# Utilising principles of visual hierarchy to reduce errors of accidental drug administration

**Amol Lotlikar**

University College London Hospital NHS Foundation Trust

## SUMMARY

Programming errors in infusion pumps pose significant safety risks. Current mitigation strategies rely on human-centred methods such as checklists or two-person checks. Redesigning pump interfaces using visual hierarchy principles could better prevent errors by emphasising critical information during drug selection and confirmation.

## KEYWORDS

Medical device, Visual hierarchy, Patient safety

### Introduction

Total Intravenous Anaesthesia (TIVA) refers to the administration of anaesthetic agents entirely through intravenous methods, facilitated by infusion pumps with pre-programmed drug delivery models. TIVA is gaining prominence in anaesthetic practice due to its clinical advantages (Johnson, 2017) and its ability to reduce the environmental impact of anaesthesia by lowering the carbon footprint Bernat, 2024).

Previous research (Kirkendall, 2020) has highlighted the potential for error when utilising smart pumps for drug delivery, which can range from wider system and performance errors to issues with the pump interface and design.

In our department we use BD Alaris$^{TM}$ pumps for all TIVA delivered. While TIVA offers numerous benefits, it also presents risks, particularly regarding error during pump programming. A departmental meeting recently highlighted a near miss incident involving the administration of an incorrect drug due to programming errors. This report highlights potential issues with the pump interface that could be contributing to increased error rates and suggests areas for future improvement, specifically regarding the visual hierarchy and design of the infusion pump screens.

### Method

To investigate this further, a snapshot survey was conducted among 187 department members, with 47 responses received. The survey findings are as follows:

- 38% had mistakenly inputted the wrong drug, concentration, or model in the last year.
- 11% of these errors led to the incorrect drug/model being delivered to a patient.
- 46.8% expressed concern about the potential for such errors in their practice.

These findings indicate that the near miss was not an isolated event, emphasising the need for further investigation and mitigation strategies. Whilst the response rate was low for the size of department, even a small number of errors can lead to significant harm (Kataoka, 2008) or death, warranting further research into potential improvements in pump design.

## Current Mitigation Strategies and Interface Design

At present, the primary strategies for mitigating programming errors rely on human-centred methods, such as checklists or two-person verification of pump programming (Woodward, 2024). However, according to Human Factors principles such as the hierarchy of controls, design-level changes are more effective than human-centred solutions (Kelly, 2023).

### Potential Issues:

- **Contrast and Readability:** The current pump screen displays white text on a black background. Research on readability and error reduction (Budiu, 2020) suggests that light text on a dark background, negative contrast polarity, may increase error rates compared to positive contrast polarity. Negative contrast polarity may have been chosen primarily for battery life conservation rather than usability.
- **Drug Programming Interface:** the current interface for the BD Alaris™ pump model follows a consistent design (Figure 1):
    - Once selected, drug and model details are displayed on the right-hand side of the screen and remain there even with the final confirmation
    - Patient demographic data is inputted sequentially on the left-hand side of the screen. Attention is therefore further focussed on the left side to ensure correct demographics are inputted.

Although this design is efficient, it lacks emphasis on the critical confirmation step before drug delivery.

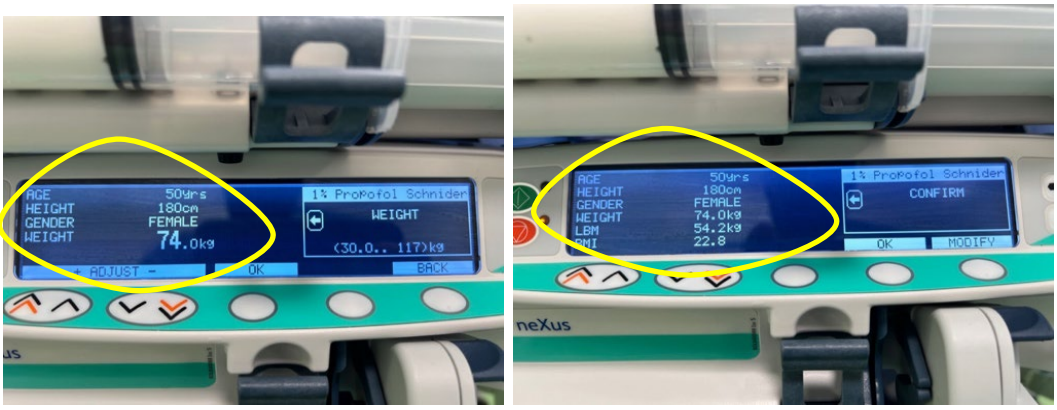


Figure 1: Current drug selection interface.

### Proposed interface improvement using principles of visual hierarchy

Visual hierarchy refers to the design principle of arranging information in such a way that guides the user's eyes to the most critical data first. This can be achieved through elements such as size, colour, contrast, and placement (Saw, 2024). With regards to medical pumps, prioritising important details such as drug selection, demographic information and alarm indicators, could ensure quick and accurate decision-making during patient care. Conversely, a lack of visual hierarchy could result in difficulty distinguishing the relative importance of critical information, leading to errors with pump programming.

There is limited research regarding visual hierarchy in medical pumps. However, insights can be drawn from web page user experience studies, where scanning behaviours have been well-documented (Pernice, 2019).

When browsing the web, users tend to scan in patterns to improve efficiency under time constraints and are also influenced by familiarity from previous experiences. It is possible that this scanning method may also occur when programming TIVA pumps due to distractions, alarms, and time pressures. In western languages, users preferentially read text on the left and towards the top of pages as well as focussing on areas that are of interest to them. Consideration of these scanning patterns to pump interface design could provide insights into where errors are occurring. As discussed, with these principles in mind, when programming the BD Alaris™ pump, users focus may be more on the left of the screen which could result in missing if the correct drug and model have been selected.

## Proposed steps

To enhance usability and reduce errors in TIVA pump programming, a proposed redesigned interface would include improved contrast and a critical confirmation step before finalising drug delivery. (Figure 2)

This simple measure, of placing the drug name and concentration on the left of the screen, prior to delivering the drug should be trialled to assess its impact on error reduction. Additionally, further work is needed to compare error rates when programming pumps under different contrast settings and in varying lighting conditions.

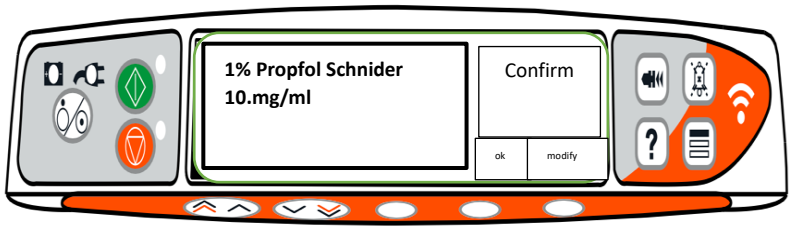


Figure 2: Proposed confirmation step.

This proposal has already been shared with the manufacturer, whose medical device team has acknowledged the suggestion. Findings from future trials should be also shared with patient safety groups for further consideration.

## Conclusion

TIVA is a valuable anaesthetic technique with clinical and environmental benefits. However, error in pump programming remains a significant safety risk. By implementing design changes informed by principles of visual hierarchy, it may be possible to reduce these errors and improve patient safety. Collaboration with equipment manufacturers to evaluate these proposed changes and dissemination of findings to professional bodies will provide an important step in identifying design elements that could enhance patient safety.

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