Published in final edited form as:
Appl Ergon. 2022 October ; 104: 103831. doi:10.1016/j.apergo.2022.103831.

Improving safety in the operating room: Medication icon labels increase visibility and discrimination

Connor Lusk[a,*], **Ken Catchpole**[a], **David M. Neyens**[b], **Swati Goel**[c], **Riley Graham**[d], **Nicolas Elrod**[d], **Amanjot Paintlia**[d], **Myrtede Alfred**[e], **Anjali Joseph**[c], **Candace Jaruzel**[f], **Catherine Tobin**[a], **Timothy Heinke**[a], **James H. Abernathy III**[g]

[a]Department of Anesthesia and Perioperative Medicine, Medical University of South Carolina, Charleston, SC, USA

[b]Department of Industrial Engineering, Department of Bioengineering, Clemson University, Clemson, SC, USA

[c]Center for Health Facilities Design and Testing, School of Architecture, Clemson University, Clemson, SC, USA

[d]College of Medicine, Medical University of South Carolina, Charleston, SC, USA

[e]Department of Mechanical and Industrial Engineering, University of Toronto, Toronto, ON, CA, USA

[f]College of Health Professions, Medical University of South Carolina, Charleston, SC, USA

[g]Department of Anesthesiology and Critical Care Medicine, Johns Hopkins, Baltimore, MD, USA

Abstract

Misreading labels, syringes, and ampoules is reported to make up a 54.4% of medication administration errors. The addition of icons to medication labels in an operating room setting could add additional visual cues to the label, allowing for improved discrimination, visibility, and easily processed information that might reduce medication administration errors. A multi-disciplinary team proposed a method of enhancing visual cues and visibility of medication labels applied to vasoactive medication infusions by adding icons to the labels. Participants were 1.12 times more likely to correctly identify medications from farther away ($p < 0.001$, AOR = 1.12, 95% CI: 1.02, 1.22) with icons. When icons were present, participants were 2.16 times more likely to be more confident in their identifications ($p < 0.001$, AOR = 2.16, 95%CI: 1.80, 2.57). Carefully designed icons may offer an additional method for identifying medications, and thus reducing medication administration errors.

Keywords

Human factors; Icons; Medication errors; Medication labeling

---

*Corresponding author. 167 Ashley Ave, Suite 301, MSC 912, Charleston, SC, 29425, USA. luskco@musc.edu (C. Lusk).

Declaration of competing interest
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

1. Introduction

Over seven million patients (da Silva and Krishnamurthy, 2016) are estimated to be affected by medication failures each year in the United States, with some studies suggesting even higher rates (Prakash et al., 2018). During an anesthetic, the rate of a medication error is 5.3% for all medications delivered in surgery, with three fourths of these considered preventable (Nanji et al., 2016). Misreading labels, syringes, and ampoules is reported to make up 54.4% of medication administration failures (Erdmann et al., 2016). Interventions to address this have focused on the use of "tall man" lettering to reduce confusion between medication names (Filik et al., 2006), and color coding to improve discrimination between medication (Webster et al., 2010). However, these efforts may not be enough (Larmen é -Beld et al., 2018). Color labels can still be confused, especially by color deficient staff (Thomas and Mollon, 2018) and tall man lettering has had mixed success (Lambert et al., 2016). In this study we report an early test of a third method, medication label icons, as a method for representing medication function for improved discrimination.

Icons are used widely in everyday life on computers, cell phones, street signs, work environments, and a variety of clinical purposes, to alert, inform, and instruct users using both graphical and textual elements (Griffith, 1994). They aim to provide instant recognition, emphasize differences in information presented, improve instructions, and increase understanding, while providing easy-to-understand "knowledge in the world" (Babbitt Kline et al., 1990; Shinar and Vogelzang, 2013). Despite calls for incorporating graphical components on labels and packaging for improving patient safety (NPSA, 2007), there has been little prior published work in this area, apart from icons for at-home medication use (Shiffman et al., 2016; Wolf et al., 2010; Malhotra et al., 2019; Zargarzadeh and Ahmadi, 2017). Medication icons in the operating room (OR) could increase visibility both in terms of accuracy and distance of recognition, while potentially representing something about the function of the medication itself (Israelski, 2010). Thus, addition of icons to medication labels in an OR setting could allow for improved discrimination, visibility, and more easily processed information (Jonassen and Henning, 1999) that might reduce the opportunities of medication administration failures.

