WHITE PAPER:

REDUCING MEDICATION ERRORS WITH NEW LABELING SYSTEM

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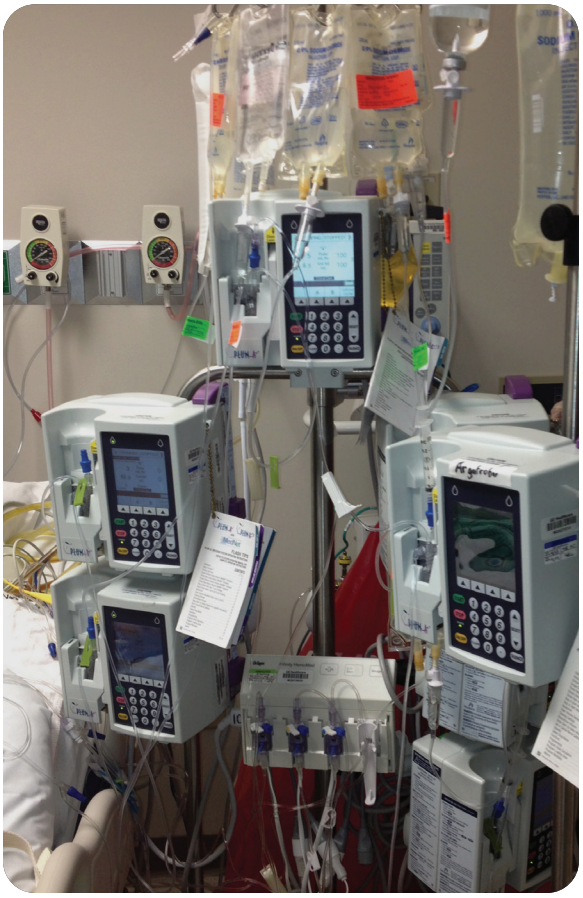
BACKGROUND

Health professionals and organizations agree that patient safety is a top priority. The NIH released a landmark book about medical errors in 2000[1]. At that time, it was estimated that 98,000 *hospitalized* patients die every year from medical errors[2,3]. More recent analysis suggests that the number is actually much higher and that there are, in fact, over 250,000 inpatient deaths per year that occur due to medical errors. This statistic would place medical error as the third most common cause of death in the US after heart disease and cancer[4].



