Ad Hoc versus Standardized Admixtures for Continuous Infusion Drugs in Neonatal Intensive Care: Cognitive Task Analysis of Safety at the Bedside

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Abstract
Continuous infusion intravenous (IV) drugs in neonatal intensive care are usually prepared based on patient weight so that the dose is readable as a simple multiple of the infusion pump rate. New safety guidelines propose that hospitals switch to using standardized admixtures of these drugs to prevent calculation errors during ad hoc preparation. Extended hierarchical task analysis suggests that switching to standardized admixtures may lead to more errors in programming the pump at the bedside.

Introduction
Neonatal intensive care patients may weigh 400 gm to 5 kg and often require continuous infusion IV drugs. A common practice is to mix the drug *ad hoc* in an IV carrier fluid at a concentration calculated from the patient's weight, so that the dose being given is readable as a simple multiple of the infusion rate displayed on the IV pump. For example, the drug dopamine is often prepared so that an infusion rate of 0.5 ml/hr delivers a dose of 5 mcg/kg/min. However, calculation and measurement errors while using this *ad hoc* process have caused adverse drug events. To reduce these errors, the Joint Commission for Accreditation of Hospitals proposed that hospitals switch to only standardized admixtures of these drugs.[1] Practical use of the standardized admixture process requires setting the infusion pump rate according to a dose-rate table specific to that drug admixture, or by using "smart pump" technology (not in widespread use in neonatal care). Safety studies have reported favorable results with the switch to standardized admixtures.[2] However, these studies have not focused on the potential impact at the bedside, where errors in programming infusion pumps are a common cause of adverse drug events.

Methods
Cognitive task analysis identified 2 bedside tasks as being elemental: 1) *checking* the current dose of drug being delivered, and 2) *changing* the dose of drug delivered. Extended Hierarchical Task Analysis (EHTA) was used to compare the complexity of these 2 tasks under the ad hoc process versus the standardized admixture process. EHTA divides the task space between the external world of the device interface and the internal cognitive world of the user, allowing for descriptive predictions of potential user errors at the human-device level.[3]

Results
Using the *ad hoc* process, EHTA showed that both study tasks could be completed with only 4 subtasks. The standardized admixture process required 7 subtasks to check the current dose and 9 subtasks to change the dose delivered. These additional steps were required to lookup information in the dose-rate table. The number of error affordances identified was equal to the number of subtasks required in all cases.

Discussion and Conclusion
Use of standardized admixtures reduces the risk associated with drug ordering and preparation.[2] However, while drug preparation is usually done just once a day, changing the drug dose by adjusting the infusion pump may occur many times a day when an infant is acutely ill. This factor may multiply the risk of errors in programming the pump. The standardized admixture process requires a greater number of cognitive tasks when caregivers must refer to an external table at the bedside to look up settings. The risk of these extra steps may be amplified during a patient crisis or when multiple continuous infusion drugs are needed concurrently. Conversely, the *ad hoc* process facilitates a simple direct action interface with the infusion pump, decreasing cognitive load on the operator. "Smart pumps" used with standardized admixtures could also provide a direct action interface for programming, retaining this benefit. However, serious infusion errors still occur with smart pumps; more human factors research is needed for the potential of smart pumps to be realized.[4]

References
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