Initiated by a local clinical incident, in which there was a mismatch between the label on the intravenous (IV) line and the medication label on the IV bag that was not detected due to the poor visibility of the medication label on the bag, a set of icons was designed for use on IV bags through an iterative process, that included anesthesiologists, designers, pharmacists, certified registered nurse anesthetists (CRNAs), and human factors (HF) engineers. This process has been reported elsewhere (Goel et al., 2022). Before deployment, we sought to test the value of the icons to improve discrimination between different IV medications in an OR. By adding our new icons to existing pharmacy labels, we aimed to compare the ability to identify the medications from a distance in a simulated OR setting, with and without icons. We hypothesized that participants would be able to discriminate between different IV medication labels from a farther distance and with higher confidence with icons than without icons. In doing so, this study aimed to be one of the first to provide evidence to support the use of medication icons as a way to improve medication identification, and thus, eventually reduce medication errors.

2. Methods

This study was conducted in a mock OR of the simulation center at a 700-bed academic medical center in the Southeastern United States comprised of 41 ORs and an annual case volume of approximately 48,000 surgeries. Institutional review board (IRB) approval was acquired prior to data collection (#Pro00111086). Anesthesiologists, anesthesia residents, CRNAs, pharmacy students, and medical students were recruited for participation via email listservs for these groups. Each participant was compensated with a $10 gift card for participation. Participants were required to have medical knowledge (e.g., healthcare provider or medical student), and speak and read English.

2.1. Icon design

The need for icons arose from local clinical concerns and occurring incidents related to vasoactive infusions. The existing pharmacy labels could not be easily distinguished without close inspection, which led to incorrect infusions and dosages. Furthermore, there had been instances of incorrect IV medication delivery that could have been detected earlier if visibility of the labels had been better. This led to the proposal to develop and test a set of icons for vasoactive medication infusions that might improve visibility and discrimination in the usual distances and lighting conditions of an OR. The new icons were developed iteratively for several of the most commonly used vasopressors and vasodilators (Fig. 1) with a multi-disciplinary team of anesthesiologists, CRNAs, pharmacists, HF engineers and designers. The design and prototyping process has been described in more detail elsewhere (Goel et al., 2022).

For initial development and experimentation purposes, we designed labels that would allow direct comparison of the presence/absence of icons. The existing pharmacy labels allowed the addition of an icon while keeping all other label parameters (size, color, information, tall-man lettering) otherwise the same (Fig. 1). The ratio of icon size to label text was preserved from our original design control labels. We scaled our icon and text labels to fit the exact size of the text already in use with regular pharmacy labels. Thus, the experimental labels were identical to control by the size of the label, the color (white), the size of lettering, and the dosages. The only difference was the added icon.

2.2. Study design

A 2 × 2 within-subjects factorial design with varying light levels (i.e., high light and low light) and medication label (i.e., with and without icons), resulted in four study scenarios, in which we tested the four sample medication labels: Epinephrine, Norepinephrine, Phenylephrine, and Nitroglycerin. Each label was placed on an identical infusion bag which were then hung on 4 IV poles. The participants were tasked with identifying which medication was on each of the 4 IV poles within each condition. The position of the medication label was varied across conditions and counterbalanced for order effects. This defined the 24 subjects necessary to balance out order effects of the IV pole/label position across conditions. Half the participants experienced the standard labels first and for the other half the icon labels were presented first. Similarly, half the participants were exposed to the low light condition first and the high light condition second. This careful design aimed to minimize as far as possible the confounding effects of the experiment.

Illumination of the simulated OR was approximated by repeated measurements in the hospital with an MT-912 light meter. The low light condition (10 lux) was a replication of the approximate illumination of an OR suite during laparoscopic and robotic procedures. The high light condition (500 lux) was a replication of the full illumination of an OR during an open Coronary Artery Bypass Graft (CABG).

2.3. Procedures

As this was a perceptual discrimination study, rather than requiring clinical expertise, we targeted participant recruitment at medical students rather than experienced anesthetists. Participants were given a $10 voucher upon completion of the study. Prior to beginning the experiment, participants completed a brief eye exam using a standard Snellen eye chart to ensure they had sufficient visual acuity. They were briefed on the medications they would be expected to identify and were provided a medication sheet they could reference during the trial with medication names (Phenylephrine, Norepinephrine, Nitroglycerin, and Epinephrine) and the associated icons.

Four similarly sized IV stands, from which infusion bags were hung, were oriented towards the participants in line, labeled A, B, C, D. The simulated OR was marked off in 1 foot increments from the location of the IV stands (zero) to 15 feet away. Participants were asked to stand at the 15 foot mark and identify the label on each of the IV bags and then to assign a confidence value to their answer on a 5-point Likert scale of 1 (not confident) to 5 (completely confident). If the participant failed to identify all four medications correctly, they were asked to step forward in 1 foot increments until they succeeded. The resulting distance and corresponding confidence (1–5) were recorded. They were given no other feedback about the accuracy of their responses. After each trial, the bag order was reset according to the randomization schedule, and the next condition was tested.

