# What Do Intravenous Medication Errors Really Look Like in the Critical Care Unit and Beyond?

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# How much does Critical Care Infusion add to clinician workload?

## TISS-76 Therapeutic Intervention Scoring System Updated in 1983

**Maximum score is 176.**
**Critically ill patient could consume ≈42 of these points solely for infusion.**
**≈24%**

- ✓ Central iv hyperalimentation (includes renal, cardiac, hepatic failure fluid)
- ✓ Concentrated K+ infusion via central catheter
- ✓ Frequent infusion of blood products (>5 units /24 h)
- ✓ Bolus iv medication (nonscheduled)
- ✓ Vasoactive drug infusion (1 drug)
- ✓ Continuous antiarrhythmic infusions
- ✓ Arterial line
- ✓ Acute digitalization - within 48 h
- ✓ Active diuresis for fluid overload or cerebral edema
- ✓ Active Rx for metabolic alkalosis
- ✓ Active Rx for metabolic acidosis.
- ✓ Active anticoagulation (initial 48 h)
- ✓ Coverage with more than 2 iv antibiotics
- ✓ CVP (central venous pressure)
- ✓ 2 peripheral iv catheter
- ✓ Replacement of excess fluid loss
- ✓ Parenteral chemotherapy
- ✓ Pitressin infusion
- ✓ 1 peripheral iv catheter
- ✓ Chronic anticoagulation
- ✓ Standard intake and output (q 24 h)
- ✓ STAT blood tests
- ✓ Intermittent scheduled iv medications
- ✓ Routine dressing changes
- ✓ Standard orthopedic traction
- ✓ Antibiotics iv (2 or less)
- ✓ Peripheral hyperalimentation / Intralipid therapy



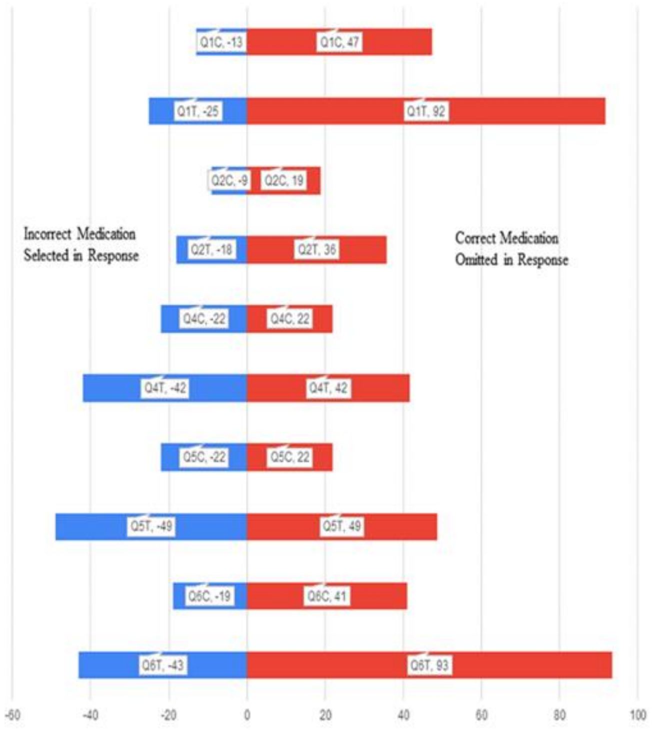

Keene AR and al. Therapeutic Intervention Scoring System : Update 1983. Crit Care Med 1983:11,1-3.

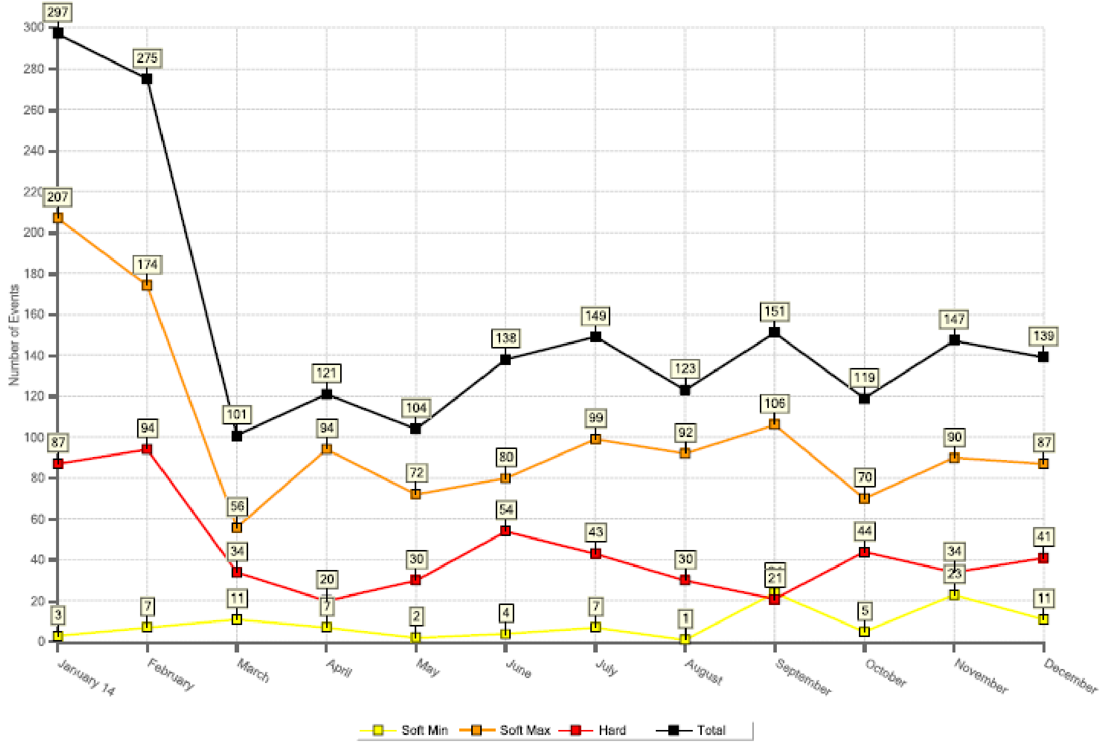
# Really... how much?

40% of nursing time is directly related to medication administration.[1]

# Is it done appropriately and in an optimal way?

**Knowledge of administration line material type and characteristic requirements (light protection and filtration)** even among specialist discipline nurses was poor.[2] **Frequency of appropriate use (of infusion devices)** 0% (0/52) pre-audit, 73.13 % (117/160) post-audit. ($p < 0.0001$).[3] **Including pressure alarm settings, hard and soft limit breaches for IV-medications.**



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2. Al-Jaber R, Samuda N, Chaker A, Waterson J. Critical Care Nurses' Knowledge of Correct Line Types for Administration of Common Intravenous Medications: Assessment and Intervention Study. JMIR Form Res. 2022 Apr 26;6(4):e36710.
3. Bergon-Sendin et Al. Smart pumps and random safety audits in a Neonatal Intensive Care Unit: a new challenge for patient safety. BMC Pediatr. 2015 Dec 11;15:206

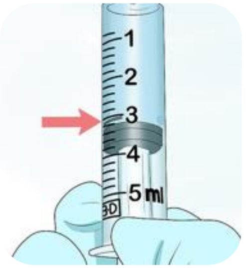
# How much production takes place, and how well is it done?

**Institute for Safe Medication Practices Survey[1]:**

- Only 52% of respondents reported that it is always easy to identify with certainty which drugs, diluents, and volumes were used when verifying the preparation of each medication.

