

Using Finite State Modeling To Compare and Contrast Infusion Devices in the Context of Device Specificity

Mark E. Nunnally, M.D.; Michael F. O'Connor, M.D.; Richard I. Cook, M.D.

Anesthesia and Critical Care, University of Chicago, Chicago, Illinois.

Device-related adverse events are a common byproduct of the use of infusion devices in modern medical practiceⁱ. We have previously reported finite state modeling as a method of studying the genesis of these incidentsⁱⁱ, and have demonstrated that complexities in the device programming structure lead to inefficient and potentially hazardous programming behaviorsⁱⁱⁱ. These may result in users becoming "lost in Menuspace". Finite state modeling also affords the investigator the opportunity to contrast various features in the "Menuspace"^{iv}. We studied and contrasted three devices (infusion devices A, B, C) under the hypothesis that task-specific pumps would display less menu complexity, and, by extension, less propensity towards adverse events.

Devices A, B, and C were systematically programmed to reveal their menu structure and the findings were formatted as diagrams. Device A was a multipurpose IV infusion device, device B a patient controlled analgesia device, and device C was an enteric nutrition pump designed to deliver feeding solutions through an enteric feeding tube. The finite state diagrams of the three devices served as a framework for device comparison.

Device A demonstrated complexity likely to make some aspects of device operation opaque to virtually every user. Specifically, over 2200 screen variations were possible with more than 10,000 different key press pathways between them. Programming was accomplished in a piecemeal fashion, so certain variables were retained when the device was reprogrammed. In contrast, devices B and C were less complex. Device B used an LED screen for most programming features and had approximately 22 different screen styles and 33 key press pathways between them. The programming of the device was stepwise, forcing the user through all steps and revealing all variables in the process. The diagram of device C was the simplest, with no different screens, and a maximum of 2 pathways between device states. Furthermore, the programming states of the device were transparent to the user, as modes were switched by a simple dial. Feedback was apparent in the forms of a spinning wheel, a LED flashing indicator, the noise of the motor, and alarm prompts explained by stickers on the device.

Usability is a critical feature of device safety. In a sample of three very different pumps, multipurpose use appears to produce programming complexity and diminished transparency as byproducts. There have been many proposals to standardize infusion equipment and limit the number of pump models available as a way to avoid infusion errors. Although standardization may be seen as a way to diminish complexity in device programming, our results would suggest it may also add to it by increasing Menuspace. Designing pumps with a singular use may increase the number of models used, but produce safer, easier to use products.

ⁱ Anesthesiology 2002; 96: A1073

ⁱⁱ Nunnally, ME et al. ASA abstract 2002

ⁱⁱⁱ 3. Nunnally, ME et al. ASA abstract 2002

^{iv} . Nunnally, ME et al. ASA abstract 2002.