2.4. Analysis

The data was analyzed using SPSS software version 27 (IBM Corporation, Armonk, NY). The sample size was a function of study design choice, to balance the different conditions and medication orders. Data was analyzed using a repeated measures binomial mixed effects logistic regression model to determine the effects of the icon labels on whether participants were able to identify the medication at 15 feet or if they needed to get closer. A linear repeated measures mixed effects regression model was used to evaluate the participants confidence in their identification of the label names. Therefore, the dependent variables were a binary (yes/no) on whether the participant had to move closer to identify the label correctly and confidence on a scale of 1–5 with 1 being not confident at all to 5 being very confident. All analyses were completed with an $\alpha = 0.05$.

3. Results

The participants were 22 medical students, one anesthesiologist, and one research professional. Sixteen of the participants had corrected vision and wore glasses or contacts; all participants were able to successfully complete the vision test via a standard Snellen eye chart (i.e., better than 20/30 vision).

3.1. Distance by icons and light levels across all medication conditions

The distance at which each label was correctly identified was used to test discrimination of a small set of icons under different light conditions (Table 1). Icons had a higher average first distance correct than labels without icons in low light (14.03 feet (SD: 0.20), 13.73 feet (SD: 0.70), respectively). Labels without icons had a higher average first distance correct in high light (14.17 feet (SD: 0.38), 14.11 feet (SD: 0.59), respectively). At 15 feet, 54% of identifications were made correctly with icons versus 46% without. The closest distance that needed to be reached to identify the labels was 6 feet (only observed in one instance). Fig. 2 is the first average distance correct for all labels across all conditions.

3.1.1. Distance by icons, light level, and medication names conditions—There were only two occurrences for all participants across all conditions when labels without icons had a higher average first distance correct larger than for the labels with icon (Norepinephrine, high light, 14.29 feet vs. 13.88 feet; and Nitroglycerin, low light, 14.79 feet vs. 14.17 feet (Table 1).

3.1.2. Likelihood of identifying the icon from the farther away—Table 2 shows the repeated measures binomial regression model results. This model is used to predict a single binary variable (outcome: moved or did not move closer) using other variables (icons, light condition). The likelihood of whether participants could identify the labels from farther away or would have to move closer is found using the adjusted odds ratio (AOR) by controlling for other predictor variables in the model. When icons were present, participants were 1.12 times more likely to correctly identify medications from farther away (AOR = 1.12, 95% CI: 1.02, 1.22) The type of medication (Epinephrine, Norepinephrine, Phenylephrine, Nitroglycerin) represented by tall man lettering also significantly improved visibility for both labels with and without icons. The Epinephrine label resulted in participants being 1.22 times more likely to correctly identify medications from farther away (AOR = 1.22, 95% CI: 1.08, 1.39). Similarly, the participants were significantly more likely to correctly identify the Nitroglycerin label from further away (AOR = 1.37, 95% CI: 1.22, 1.55). The light condition did not significantly impact the distance at which the labels were correctly identified. The random effects parameter was 0.03.

3.2. Confidence by icons and light levels across all medication conditions

A relative comparison of confidence between medications was determined. Participants were asked to report a confidence value from 1 (not confident) to 5 (completely confident) in addition to their identifications for each of the IV bag labels. On average, icon labels had higher confidence ratings (high light: 3.32, SD: 0.91; low light: 2.69, SD: 0.81) than labels without icons (high light: 2.30, SD: 0.48; low light: 1.78, SD:0.51) for all conditions: Fig. 3 is the average confidence for all labels across all conditions.

3.2.1. Confidence by icons, light level, and medication names conditions—

Confidence ratings were higher for all conditions with icon labels over labels without icons. Epinephrine and Nitroglycerin icon labels had higher confidences (4.25 and 3.96) than Norepinephrine and Phenylephrine (2.58 and 2.50) in high light. Epinephrine and Nitroglycerin icon labels (3.71 and 2.96) also had higher confidences than Norepinephrine and Phenylephrine in low light (2.04 and 2.04).

3.2.2. Likelihood of confidence in the identification of the labels—

When icons were present, participants were 2.16 times more likely to be more confident (AOR = 2.16, 95% CI: 1.80, 2.57) (Table 3). In high light, participants were 1.30 times more likely to be more confident than in low light (AOR = 1.30, 95% CI: 1.11, 1.53). The Nitroglycerin label resulted in participants being 1.51 times more likely to be more confident (AOR = 1.51 95% CI: 1.19, 1.93). The random effects parameter was 0.20.

4. Discussion

Our study found that the addition of carefully designed set of icons to standard pharmacy labels improved discrimination and confidence of IV medication identification in a simulated OR setting. The presence of icons significantly increased the distance at which IV medications could be identified, albeit only by a small margin. No significant difference was found between low light and high light conditions for distance, but there was a significant difference in confidence. When icons were present, participants were also significantly more likely to be more confident in medication selection. The average confidence in each participant’s answer was improved with the presence of the inotrope icon and the vasodilator icon, but not with the vasoconstrictor icon.