**Nearly three-quarters (74%) of all survey respondents were aware of at least one compounding error that had occurred during the past 12 months:**

- Incorrect dose or concentration (58%)
- Incorrect base solution (51%)
- Incorrect base solution volume (43%)
- Incorrect reconstitution of a drug (volume or diluent) (36%)
- Incorrect drug (35%)
- Survey was undertaken in sterile compounding units… not in busy ICUs…
- ‘A deviation in concentration of more than 20% was found in ward-prepared infusions, although this was caused by volume discrepancies of less than 0.2 mL. The frequency and magnitude of deviations found in infusions prepared in pharmacy was lower than in those prepared by NICU…’[1,2]





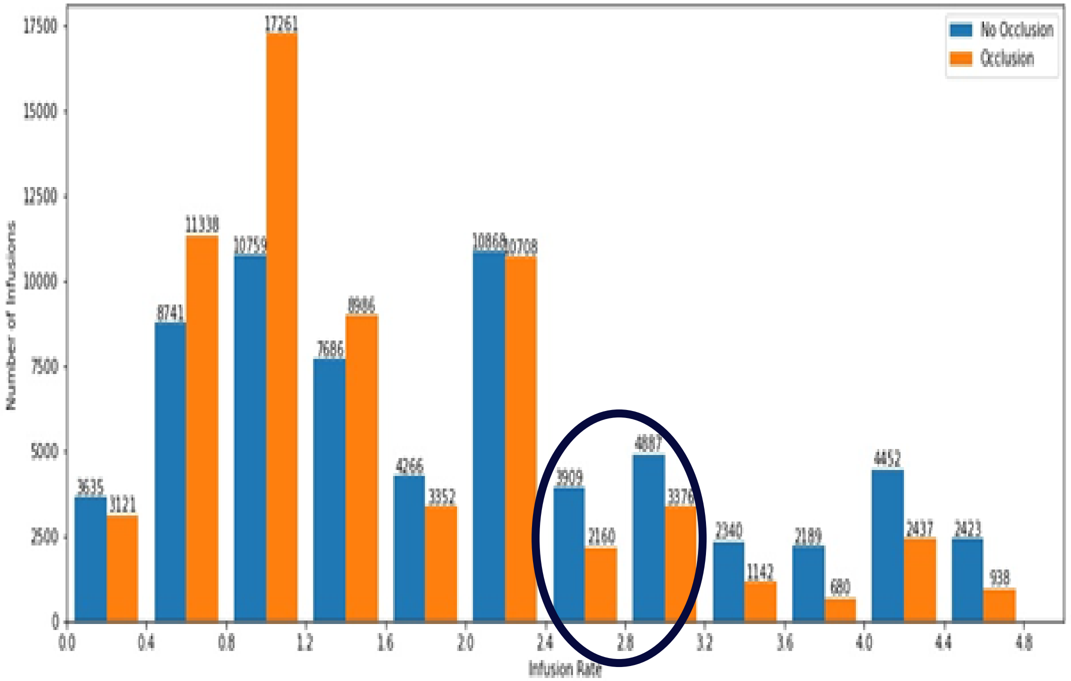


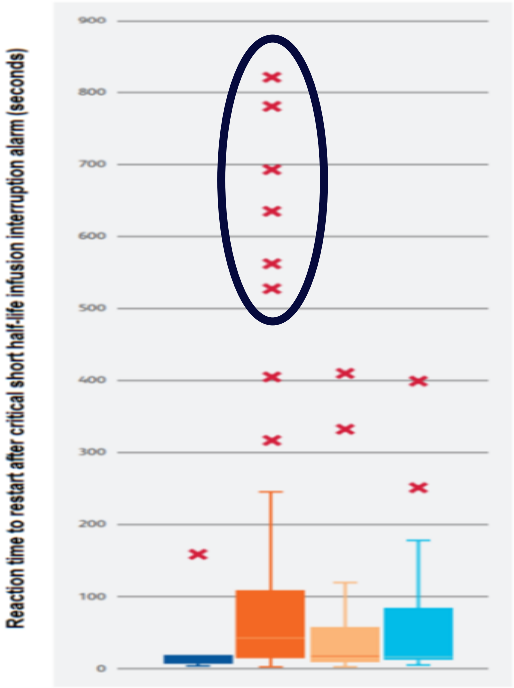
1. Institute for Safe Medication Practices. ISMP survey provides insights into pharmacy sterile compounding systems and practices. Institute for Safe Medication Practices. 2020 Oct. URL: https://ismp.org/resources/ismp-survey-provides-insights-pharmacy-sterile-compounding-systems-and-practices [accessed 19 September 2023]
2. Aguado V, Weeks K, Tunstell P, Turnock K, Watts T. Arenas-López S. Accuracy of the concentration of morphine infusions prepared for patients in a neonatal intensive care unit. Archives of disease in childhood. 2013 98. 10.1136/archdischild-2013-304522.

# Are Critical Infusions Administered Optimally and Maintained without Interruption?

ML Predictor model showed that low-rate infusions with rates ranging from 2 to 2.8 mL/hr performed best for achieving a balance between infusion longevity and fluid load per infusion, with an occlusion versus no-occlusion ratio of 0.553. Rates between 0.8 and 1.2 mL/hr exhibited the poorest performance.[1]

Mean and median response times to critical short half-life infusion interruptions generally within the half-lives of the selected medications, there was a high prevalence of outliers in terms of reaction times for all the critical short half-life infusions studied.[2]







1. Kia A, Waterson J, Bargary N, Rolt S, Burke K, Robertson J, Garcia S, Benavoli A, Bergström D. Determinants of Intravenous Infusion Longevity and Infusion Failure via a Nonlinear Model Analysis of Smart Pump Event Logs: Retrospective Study JMIR AI 2023;2:e48628
2. Waterson & Bedner. Types and Frequency of Infusion Pump Alarms and Infusion-Interruption to Infusion-Recovery Times for Critical Short Half-Life Infusions: Retrospective Data Analysis. JMIR Hum Factors 2019. Vol. 6. Iss. 3.

# How are we doing on VAP?

## Pathogenesis of HAP/VAP

Bacterial colonisation → Aspiration → HAP/VAP

## Preventive strategy

- Hand hygiene
- Appropriate staffing ratios
- Staff education
- MDR pathogen isolation
- Avoid unnecessary antibiotic administration
- Avoid unnecessary stress ulcer prophylaxis
- Sucralfate for stress ulcer prophylaxis
- Oral intubation
- Short course parenteral antibiotics
- Selective digestive decontamination and oral chlorhexidine

- Appropriate NIPPV use to avoid intubation
- Shorten duration of mechanical ventilation
- Subglottic suctioning
- Semi-erect position
- Prevent accidental extubation
- Maintain adequate cuff pressure
- Avoid gastric overdistention
- Avoid ventilator circuit changes/manipulation
- Drain ventilator circuit condensate
- Avoid patient transports
- Prevent accidental extubation

## 'Vent bundle'

- Suctioning
- Head of bed > 30º
- Oral Care
- Sedation holiday
- SSD-ETT

'Adoption of these care bundles should rationalise VAP prevention practises and improve outcomes, such as length of stay…'[1]
(Provided you do them all… consistently)



Rello J, Lode H, Cornaglia G, Masterton R; VAP Care Bundle Contributors. A European care bundle for prevention of ventilator-associated pneumonia. Intensive Care Med. 2010;36(5):773-780.