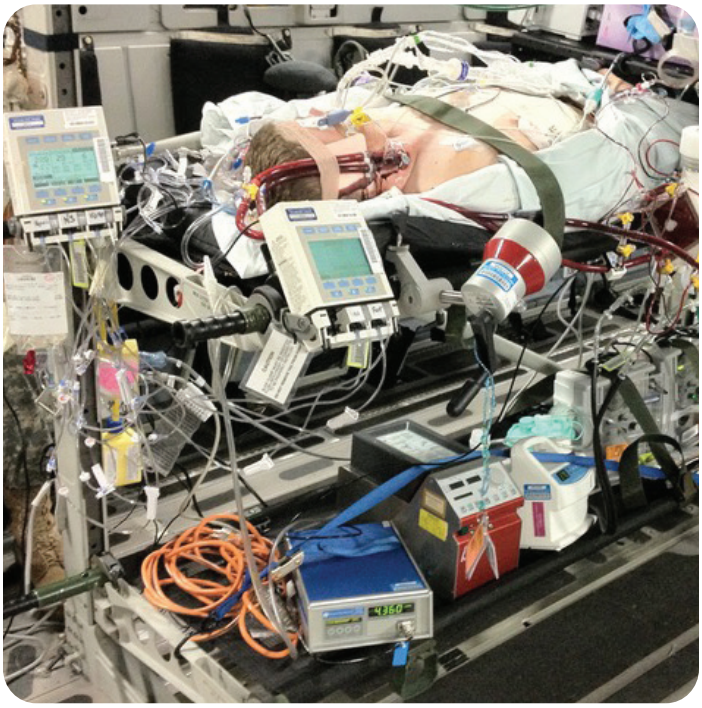
Twenty-one percent of American adults report having "personally experienced a medical error;" and more than half of these reported errors occurred in the outpatient setting. The most common reported errors (59%) were related to diagnosis but 60% of complaints were medication-related[5]. It is thought that medication errors comprise a major portion of medical errors. Fortunately, most medication errors do not result in patient injury. Those medication errors that result in patient harm are termed preventable adverse drugs events (ADEs).[6] Medication errors that have the potential to cause harm but in which no injury occurs are termed potential ADEs. The exact number of ADEs is unknown. The Institute of Medicine estimates that medication errors cause 1 out of 131 outpatient and 1 out of 845 inpatient deaths. Patients with comorbidities such as poor hepatic and renal function, advanced age, cognitive dysfunction, polypharmacy, and noncompliance are at higher risk of a medication error.[7] Studies conducted on hospitalized patients estimate that 6.7% of hospitalized patients experience a serious ADE and 0.32% have a fatal ADE. If these estimates are correct, there are more than 2,216,000 serious ADEs in hospitalized patients, causing over 106,000 deaths annually.[8] That would make ADEs the 4th leading cause of death—ahead of pulmonary disease, diabetes, AIDS, pneumonia, accidents, and automobile deaths—and therefore a significant public health problem that is, for the most part, preventable.[9,10] Note that these statistics do not include the number of ADEs that occur in ambulatory settings or nursing homes. Additionally, medication-related errors are expensive, costing each hospital over $5 million annually and adding $3.5 billion to US health care costs.[11]

Sixty percent of serious ADEs in the US and 56% in the UK involve intravenous (IV) medications.[12,13] Drug administration is a complex process; the delivery of a single IV medication dose requires the precise execution of numerous steps in which an error can occur. Conditions that influence drug administration errors include inadequate written communication, supply and storage issues, high perceived workload, staff health, equipment problems, patient factors, and interruptions and distractions.[14] Ninety percent of hospitalized patients receive at least one IV medication[15]. The more drugs that are infused IV, the greater the chance of an ADE. It is estimated that each additional IV medication increases the chance of ADE by 3%[16,17].

INTENSIVE CARE UNITS: GROUND ZERO FOR MEDICATION ERRORS

If IV medication errors are the most predominant and serious type of medication error, the hospital location where

patients are at greatest risk of serious harm is the ICU. In the ICU, all patients receive IV infusions and typically more than one. ICU patients are critically ill, making them highly vulnerable to harm from mistakes in timing, dosing, and type of IV medication. Medication errors account for 78% of serious errors in the ICU and 60% of these involve injectable medications[18,19]. ICU patients experience 1.7 medication errors per day[20]. The overall error rate is 14.3%. Documentation errors are the most prevalent type of error; this includes inaccurate or incomplete labeling of IV tubing which can lead to confusion and errors during drug administration, especially in urgent situations[18]. ICU patients typically receive infusions with one or more medications termed 'high-alert' medications by the Institute for Safe Medication Practices (ISMP). These include insulin, heparin, opioids, potassium, neuromuscular blocking agents, and chemotherapy drugs and can cause critical and catastrophic harm if not administered properly and are involved in many cases of ADE[21-23].



DEEP DIVE INTO IV MEDICATION ERRORS

A. MULTIPLE INFUSIONS

There has been some research conducted regarding errors resulting from IV infusions and specifically the higher risk scenario of multiple, concurrent IV infusions. The ISMP Canada and Health Technology Safety Research Team evaluated two databases in 2012: ISMP Canada's Canadian Medication Incident Reporting and Prevention System and the US Food and Drug Administration's Manufacturer and User Facility Device Experience (MAUDE)[24]. Multiple safety issues were found relating to line set-up and removal, line identification, and the use of secondary infusions[24]. In follow-up, investigators created a simulated ICU to study factors related to errors involving multiple primary line set-up; line identification; dead volume management; and secondary infusions[15].