These preliminary results are encouraging for the value of medication icons as an alternative, or an addition to, color coding and tall-man lettering for improving identification. Though the addition of the icon did not hugely improve discrimination distance, we noted far stronger effects of confidence. Indeed, several experimental design decisions were made to deliberately make the tasks as equipoised as possible, reducing the potential value of icons. Though they could have been much larger, we wanted to ensure the icons were small enough to fit the existing pharmacy labels to preserve everything else about the label (the size, the info on it, the size of the lettering) across all experimental conditions, and based on label designs that are used in actual practice. In clinical practice, icons could be larger and thus allow discrimination at a greater distance. Similarly, we deliberately used two ‘vasoconstrictor’ icons on two of our four medications to explore the potential for confusion where multiple similar medications might be hung. Participants likely depended on identifying the medication name to distinguish those medications. By having the same four labels in different orders, pure guessing, or a combination of identification and guessing, were possible. This is why the difference in confidence ratings between icon and no icon are perhaps the most important and strongest result we found. Thus, achieving a statistically significant difference in both key measures demonstrates the potential value of icons for medication labelling.

The American Society of Anesthesiologists supports color-coding medication labels to provide at-a-glance information that decreases human reliance on memory, vigilance, and calculations (Vender, 2019). Icons are often used for warning labels and electronic application operations across a wide variety of contexts as they allow instant recognition at an additional familiar level (Houts et al., 2006; Montagne, 2013; ANSI, 2011); convey semantic information (Hou and Hu, 2022) and facilitate noticing, recalling, and complying with information (Frienmann, 1988). Icons may serve as an additional cue as to the type, function, or dose of medications, without fully reading through labels, as the combination of pictogram and text on the icon label may enhance readability, legibility, and visual search performance of anesthesia providers (Hou and Hu, 2022). Although it is expected every provider will read every medication label every time they administer a medication, misperceptions can occur in spite of vigilance, intelligence, or experience (Vender, 2019). As a consequence, one frequently used design approach is redundant encoding (where multiple different cues convey the same message); the value of which has been observed in both experimental and applied settings over many years (Miller, 1982; Mordkoff and Yantis, 1993; Morton, 1969; Maximous et al., 2021; Bratch and Pandit, 2021). Thus tall man lettering, color and an icon in combination could provide multiple redundant encoding, reducing considerably the opportunity for misperception. Visibility of the system state is also another safety-related design theme, where being able to see what is happening at all times from all areas in the OR, not just the anesthesia area, enhances awareness and reduces the reliance on individual checking. Barcode scanning systems still can be susceptible to errors as medications can be scanned, hung, and administered without close inspection or a check from another provider (Koppel et al., 2008). In this case, an icon on the label enhances the visibility of the medications that have been hung, thus enhancing the opportunity to detect medication failures at any point. A icon design that also imparts function means that familiarity with the medication name is not necessary to understand how it acts. This has less value for anesthesiologists (who are familiar with the actions of the medications they are delivering) but might impart better awareness to the rest of the team.

In this study, we represented vasodilators, vasoconstrictors, and inotropes in icon form. However, exactly what information could and should be imparted through medication icons needs further study. Too many different icons could make discrimination difficult or rely too much on memorizing them. Too much complexity in the icons or the labels themselves might add visual complexity that could hide important information. We also need to extend our studies from a small number of IV medications to a full range of potential infusions and from ORs to intensive care units (ICUs). We also need to extend our studies beyond discrimination tasks to explore the greater awareness that icons might impart with factors such as time pressure, distractions, and multiple people in the room which may contribute to errors with reading medications. By displaying knowledge ‘in the world’, icons that represent medication function could lead to quicker learning for trainees, and enhance the situational awareness of other OR team members. An established standard set of iconographies would facilitate implementation across the discipline and drive the need for regulation, control, and development. Incorporating iconography may lead to the development of an icons taxonomy to facilitate decision-making and identification, reducing medication failures and improving patient care. Currently we are conducting a pilot implementation to explore feasibility and providers perceptions in clinical practice, but eventually, of course, it will be important to test the efficacy of icon labels in a full clinical trial.