# How are we doing on HR?

- 'Job demands most consistently associated with elevated burnout: role ambiguity, role conflict, and workload.'[1]
- The association between job demands, job resources, and burnout are positively associated with Emotional Exhaustion, which in turn cause an increase in Depersonalization.[2] (Jourdain & Chênevert, 2010).

| How Often? | | | | | | |
|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| Never | A few times a year or less | Once a month or less | A few times a month | Once a week | A few times a week | Every day |
| I feel used up at the end of the workday. | | | | | | |
| I feel burned out from my work. | | | | | | |
| I feel I'm positively influencing other people's lives through my work. | | | | | | |
| I feel very energetic. | | | | | | |
| I feel I'm working too hard on my job. | | | | | | |
| I don't really care what happens to some patients. | | | | | | |
| I feel exhilarated after working closely with my patients. | | | | | | |
| I have accomplished many worthwhile things in this job. | | | | | | |
| I feel like I'm at the end of my rope. | | | | | | |

1. Alarcon, G. A meta-analysis of burnout with job demands, resources, and attitudes. Journal of Vocational Behavior, 2011 79(2), 549-562.
2. Jourdain, G. & Chênevert, D. Job demands-resources, burnout and intention to leave the nursing profession: A questionnaire survey. International Journal of Nursing Studies, 2010 47, 709-722.
3. Maslach, C., & Jackson, S. E. Maslach Burnout Inventory--ES Form (MBI) [Database record]. 1981 PsycTESTS.

# How can connectivity, automation and integration help?

Prescription

Preparation

Dispensing

Administration

Patient

Surveillance and reporting

**Hint: How we use the solutions are the key...**

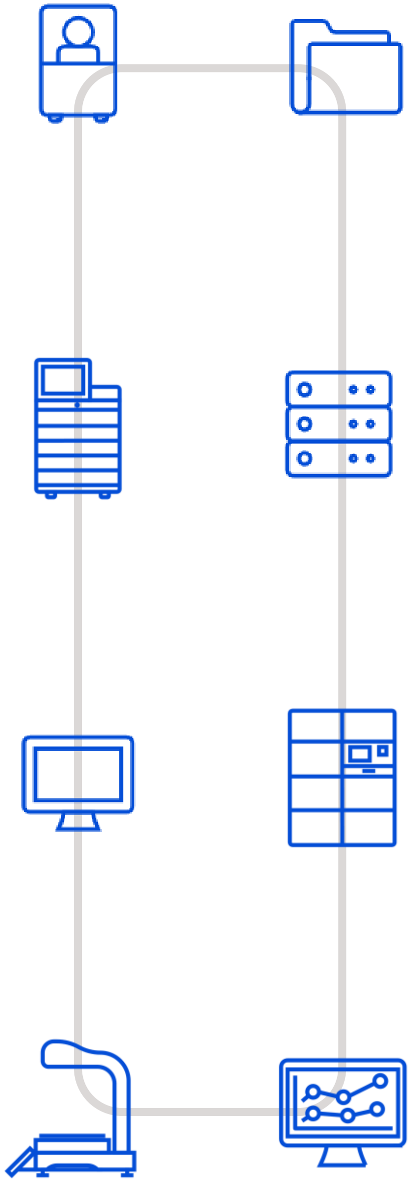
# TISS ‘24%’ Workload and ‘40%’ Medication Time: A Lesson from Oncology

## Pre-Study Conditions[1]

- All chemotherapy, approximately 5,800 doses PA compounded by nursing staff.
- 1 Nurse from inpatient unit dedicated to compounding. 3.5 Nurses on unit average.
- 3 pharmacy technicians, 2 pharmacists.
- No 2-Nurse check. Staffing Constraints and National Guidance.
- In-patient Chemotherapy Unit, 8 beds.
- Walking time between workstation and patient locations: Average Estimate. 10.8 Minutes daily.

## Study Conditions continuing into post-study period[1]

- 3.5 Nurses on unit average.
- No 2-nurse check. Staffing Constraints and National Guidance.
- Physician prints, verifies and signs therapy plan, handover to nurses.
- 3 pharmacy technicians, 2 pharmacists.
- Total doses compounded rose from 5,800 to 14,000.
- In-patient Chemotherapy Unit, 8 beds.
- Walking time between workstation and patient locations: Average Estimate. 10.8 Minutes daily.





1. Meren ÜH, Waterson J. Evaluating an Automated Compounding Workflow Software for Safety and Efficiency: Implementation Study. JMIR Hum Factors 2021;8(4):e29180.

# So, IV-Medication production nearly trebled (5,700 to 14,000) with no change in headcount. How much time is saved by scanning for verification?

## Items scanned using BD Cato™ Readymed per nurse per daily batch

| | Average time for each daily batch in minutes per nurse. | Average No. of medications in each processed daily batch per nurse. Total med n= 321. | Medication Processing Rate (minutes/medication) |
|---|---|---|---|
| Mean (SD) | 10.476 (10.666) | 15.286 (7.191) | 0.697 (0.446) Max 1.875, Min 0.222 |
| Median | 7 | 14 | 0.571 |
| Q1, Q3 (IQR) | 4,10 (6) | 12,19 (7) | 0.316, 1.0000 (0.684) |

- Average time for processing meds pre-study was 6 minutes per item with prep-time etc.
- At the mean of 41 seconds this gives a saving of 5 minutes and 19 seconds (5.303 decimal minutes) per item.[1]
- Processing 14,000 items PA (current production rate via pharmacy) gives a saving of nursing time of 14,000 X 5.303 = c. 74242 minutes = 1237 hours = 51.557 days PA.
- For a hospital processing 60,000 items PA savings are therefore 318,180 minutes = 5303 hours = 220.96 days PA.



1. Meren ÜH, Waterson J. Evaluating an Automated Compounding Workflow Software for Safety and Efficiency: Implementation Study. JMIR Hum Factors 2021;8(4):e29180.

# But is it safer? Lessons from established pharmacy systems

## Classical

DOCTOR → PHARMACIST → NURSE

1. Doctor prescribes chemotherapy on CPOE, aided by clinical decision support & lab results. Prescription sent electronically to the pharmacy.
2. Pharmacist-verified order is sent electronically in real time to Pharmacy Compounding Solution. Orders are automatically prioritized in time order.
3. Compounding Software produces a 'Recipe' from the prescription and suggests components and minimum size vials to reduce waste and to guide process. Barcode scans of vials confirm the right drug. Video capture of steps. Gravimetric tolerance check.
4. Pharmacist verifies preparation, unique barcode medication label printed once all steps are corrected followed.
5. Nurse Assesses patient. Opens BCMA App. Scans medication and patient ID. Right patient-right drug check. Documented administration.

## Nurse led

DOCTOR → PHARMACIST → NURSE

1. Doctor prescribes chemotherapy on CPOE, aided by clinical decision support & lab results. Prescription sent electronically to the pharmacy.
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Push from CPOE into compounding software queue.

Pharmacist reviews order.

Nurse reviews on-screen 'recipe'. Scans components for expiry date, dose and name check.

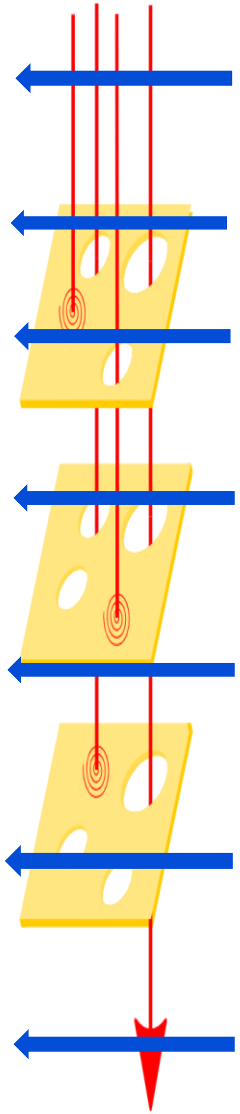
Assembles key components: Medication ampoules Diluent packaging.