B. IV LINE SET-UP AND REMOVAL

The most prevalent safety issues occurred during the setup of IV lines, including rate and line mix-ups (22.6% of errors). In these cases, IV lines were crossed and switched to the wrong pump. For example, a saline pump intended to infuse a saline infusion contained IV tubing from another drug, resulting in inappropriate medication boluses and overly rapid infusion of medication. High-alert medications were involved in 71% of multiple IV infusion errors and 92% of all IV-line mix-ups. Heparin was the high-alert medication most frequently involved in errors (16%) followed by insulin (7.6%) and parenteral nutrition (5.2%). The National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP) Medication Error Index has classified these types of error as "D" through "I" meaning they are likely to cause patient harm or require medical intervention to preclude harm if undetected.

Common scenarios requiring set up of multiple IV lines include those with patients who require multiple medications administered concurrently, patients transferred to a new unit that uses different pumps or drug infusion concentrations, or IV lines that need to be changed without interrupting an infusion. Since humans are more likely to err when multitasking, incidents occur from mix-ups when infusions are set up "in parallel," for instance during set-up of secondary (or "piggyback") infusions where one or more lines are administered through the same pump and IV by using the administration set side ports. Secondary infusions account for 12.8% of errors occurring during set-up. Other mistakes that occur during multiple IV-line set-up include IV tubing and pump mix-ups, drug order and pump mix-ups, and label mix-ups. So-called "smart pumps" or pumps integrated with an EMR do not solve this problem and cannot prevent mix-up errors because the wrong tubing can still be inserted into a smart pump. In fact, errors occur up to 60% of the time[25].

C. IV LINE IDENTIFICATION AND LABELING

Ideally, each infusion should have a visually distinct pathway. In reality, components become disorganized and

multiple IVs can lead to "spaghetti syndrome"[26]. Most ICU patients have multiple types of tubes in place. In addition to IV tubing, there are tubes for pressure monitoring (i.e., arterial or venous pressure), ventilation, and waste collection as well as electrical cables. A standardized set-up does not exist. IV lines do not always line up with their corresponding pump. Because many tubes look similar, infusion mix-up errors and delays in therapy occur not infrequently as a result of multiple infusions. In 2010 the AAMI and US FDA identified the need to improve the management of multiple IV infusions[27]. As recently as 2015, the ECRI rated infusion mixups one of the Top 10 Health Technology Hazards for 2015[28].

Labeling is a recognized safety strategy for the prevention of medication errors. However, there is huge variation in labeling practices. **Problems with labeling include:**

1. Lack of standardization

2. Use of labels that are not designed for that purpose

3. Poor adherence of labels to tubing; poor fit

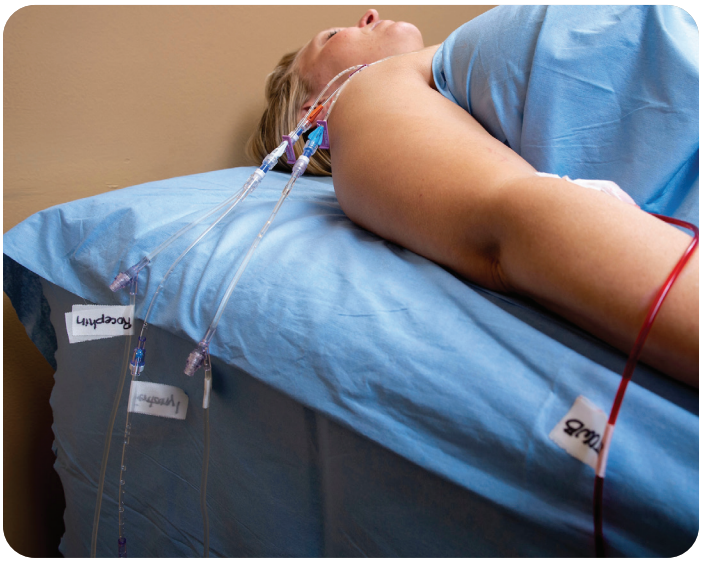
4. Difficulty reading labels when wrapped around tubing including illegible handwriting