4.1. Limitations

For reasons of experimental control, we did not manipulate icon size, nor use different label colors, and allowed potential confusions between two vasoconstrictor icons. Thus we feel that this study, if anything, under-estimates the value of icons as opposed to no icons. As this was essentially a perceptual discrimination task, we chose not to utilize experienced providers, and feel that similar results would have been achieved with more experienced subjects. However, clearly this was a potential limitation. Anesthesiologists, CRNAs, pharmacy students, and medical students were all recruited, but many were unavailable during the study or were unable to step away from clinical duties in the OR. We hope to recruit more anesthesiologists and CRNAs in future studies on icon labels. While the one anesthesiologist and one research professional could have skewed the results, we are confident the design of the labels only assisted every subject in their selections. However, in the future, we aim to have a more homogeneous subject population. We have added more information on this in the limitations section. A maximum distance of 15 feet was tested, which may not reflect realistic working distances as most anesthesia work is conducted much closer to hung IV medications. However, visibility of IV medications at this and longer distances may be valuable; and within the study design, distance was used as a variable to manipulate experimental difficulty to guard against experimental ceiling and floor effects. In fact, we found an apparent ceiling effect as many participants identified medications correctly at the 15 foot mark regardless of whether or not there were icons present. We suspect that even better results for the icons would have been achieved at longer distances. Finally, this was a discrimination task in a highly experimentally controlled setting, and was not, itself, representative of real clinical work. Thus, while this study was not designed to test the value of medication label icons for improving medication delivery it remains a positive demonstration of the value of this concept, justifying further development.

5. Conclusion

Carefully designed icons may offer an additional method for identifying medications, and thus reducing medication administration errors. Medication labeling designs have hitherto focused on using fonts and colors to reduce medication confusion and thus increase safety (Berman, 2004). Defaulting to these traditional methods of adapting labels to reduce failures has been exhausted. Adopting graphical methods, such as icons, may be an effective way to convey information and increase readability. Icons are valuable for visibility in the OR and increase legibility of labels while providing information at a glance; a small intervention that may have a significant impact on reducing medication delivery failures in the OR. Future research should elucidate the impact of icon labels on outcomes, by conducting a larger randomized control study in clinical practice.

Disclosures/funding

This project was funded under grant number HS026625-01 from the Agency for Healthcare Research and Quality (AHRQ), U.S. Department of Health and Human Services (HHS).

References

ANSI, 2011. ANSI/NEMA Z535.3-2011 Criteria For Safety Symbols.

Babbitt Kline TJ, et al. , 1990. Visibility distance of highway signs among young, middle-aged, and older observers: icons are better than text. Hum. Factors 32 (5), 609–619. [PubMed: 2074112]

Berman A, 2004. Reducing medication errors through naming, labeling, and packaging. J. Med. Syst 28 (1), 9–29. [PubMed: 15171066]

Bratch R, Pandit JJ, 2021. An integrative review of method types used in the study of medication error during anaesthesia: implications for estimating incidence. Br. J. Anaesth 127 (3), 458–469. [PubMed: 34243941]

da Silva BA, Krishnamurthy M, 2016. The alarming reality of medication error: a patient case and review of Pennsylvania and National data. J. Community Hosp. Intern. Med. Perspect 6 (4), 31758. [PubMed: 27609720]

Erdmann TR, et al. , 2016. Profile of drug administration errors in anesthesia among anesthesiologists from Santa Catarina. Brazilian Journal of Anesthesiology (English Edition) 66 (1), 105–110.

Filik R, et al. , 2006. Labeling of medicines and patient safety: evaluating methods of reducing drug name confusion. Hum. Factors 48 (1), 39–47. [PubMed: 16696255]

Frienmann K, 1988. The effect of adding symbols to written warning labels on user behavior and receall. Hum. Factors 30 (4), 507–515.

Goel S, et al. , 2022. Improving anesthesia medication label design through the use of icons. Proceedings of the Human Factors and Ergonomics Society 66 (Accepted) In press.

Griffith D, 1995, 1994 ISBN 0-471-59901-8. Ergonomics in Design. The Icon Book: Visual Symbols for Computer Systems and Documentation by William Horton, 3 John Wiley & Sons, Inc. (4), 29–29.

Hou G, Hu Y, 2022. Designing combinations of pictogram and text size for icons: effects of text size, pictogram size, and familiarity on older adults' visual search performance. Hum. Factors (in press).

Houts PS, et al. , 2006. The role of pictures in improving health communication: a review of research on attention, comprehension, recall, and adherence. Patient Educ. Counsel 61 (2), 173–190.

Israelski E, 2010. Using Human Factors Engineering to Improve Patient Safety: Problem Solving on the Front Line, Second Edition, 2010, vol. 44. Biomed Instrum Technol, p. 474, 6. [PubMed: 21142510]

Jonassen DH, Henning P, 1999. Mental models: knowledge in the head and knowledge in the world. Educ. Technol 39 (3), 37–42.

Koppel R, et al. , 2008. Workarounds to barcode medication administration systems: their occurrences, causes, and threats to patient safety. J. Am. Med. Inf. Assoc 15 (4), 408–423.