Gravimetric verification and video record completed and logged by system.

Adds administration lines to diluent bag/syringe as required.

Software creates compounded medication label:
Patient Details
Administration Rate.
Dose/Volume.
Preparation Dated and Timed.

Review and check of process via software- scans, image capture, gravimetric verification, final label check off

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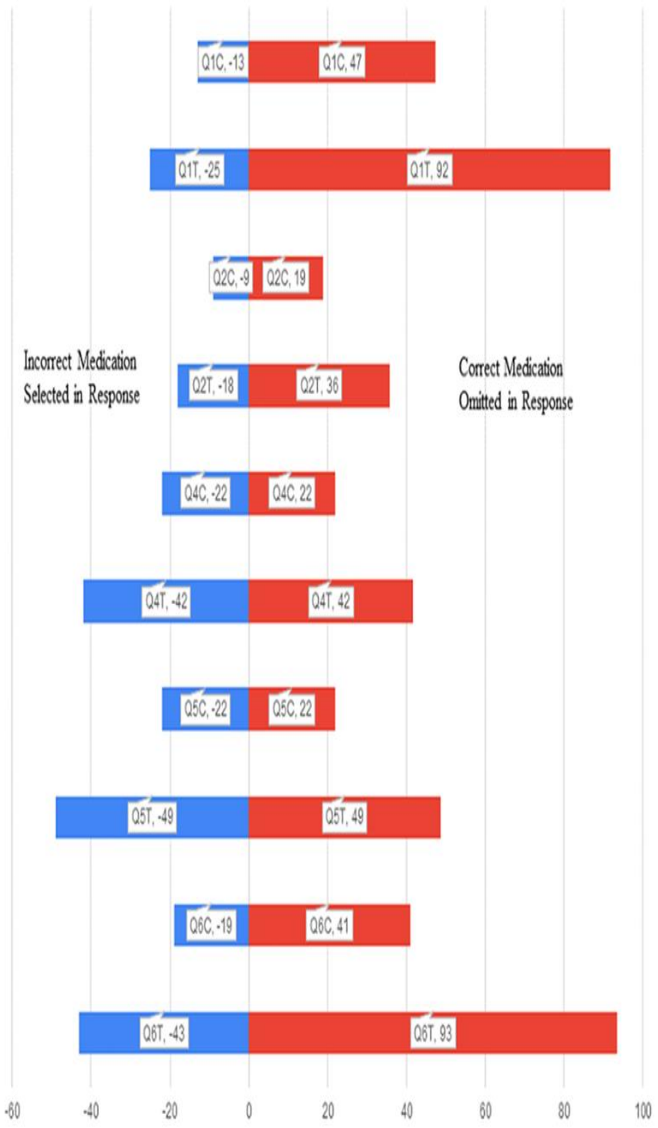
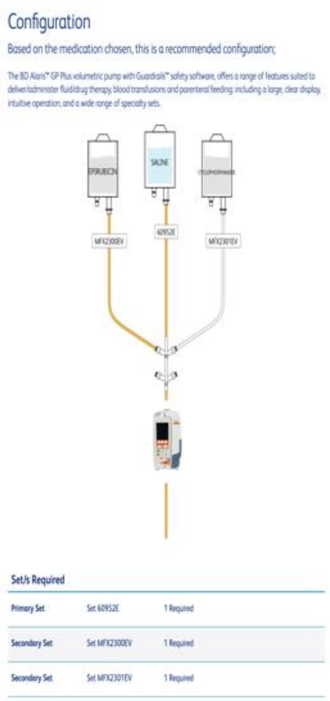
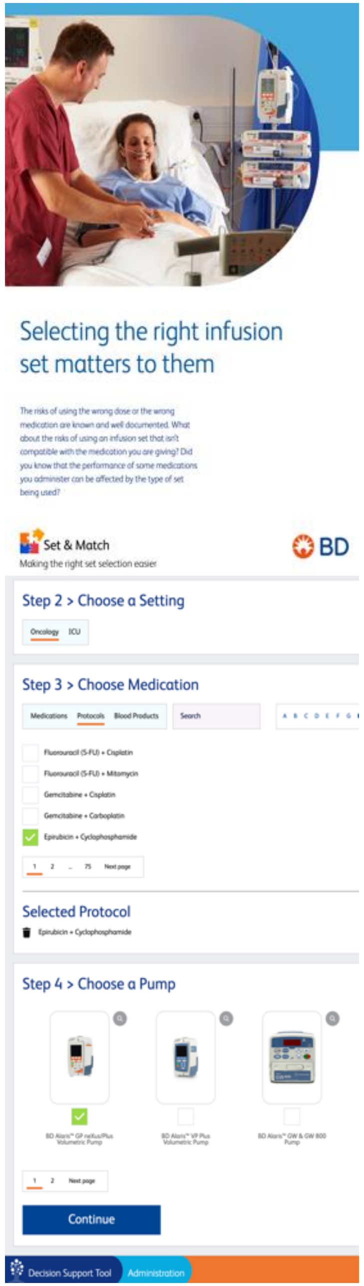
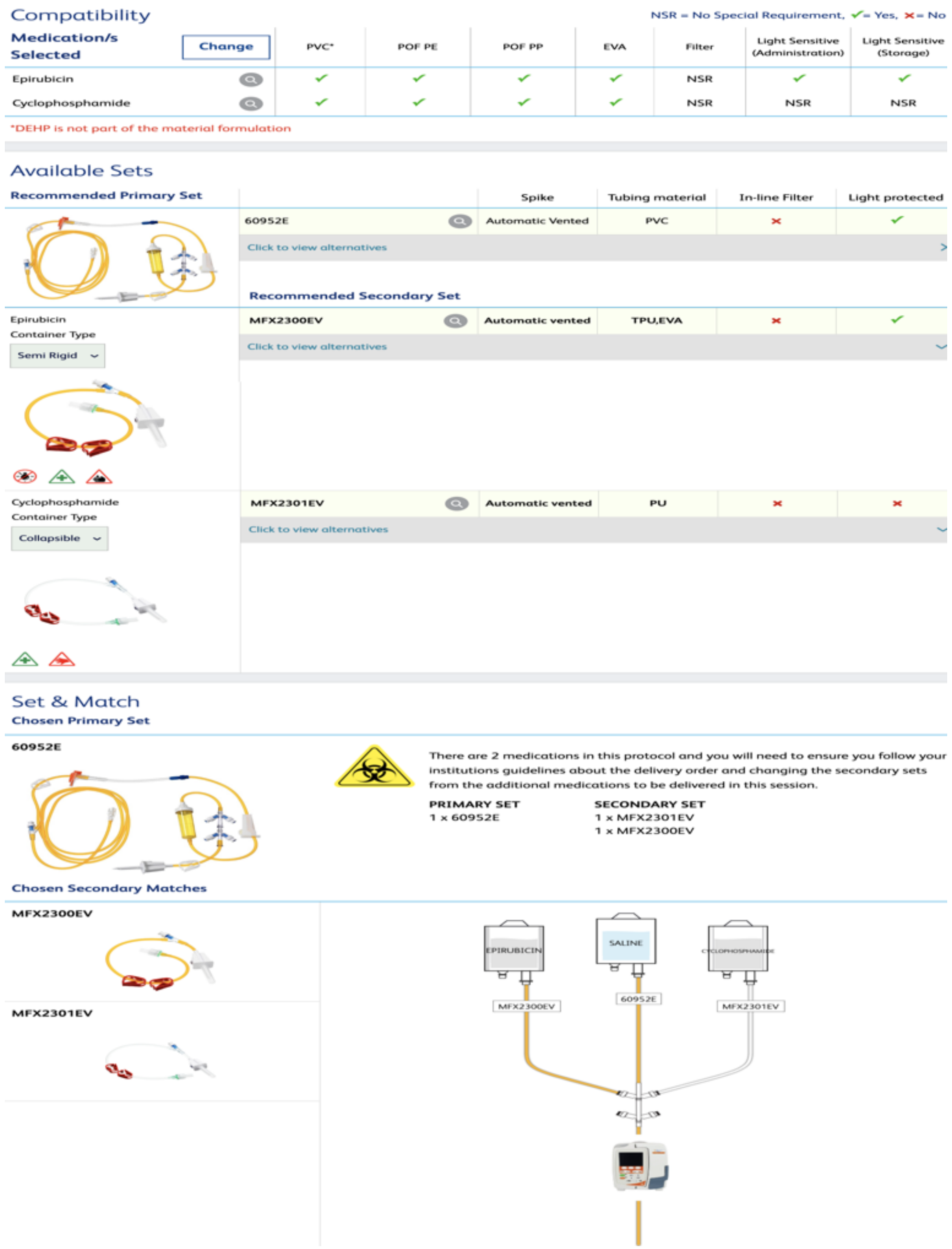





