



Color-coded prefilled medication syringes decrease time to delivery and dosing errors in simulated prehospital pediatric resuscitations: A randomized crossover trial^{☆, ☆}



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ABSTRACT

Background: Medication dosing errors remain commonplace and may result in potentially life-threatening outcomes, particularly for pediatric patients where dosing often requires weight-based calculations. Novel medication delivery systems that may reduce dosing errors resonate with national healthcare priorities. Our goal was to evaluate novel, prefilled medication syringes labeled with color-coded volumes corresponding to the weight-based dosing of the Broselow Tape, compared to conventional medication administration, in simulated prehospital pediatric resuscitation scenarios.

Methods: We performed a prospective, block-randomized, cross-over study, where 10 full-time paramedics each managed two simulated pediatric arrests *in situ* using either prefilled, color-coded syringes (intervention) or their own medication kits stocked with conventional ampoules (control). Each paramedic was paired with two emergency medical technicians to provide ventilations and compressions as directed. The ambulance patient compartment and the intravenous medication port were video recorded. Data were extracted from video review by blinded, independent reviewers.

Results: Median time to delivery of all doses for the intervention and control groups was 34 (95% CI: 28–39) seconds and 42 (95% CI: 36–51) seconds, respectively (difference = 9 [95% CI: 4–14] seconds). Using the conventional method, 62 doses were administered with 24 (39%) critical dosing errors; using the prefilled, color-coded syringe method, 59 doses were administered with 0 (0%) critical dosing errors (difference = 39%, 95% CI: 13–61%).

Conclusions: A novel color-coded, prefilled syringe decreased time to medication administration and significantly reduced critical dosing errors by paramedics during simulated prehospital pediatric resuscitations.

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1. Introduction

Medication errors are committed by healthcare providers, including physicians, nurses and paramedics, in virtually all healthcare settings.^{1–7} Since the release of the Institute of Medicine's (IOM) 1999 report addressing errors in healthcare, increased emphasis has been placed on reducing medical errors from faulty processes, systems, and environments that lead well-meaning clinicians to make mistakes or fail to prevent them.⁸

One of the highest risks for medication error exists during pediatric emergencies, particularly in the prehospital setting. A

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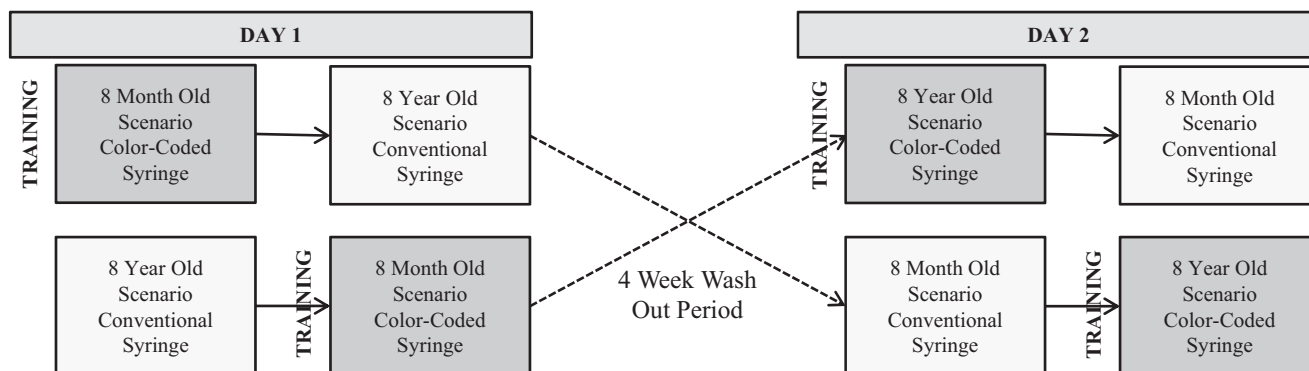


Fig. 1. Study design schematic.

single paramedic is often exclusively responsible for gathering and analyzing pertinent information, making prompt decisions, and performing advanced interventions prior to the transfer of a critically ill patient to the emergency department (ED). Often this must be done amidst social chaos and under psychologically stressful conditions, increasing the potential for medication errors.

The color-coded Broselow™ Pediatric Emergency Tape (Vital Signs, Inc., Totowa, NJ) was developed to standardize both weight assessment and drug dosing for pediatric patients in a successful effort to decrease dosing errors. It is one of the most reliable and commonly used tools for pediatric resuscitations.^{9–12} Unfortunately, this approach does not eliminate dosing errors as clinicians must still determine the volumes of medications from ampoules in order to deliver the correct dose. Translation of medications from the Broselow Tape has been proposed; yet to our knowledge, no one has attempted to develop color-coded, prefilled syringes that could be used in conjunction with the Broselow Tape to facilitate timely and accurate drug administration in the prehospital environment.¹³

The objective of this study was to compare novel, prefilled medication syringes labeled with color-coded volumes corresponding to the weight-based dosing of the Broselow Tape to conventional methods of drug administration in simulated prehospital pediatric resuscitations. We hypothesized that time of preparation to administration of drugs would be shorter, and the proportion of dosing errors would be lower when using prefilled, color-coded syringes (intervention) when compared to conventional medication preparations (control).

2. Methods

2.1. Study design

We performed a prospective, block-randomized, cross-over study with data collected during two standardized simulated pediatric cardiac arrest scenarios on May 17, 2011 and repeated on June 16, 2011 (Fig. 1). The prehospital environment was recreated by conducting simulations *in situ*, or inside working, off duty ambulances, with the same medication kits used in the field. Consistent with standard practice, we provided two firefighter/emergency medical technicians to assist with resuscitation by performing chest compressions and bag-valve-mask ventilations at the direction of the paramedic. Pediatric cardiac arrest scenarios were developed and face validity was assessed by a panel of experts in pediatric emergency medicine, prehospital emergency care and further adapted to local protocols and paramedic scope of practice. Scenarios were piloted and refined prior to implementation (Appendix A). For purposes of prehospital resuscitation,

epinephrine and atropine were developed as color-coded syringes for use in this study (Fig. 2).

Prior to beginning simulations, each participant was instructed to manage the scenario, treat with medications as they would in normal practice using the Broselow Tape for determining dosages and verbalize their medication orders. Before the experimental method scenarios, subjects received a 3-min training (*i.e.*, pre-recorded video instruction and hands-on use) of the prefilled, color-coded syringes. Specific training was not given prior to conventional medication administration scenarios to reflect current practice. A scenario moderator read details of the case presentation to the study subject prior to entering the patient care compartment of the ambulance.

On the first day, each participant was randomly assigned by a study investigator (ADS) using a fair coin to a scenario involving a simulated patient 8 years of age and using their standard medication kit or a simulated patient 8 months of age and using the same kit but with prefilled, color-coded medication syringes in place of conventional ampoules. Each subject then participated in the other scenario following a 10 min intermission. During simulations, moderators made written notations without interference in simulation dynamics.

Upon completion of both scenarios, each subject completed a closed-response survey. Subjects provided demographics, rated adequacy of training with the Broselow Tape, standard medication kits and prefilled, color-coded syringes, ease of use of both medication delivery systems, perceived scenario difficulty, confidence in accuracy of using prefilled, color-coded syringes, and whether they believed prefilled, color-coded syringes would be a safer alternative to dose calculation during resuscitations (Appendix B). Subjects returned four weeks later repeating the scenarios in reverse order



Fig. 2. Color-coded, prefilled syringes.

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