Lambert BL, Schroeder SR, Galanter WL, 2016. Does Tall Man lettering prevent drug name confusion errors? Incomplete and conflicting evidence suggest need for definitive study. BMJ Qual. Saf 25 (4), 213–217.

Larmené-Beld KHM, Alting EK, Taxis K, 2018. A systematic literature review on strategies to avoid look-alike errors of labels. Eur. J. Clin. Pharmacol 74 (8), 985–993. [PubMed: 29754215]

Malhotra R, et al. , 2019. Bilingual text with or without pictograms improves elderly Singaporeans' understanding of prescription medication labels. Gerontol 59 (2), 378–390.

Maximous R, et al. , 2021. Interventions to reduce medication errors in anesthesia: a systematic review. Can. J. Anaesth 68 (6), 880–893. [PubMed: 33709263]

Miller J, 1982. Divided attention: evidence for coactivation with redundant signals. Cognit. Psychol 14 (2), 247–279. [PubMed: 7083803]

Montagne M, 2013. Pharmaceutical pictograms: a model for development and testing for comprehension and utility. Res. Soc. Adm. Pharm 9 (5), 609–620.

Mordkoff JT, Yantis S, 1993. Dividing attention between color and shape: evidence of coactivation. Percept. Psychophys 53 (4), 357–366. [PubMed: 8483699]

Morton J, 1969. The use of correlated stimulus information in card sorting. Percept. Psychophys 5 (6), 374–376.

Nanji KC, et al. , 2016. Evaluation of perioperative medication errors and adverse drug events. Anesthesiology 124 (1), 25–34. [PubMed: 26501385]

NPSA, 2007. Design for Patient Safety: A Guide to the Graphic Design of Medication Packaging NPSA.

Prakash S, et al. , 2018. Safe labeling practices to minimize medication errors in anesthesia: 5 case reports and review of the literature. In Pract 10 (10), 261–264.

Shiffman S, et al. , 2016. Testing of candidate icons to identify acetaminophencontaining medicines. Pharmacy 4 (1), 10. [PubMed: 28970383]

Shinar D, Vogelzang M, 2013. Comprehension of traffic signs with symbolic versus text displays. Transport. Res. F Traffic Psychol. Behav 18, 72–82.

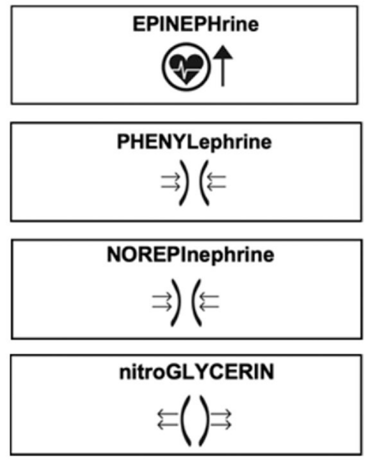
Thomas PBM, Mollon JD, 2018. Syringe labels seen through the eyes of the colourdeficient clinician. Br. J. Anaesth 121 (6), 1370–1373. [PubMed: 30442268]

Vender LSJJS, 2019. Pro/con debate: color-coded medication labels – PRO: color-coded medication labels improve patient safety. Anesthesia Patient Safety Foundation Newsletter 33 (3), 72–73.

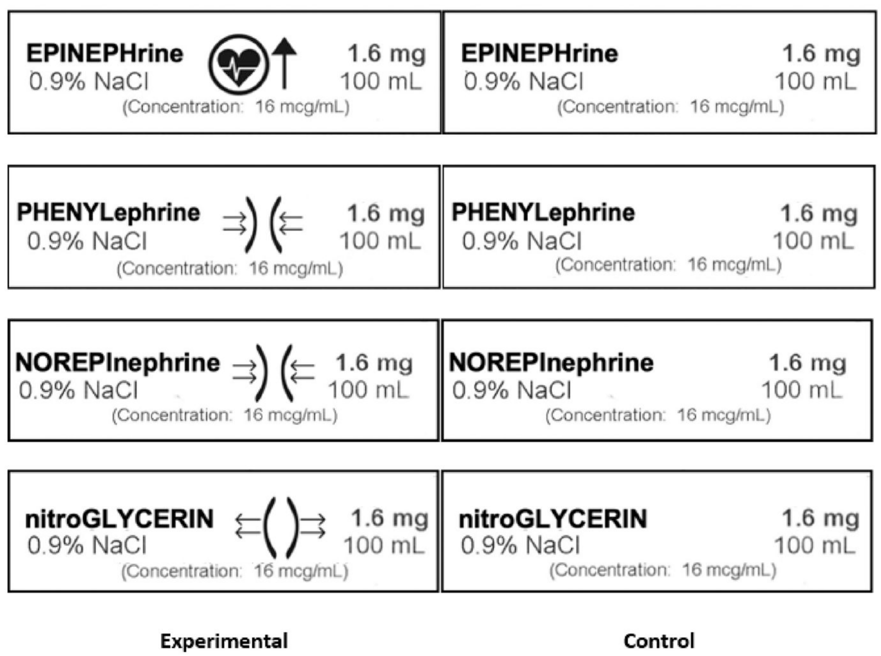
Webster CS, et al. , 2010. Clinical assessment of a new anaesthetic drug administration system: a prospective, controlled, longitudinal incident monitoring study. Anaesthesia 65 (5), 490–499. [PubMed: 20337616]