Al-Jaber R, Samuda N, Chaker A, Waterson J. Critical Care Nurses' Knowledge of Correct Line Types for Administration of Common Intravenous Medications: Assessment and Intervention Study. JMIR Form Res. 2022 Apr 26;6(4):e36710.
Al-Jaber R, Dickman A, El-Harmeel M, Schneider J, Taladriz Sender I, Sutherland A, Terkola R, Tuffin P. A modified Delphi panel to determine best practice for intravenous medication administration line material and attributes selection.' EJHP- Forthcoming.

# Occlusion alarm events in PICU and NICU

- 36% related to closed or clamped lines.
- 4% to syringe change.
- 16% to drug injection.
- 8% to patient-related factors.
- 36% occurred without any apparent external cause during ongoing infusion, among these drug incompatibilities were a potential cause for 12 events.
- Alarms from infusion pumps were frequent in the NICU/PICU setting, a quarter of them resulting from line occlusion. Other than well-known triggers (mechanical and patient factors), drug incompatibilities were identified as a potential cause for occlusion alarms in this pilot study.





Fonzo-Christe C, Bochaton N, Kiener A, Rimensberger PC, Bonnabry P. Incidence and Causes of Infusion Alarms in a Neonatal and Pediatric Intensive Care Unit: A Prospective Pilot Study. J Pediatr Pharmacol Ther. 2020;25(6):500-506. doi: 10.5863/1551-6776-25.6.500. PMID: 32839653; PMCID: PMC7439949.

# Results: Alarm frequency and type[1]

| Parameter | | Frequency in critical care areas, n | | | | | Frequency in whole hospital, n | Alarm frequency, % |
|---|---|---|---|---|---|---|---|---|
| | | All | NICU | GICU | CCU | PICU | | |
| Total infusion starts | | 187,441 | 30,527 | 45,756 | 110,254 | 904 | 1,600,832 | N/A[e] |
| Alarms per infusion, mean | | 4.50 | 3.71 | 4.36 | 1.33 | 8.61 | 1.39 | N/A |
| Alarm types | Total alarms | 467,437 | 113,277 | 199,482 | 146,694 | 7784 | 2,211,457 | 100 |
| | Flow error (ie. Drip counter) | 0 | N/A | 0 | 0 | N/A | 0 | 0 |
| | Air-in-line accumulation exceeded | 6975 | N/A | 6700 | 275 | N/A | 27,583 | 1.25 |
| | Air-in-line single bubble exceeded | 17,100 | N/A | 12,724 | 4376 | N/A | 108,701 | 4.92 |
| | Callback | 134,754 | 22,396 | 68,037 | 42,740 | 1581 | 802,691 | 36.30 |
| | Door open while infusing | 14 | N/A | 14 | 0 | N/A | 2710 | 0.12 |
| | Drive engage failure | 10,850 | 5629 | 175 | 4624 | 422 | 13,807 | 0.62 |
| | End of infusion | 20,762 | 4650 | 849 | 13,995 | 1268 | 23,903 | 1.08 |
| | Near end of infusion | 107,236 | 10,695 | 49,517 | 45,668 | 1356 | 278,969 | 12.61 |
| | Occlusion (downstream) | 136,148 | 62,944 | 49,444 | 21,314 | 2446 | 847,438 | 38.32 |
| | Occlusion (upstream) | 14,602 | N/A | 11,710 | 2892 | N/A | 86,592 | 3.92 |
| | Syringe disengaged | 15,400 | 6738 | 290 | 7915 | 457 | 15,288 | 0.69 |
| | End of syringe | 3396 | 225 | 22 | 2895 | 254 | 3775 | 0.17 |



1. Waterson & Bedner. Types and Frequency of Infusion Pump Alarms and Infusion-Interruption to Infusion-Recovery Times for Critical Short Half-Life Infusions: Retrospective Data Analysis. JMIR Hum Factors 2019. Vol. 6. Iss. 3.

# What are the likely effects of alarm fatigue on staff?

- 2,184 clinical alarms over 48 hours of observation.
- 45.5 clinical alarms per hour per patient.
- 1,394 alarms (63.8%) categorized as false alarms.
- Alarm fatigue score 24.3 ± 4.0 out of 35.
- Highest scoring item: 'Frequent false alarms, lead to reduced attention or response to alarms'.[1]

**Study of all alarms in the ICU: Includes Ventilators, monitors and enteral feeding pumps as well as infusion pumps[2]**

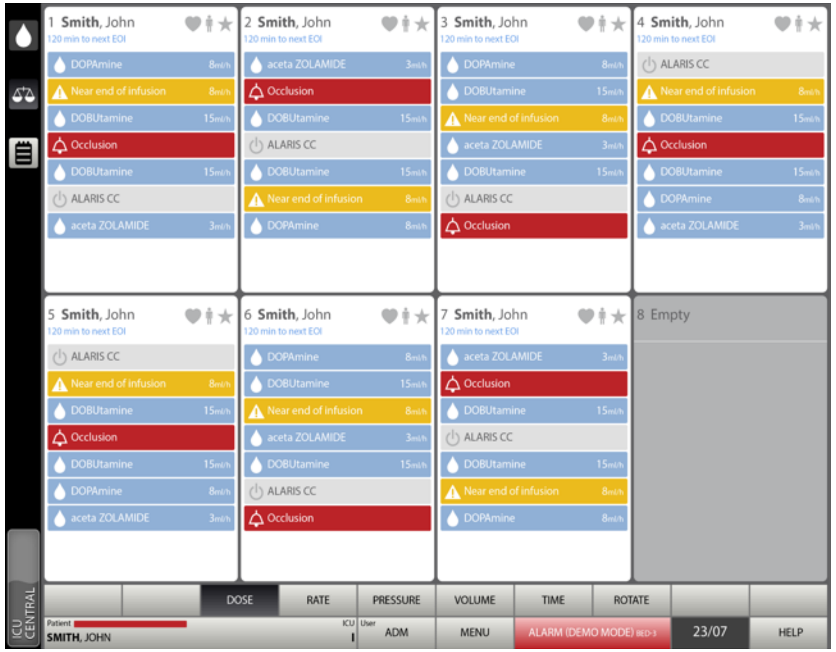
- 200-hour study period, single ICU room.
- 1271 separate entries by individuals to the room.
- 1214 alarms.
- Alarms occurrence 6.07 per hour.
- Alarms active for 3.28 min per hour.
- 23% effective, 36% ineffective, 41% ignored.
- Median alarm duration 17 secs.

