mechanism of colour providing a warning signal.

CONCLUSION

Drug name confusions and other wrong drug errors continue to occur frequently, risking additional patient harm. The study by Lohmeyer *et al* makes a valuable contribution to the literature about the effectiveness of mixed case lettering in preventing syringe selection errors in a simulated critical care setting. The study adds to a growing literature that shows benefits of mixed case lettering in terms of error reduction in laboratory or simulated settings. The use of eye tracking also adds value by shedding light on potential mechanisms by which the text enhancements have their effects. Future studies should expand beyond mixed case lettering to study other forms of text enhancement in real clinical settings. But more importantly, the field should seek to develop multimodal strategies that reduce the risk of wrong drug errors at every stage of the drug use process.

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