Wolf MS, et al. , 2010. Improving prescription drug warnings to promote patient comprehension. Arch. Intern. Med 170 (1), 50–56. [PubMed: 20065199]

Zargarzadeh AH, Ahmadi S, 2017. Comprehensibility of selected United States Pharmacopeia pictograms by illiterate and literate Farsi speakers: the first experience in Iran - Part II. J. Res. Med. Sci. : the official journal of Isfahan University of Medical Sciences 22, 101–101.

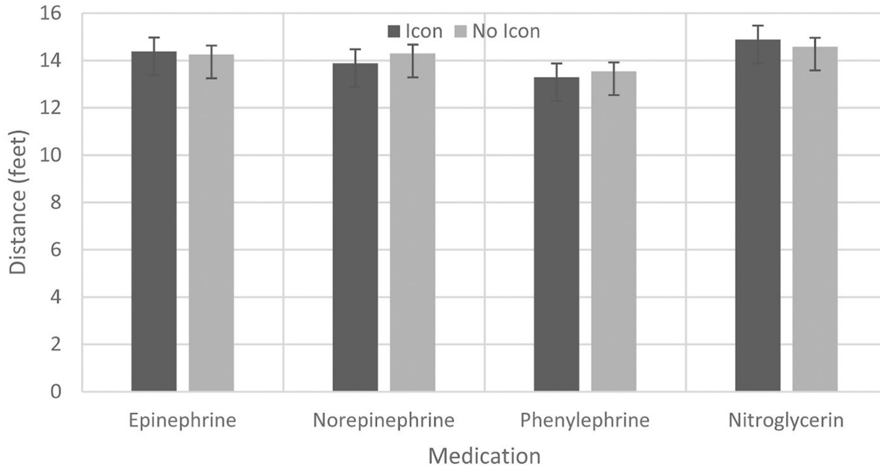


(a) Novel Icons

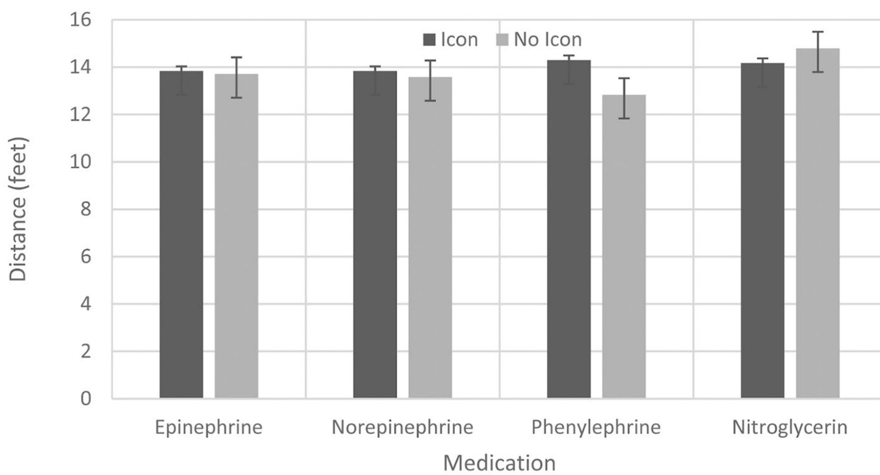


(b) The experimental and the control labels used in this study

Fig. 1.
Icon label development.