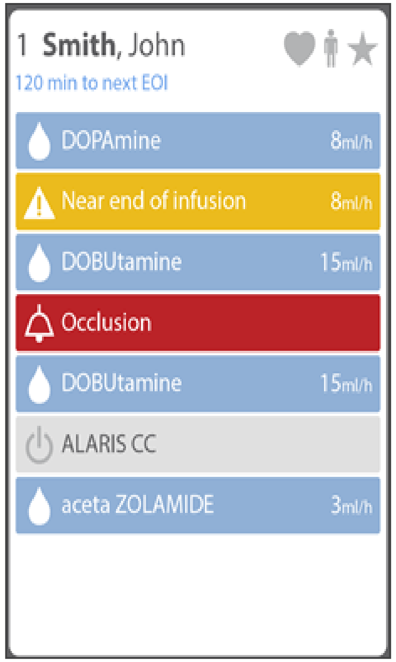


1. Cho OM, Kim H, Lee YW, Cho I. Clinical alarms in intensive care units: Perceived obstacles of alarm management and alarm fatigue in nurses. Health Inform Res. 2016; 22(1): 46-53.
2. Gorges M, Markewitz BA, Westenskow DR. Improving alarm performance in the medical intensive care unit using delays and clinical context. Anesth Analg. 2009; 108(5): 1546-1552.

# Alaris$^{TM}$ Infusion Central (AIC):
# Simple Interface - Prioritises Next Required Intervention

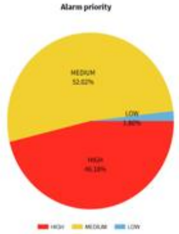
## Wi-Fi Enabled Central Surveillance of Infusion Pumps

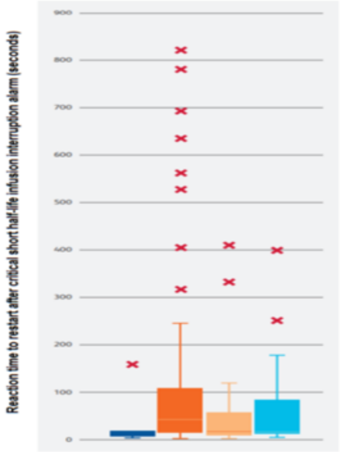


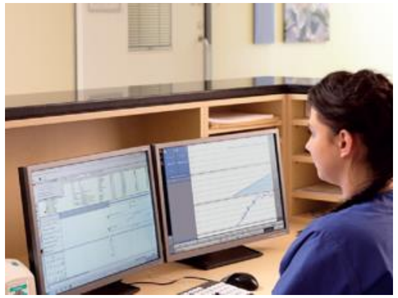


Infusions events dashboard, via central screen




| Quarter | Category | Number of alarms | Minimum RT | Maximum RT | Average RT | Median RT | Standard deviation RT |
|---|---|---|---|---|---|---|---|
| 15/02/2019 - 15/03/2019 | HIGH | 614 | 3.98 | 120.02 | 83.96 | 88.01 | 17.33 |
| | MEDIUM | 879 | 0.03 | 70117.65 | 628.22 | 68.01 | 5441.87 |
| | LOW | 20 | 4.20 | 304.15 | 66.03 | 46.01 | 85.51 |
| | ALL | 1113 | 0.03 | 70117.65 | 370.64 | 68.07 | 3961.17 |



**New:**

- Critical Medication Marked Out by Audio and Visual
- Pre-Pressure Alerts (No Infusion Interruption)
- Metrics Direct from the Software: Alarm Types, Amount and Reaction Times.
- Alarm Routing: Closer to the 'Silent ICU'.

# NICU: Universitair Ziekenhuis Antwerpen


## Alarm Visibility and Infusion Continuity: Environmental Change and Technology Assistance.[1]

- Infusion continuity, especially of vasoactive medications is a key element of neonatal intensive care.
- The management of IV pump alarms is crucial to infusion continuity and has been linked to alarm fatigue.
- Implemented central infusion monitoring and changed the environment of the NICU.
- Quantitative data drawn from the event logs of syringe pumps in continuous use in the NICU over a period of 346 days pre-changes and 346 days post-changes were appraised in order to assess the impact of these changes.

| Critical Drug | Pre-Changes Reaction Time [Secs] | Post Changes Reaction Time [Secs] | Pre-Changes Occlusion Count | Post Changes Occlusion Count | Pre-Changes Usage | Post Changes Usage |
|---|---|---|---|---|---|---|
| Adrenaline | 23.5 | 7.5 | 2 | 2 | 22 | 19 |
| Dobutamine | 50.83 | 48.5 | 42 | 30 | 362 | 420 |
| Milrinone | 69 | 55.07 | 11 | 7 | 86 | 45 |
| Noradrenaline | 64.32 | 24.94 | 25 | 35 | 125 | 390 |
| Prostacyclin | 99.16 | 35 | 6 | 9 | 38 | 83 |
| Dopamine | 38.47 | 46.17 | 17 | 23 | 207 | 168 |
| | Percentage Mean Change: | Decreased 37% | Mean Change: | Decreased 25% | Mean Change: | Increased 34% |

Pre- and Post-Changes critical drug usage, occlusion event count and reaction times.