5. Inconsistent use of color-coding

6. Placement of label on wrong component

7. Lack of label removal when a medication is discontinued.

Pinkney looked at three interventions to improve the accuracy and speed of *line* identification and found fewer errors when line labels and organizers were used, concluding that the results should motivate the use of standardized line labels/organizers in patients with multiple IV infusions[26]. In the simulated study, when preprinted labels and organizers were employed, participants made fewer errors and participants rated the labels more favorably than other interventions.



One study found that when color coded preprinted labels were used, the average performance time for labeling and error identification were significantly improved over handwritten labels, and the nursing staff preferred predesigned labels[29,30]. Black and white labels might promote careful reading of the label but it has been suggested that an emergency line should be a different color to facilitate quick identification. Colored IV tubing has not been recommended for several reasons. Human factors studies show that humans have poor memory recall of specific colors. Colored IV tubing will not universally fit in all manufactured IV pumps. Opaque and/or colored medications can distort the perceived tubing color. Additionally, it can be hard to see the colors in a dark setting or at night[31].

A failure by clinicians to identify the correct line has led to:

1. Delays in therapy

2. Infusion pump settings changed on the incorrect pump

3. Medication injected into the dead space volume of the incorrect line

4. Disconnection of the wrong infusion

5. Shift handover errors[32].

D. LABELING STANDARDS, COLOR CODING AND HUMAN FACTORS

Standardized labeling is a process that can make drug administration safer, but studies aimed at standardized labeling of infusion lines are limited. Simulation studies have shown that standardized systems of line-labeling can improve identification[29] but the value of color coding has not been settled[33,34].

Color-coding, the systematic application of color to identify specific products, is an important component of human factors engineering. Color perception is fast, accurate, automatic, and effortless. Color has been used effectively to improve many functions[35]. Labeling of medications is not a new idea. Dating back to the eighteenth century, apothecaries had systems such as keeping poisons in cobalt blue textured bottles of unusual shapes with sinister warning labels[36]. International color-coded labels are *recommended* for syringes, preparation bags, PCA and PCEA devices, administration routes, medication carts, and medication storage devices[37]. The use of medication color-coding has been criticized. Some experts believe that people are more likely to read a drug label if it is in black and white[38]. There

are more drugs and drug groups than colors available for labeling. Human factors studies show that humans have poor memory recall of specific colors[39]. Also, the prevalence in the general population of color vision deficiency (CVD) is 8% in men and 0.4% in women. While endorsed by the ASA, color-coded labels are opposed by several organizations: ISMP, FDA, AMA, ASHP[40,41].

INTERNATIONAL ANAESTHETIC LABELING STANDARD

Anesthesia practice has employed color-coded safety cues for many years. In 2008, the *International Anaesthetic Labeling Standard* was introduced to reduce medication errors in anesthetic practice[42]. It designates the color, size, design and general properties of the labels and provides requirements for user-applied labeling of medications, fluids, conduits, and non-injectables. **According to the standard:**

Labels:

- **Must fit properly.**
- **Must be durable and resistant to fluids and wear.**
- **Must remain attached and intact for their duration of use.**
- **Must remain legible for the duration of use if written on in ink.**
- **Are color-coded to help with identification.**

Medications

- **Are classified according to medication class.**
- **Are categorized according to their primary therapeutic use (not pharmacological class).**
- **Antagonist medications have a colored border with diagonal stripes (e.g., naloxone has a blue label with a blue and white diagonal-stripe border).**
- **Medications in the miscellaneous category have black text on a white background.**

AUSTRALIAN COMMISSION ON SAFETY AND QUALITY IN HEALTH CARE. NATIONAL STANDARD FOR USER-APPLIED LABELING OF INJECTABLE MEDICINES, FLUIDS AND LINES.