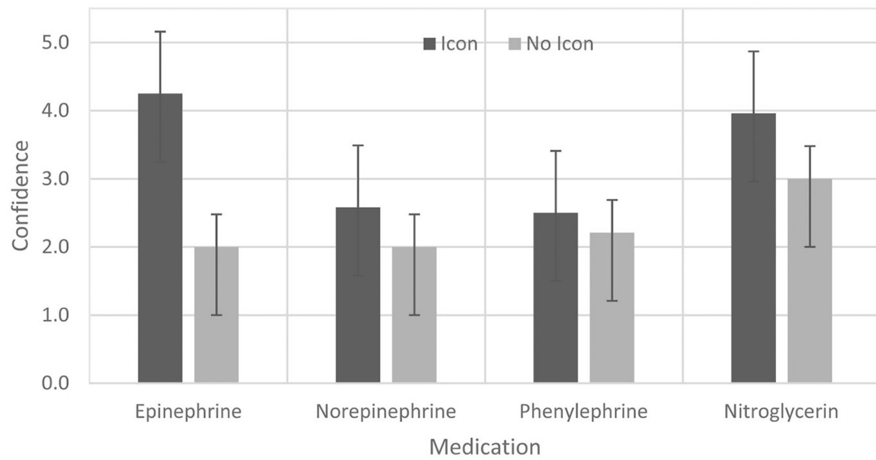


(a) High Light Condition

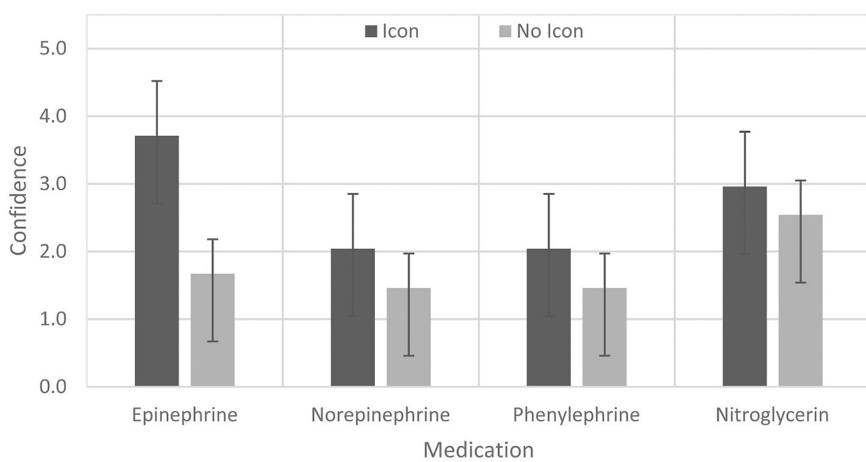


(b) Low Light Condition

Fig. 2.
The average distance correct for all labels in (a) high light condition and (b) low light condition (SD error Bars).



(a) High Light Condition



(b) Low Light Condition

Fig. 3.

The average confidence for all labels in (a) high light condition and (b) low light condition (SD error Bars).

Table 1

Distance by icons and light level by medication names conditions.

Medication	Light	Average Distance (Feet)		95% CI	
		Icon	No Icon	Icon	No Icon
Epinephrine	**High**	14.38	14.25	(13.65, 15.10)	(13.80, 14.70)
	Low	13.83	13.71	(12.88, 14.79)	(12.81, 14.60)
Norepinephrine	**High**	13.88	14.29	(13.18, 14.57)	(13.77, 14.81)
	Low	13.83	13.58	(13.00, 14.66)	(12.68, 14.49)
Phenylephrine	**High**	13.29	13.54	(12.47, 14.11)	(12.79, 14.30)
	Low	14.29	12.83	(13.74, 14.84)	(11.73, 13.94)
Nitroglycerin	**High**	14.88	14.58	(14.70, 15.05)	(14.25, 14.92)
	Low	14.17	14.79	(13.50, 14.83)	(14.59, 15.00)

Table 2

Predicting the likelihood that the icons were identified from the farthest distance (15 feet).

Parameter	Estimate	Standard Error	t-statistic	p-value	Adjusted odds ratio (AOR)	95% CI on the AOR
Intercept	0.43	0.07	6.34	0.00	1.53	(1.34, 1.76)
Icons Present	0.11	0.04	2.53	0.01	1.12	(1.02, 1.22)
High Light Level	0.04	0.04	0.94	0.35	n.s.	n.s.
Epinephrine	0.20	0.06	3.12	0.00	1.22	(1.08, 1.39)
Nitroglycerin	0.32	0.06	5.21	0.00	1.37	(1.22, 1.55)
Norepinephrine	0.06	0.07	0.91	0.36	n.s.	n.s.

Note: n.s. indicates that a parameter is not significant at $\alpha = 0.05$.

Table 3

Confidence model.

Parameter	Estimate	Standard Error	t-statistic	p-value	Adjusted odds ratio (AOR)	95% CI on the AOR
Intercept	1.21	0.12	10.02	0.00	3.35	(2.62, 4.29)
Icons Present	0.77	0.09	8.52	0.00	2.16	(1.80, 2.57)
High Light Level	0.27	0.08	3.32	0.00	1.30	(1.11, 1.53)
Epinephrine	0.08	0.11	0.73	0.47	n.s.	n.s.
Nitroglycerin	0.41	0.12	3.39	0.00	1.51	(1.19, 1.93)
Norepinephrine	−0.07	0.10	−0.73	0.47	n.s.	n.s.

Note: n.s. indicates that a parameter is not significant at $\alpha = 0.05$.