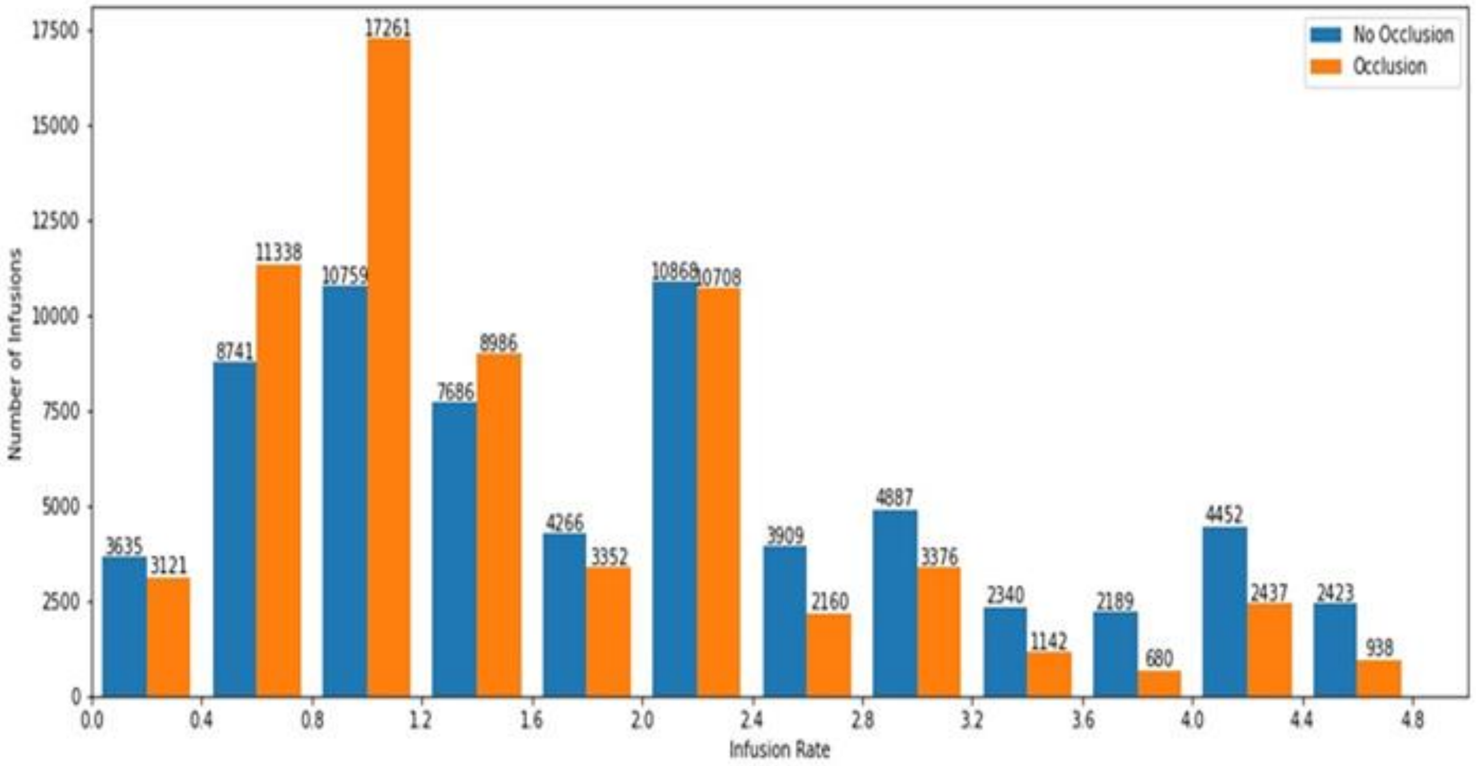


1. 2nd Congress of joint European Neonatal Societies. Oct 31-4 Nov 2017: 58th ESPR Annual Meeting, 7th International Congress of UENPS, 3rd International Congress of EFCNI. Journal of Pediatric and Neonatal Individualized Medicine 2017;6(2) Published online: 2017 Oct 31.

# Pursuing emerging evidence for critical infusion optimization: Machine learning and predictive models.[1]

## ML algorithms applied to infusion event data:

- Medication type of less significance to infusion longevity compared to the rate and care unit.
- Rates ranging from 2 to 2.8 mL/hr performed best for achieving a balance between infusion longevity and fluid load per infusion, with an occlusion versus no-occlusion ratio of 0.553.
- Rates between 0.8 and 1.2 mL/hr exhibited the poorest performance.
- Provides insights for proactive management of intravenous access and preservation.
- Offers information regarding the average duration of uninterrupted infusions that can be expected.
- Compounding to create customized concentrations for individual optimal rate infusions is possible.
- Potential of ML for predicting outcomes and life spans of specific therapies delivered via medical devices.




Needs a lot of data- data capture is key to the use of passive data for safety, efficiency and technique optimization.



1. Kia A, Waterson J, Bargary N, Rolt S, Burke K, Robertson J, Garcia S, Benavoli A, Bergström D. Determinants of Intravenous Infusion Longevity and Infusion Failure via a Nonlinear Model Analysis of Smart Pump Event Logs: Retrospective Study JMIR AI 2023;2:e48628

# The basics remain important but can be developed with connectivity

## Act: Hold the gain

Rapid updating of DERS libraries to meet identified IV-medication safety gaps can be made via BD connected solutions.[7]

## Plan to protect

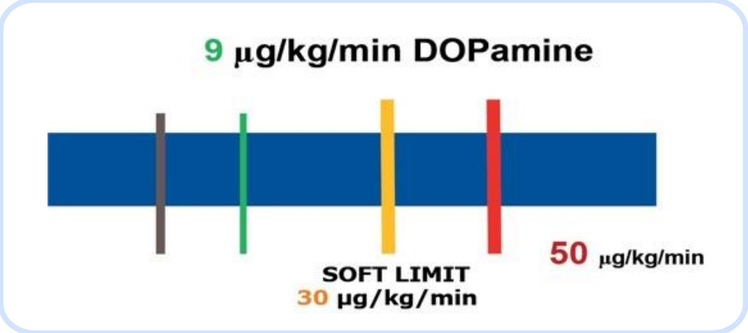
Up to 56% of all adverse events among hospitalized Patients are the result of preventable medication errors.[1,2]
38% of errors occur in the administration phase.[3]
90% of hospitalized patients receive IV medications.[4]

## Check on progress

BD CQI™ comprehensively audits IV-medication 'good saves' and compliance with your medication safety program.[7]

## Do: Make changes

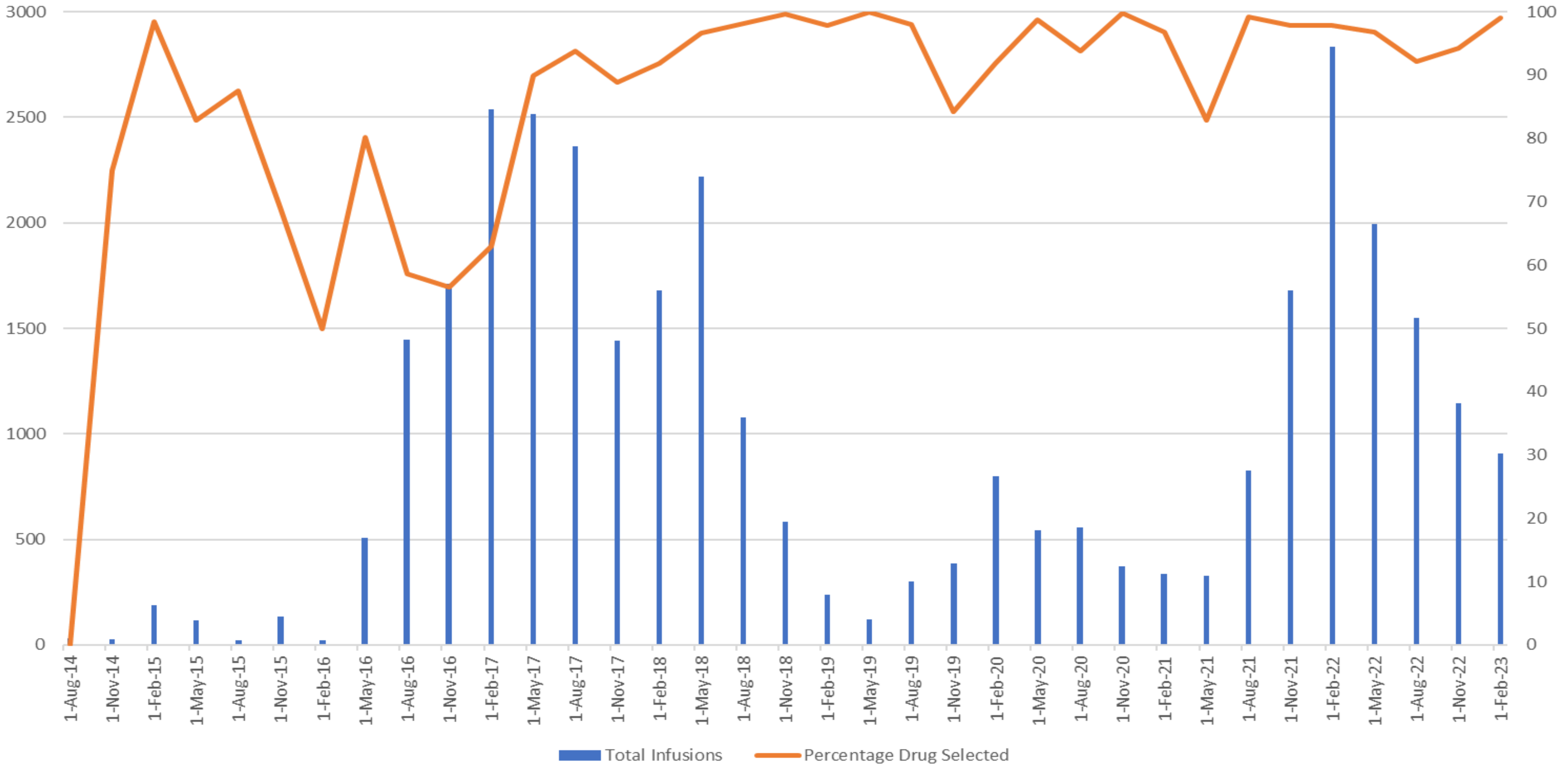
Implementing BD Guardrails™ Dose Error Reduction Systems has been shown to reduce harm and serious events at the point of care.[5,6]