A review of medication incidents reported in Australia from 2003-2009 found many labeling errors: unlabeled/incorrectly labeled bags and syringes, mistaken assumption that the unlabeled bags or syringes contained normal saline, unlabeled insulin infusions, unlabeled/incorrectly labeled lines, and incorrectly placed labels. These errors resulted in (1) the wrong medicine being administered or (2) the medicine administered by the incorrect route or (3) to the wrong patient- three of the five 'patient rights' of medication administration (right patient, right medication, right dose, right time, and right route). Serious patient harm, including death, was caused by medication administered intrathecally rather than intravenously; an unlabeled bag of magnesium sulfate solution delivered to a patient who already had a bag of magnesium infusing; and the connection of oxygen tubing to an IV line in a pediatric patient[43]. In 2012 the Australian Commission of Safety and Quality in Health Care adopted a National Standard for user-applied labeling of injectable medicines, fluids, and lines, following in the footsteps of other international organizations, including the World Health Organization, Joint Commission, Institute for Safe Medication Practices in the United States and ISMP Canada. **The Australian National Standard requires:**

- **Infusions can be labeled with pre-printed line labels including the name of medicine or fluid.**
- **Color-coding should follow anesthetic labeling standard.**
- **Miscellaneous high-risk medication labels should be printed red on white.**
- **Anticoagulants/antiplatelet drug labels are teal with black printing.**
- **Text must be clearly legible.**
- **Label material must remain intact for duration of use.**
- **Label glue must ensure label attached for duration of use.**
- **Preprinted warning label to identify cytotoxic medicine infusing.**

A 2011 survey of European Society of Intensive Care Medicine (ESICM) members regarding standardized drug labeling in intensive care showed that it is not widely followed[44]. Only 35% of respondents reported use hospital-wide, 39% in the ICU. There were regional differences with ISO label standard use. The ISO label standard was used by only 30%. There was no difference between use in private, public, and university hospitals. Also noted was that the type of medications used in the ICU setting is more numerous and variable than that used in anesthetic practice. It was suggested that the pharmaceutical industry should supply labels with their medications[45].

LABELING AND PEDIATRIC PATIENTS

Pediatric patients, infants and neonates are at increased risk for medication errors due to the smaller and more precise dosing regiments they require, especially during

emergency treatment. Pediatric resuscitations are high-stress situations requiring rapid decision-making. Commercially pre-filled, labeled syringes afford extra safety but are expensive. Color-coded stickers are beneficial and can reduce mix-ups between drug groups[46].

A simulated pediatric emergency scenario demonstrated that color-coded medication safety (CCMS) systems based on patient size reduce pediatric medication delay and improve nursing accuracy[47]. Use of a pre-filled, color-coded medication delivery system reduced the time to prepare and administer medications, reducing dosing errors during simulations.

CONCLUSION

It is clear that preventable harm from medication errors can in part be attributed to inadequate and delayed identification of the appropriate IV lines through which to deliver therapy. It is hard to understand why patients are still being harmed in 2020 by misidentification of IV lines, given the above understanding of the root causes of adverse events with IV medication and the guidelines in place. It appears logical that a labeling system that is aligned with these best practice guidelines ***and*** leverages the power of the visual and tactile senses of the clinician may reduce the frequency of incorrect or delayed IV-line selection. The Sāfen® suite of labels has been designed by clinicians, engineers and human factors experts to maximize visual and tactile clues for correct IV-line identification, using color, pattern, shape, texture, size, adherence/fit and durability. Reducing patient harm from delayed and incorrect identification of IV lines is aligned with Sāfen's® mission to improve patient safety.

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