1. European Medicines Agency. Good Practice Guide on Recording, Coding, Reporting and Assessment of Medication Errors. 2014. Report No.: EMA/762563/2014 . 2. National Coordinating Council for Medication Error Reporting and Prevention. Medical Errors. © 2016 National Coordinating Council for Medication Error Reporting and Prevention 2014 Available from: URL: http://www.nccmerp.org/about-medication-errors 3. Von Laue NC, Schwappach DL, Koeck CM. The epidemiology of preventable adverse drug events: a review of the literature. Wien Klin Wochenschr 2003 Jul 15;115(12):407-15. 4. Husch M, Sullivan C, Rooney D, Barnard C, Fotis M, Clarke J, et al. Insights from the sharp end of intravenous medication errors: implications for infusion pump technology. Qual Saf Health Care 2005 Apr;14(2):80-6. 5. Sutherland A, Gerrard WS, Patel A, Randall M, Weston E. The impact of drug error reduction software on preventing harmful adverse drug events in England: a retrospective database study. BMJ Open Qual. 2022 Jul;11(3):e001708. doi: 10.1136/bmjoq-2021-001708. PMID: 35820711; PMCID: PMC9277403. 6. Manrique-Rodríguez S, Sánchez-Galindo A, López-Herce J, Calleja-Hernández MÁ, Martínez-Martínez F, Iglesias-Peinado I, Carrillo-Álvarez A, Sanjurjo-Sáez M, Fernández-Llamazares C. Implementing Smart Pump technology in a pediatric intensive care unit: a cost-effective approach. Int J Med Inform. 2014 Feb;83(2):99-105. doi: 10.1016/j.ijmedinf.2013.10.011. Epub 2013 Nov 13. PMID: 24296271. 7. Waterson J, Al-Jaber R, Kassab T, Al-Jazairi AS. Twelve-Month Review of Infusion Pump Near-Miss Medication and Dose Selection Errors and User-Initiated "Good Save" Corrections: Retrospective Study. JMIR Hum Factors. 2020 Aug 11;7(3):e20364. doi: 10.2196/20364. PMID: 32667895; PMCID: PMC7448173.

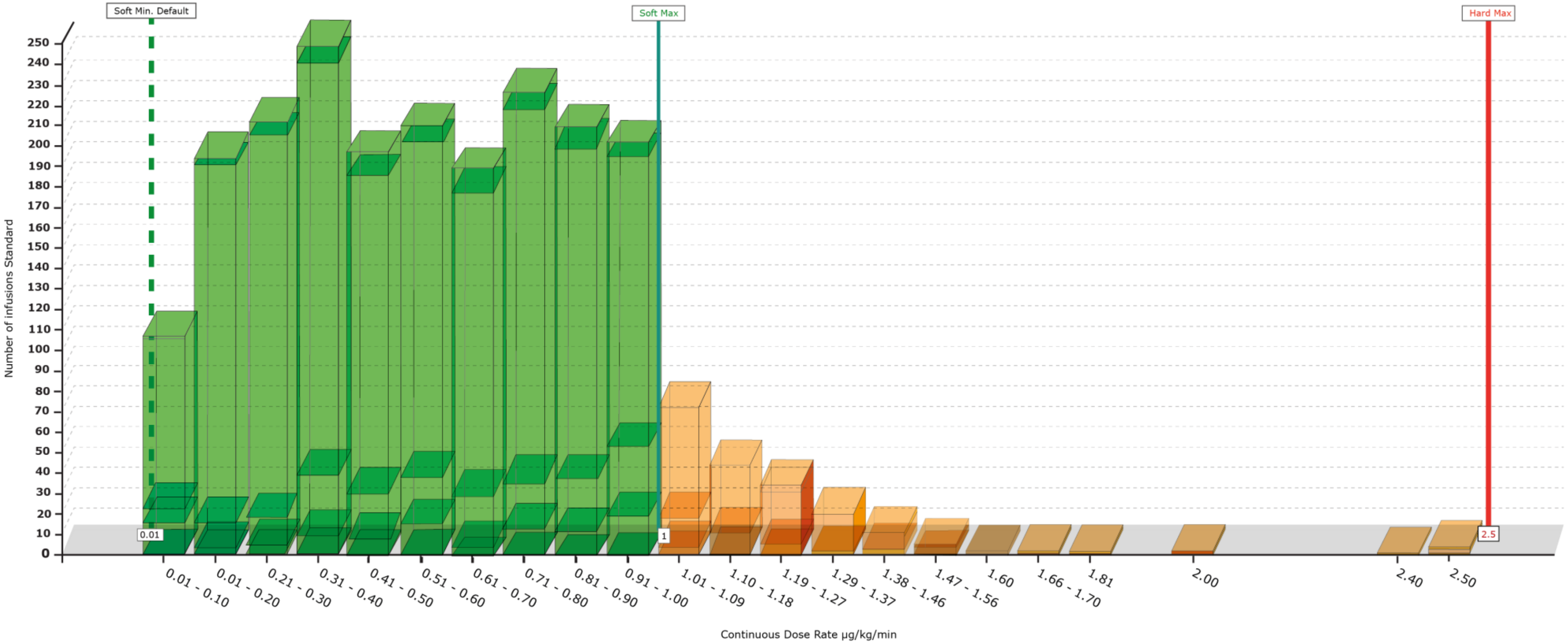
# Compliance is affected by feedback and ability to act: Connectivity[1]

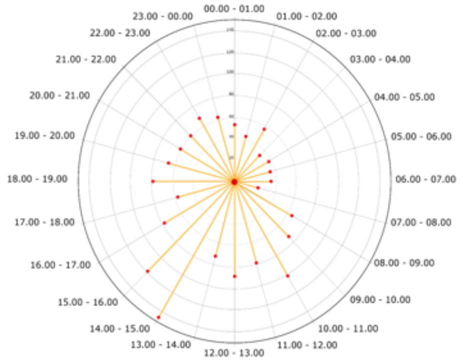
## Drug library usage: Alaris Communication Engine (ACE) Introduced in April 2017 (25th-29th)




# Pull Data via Ace: Adjust limits- reduce nuisance alarms, check compliance: Monthly and 3 monthly. Daily dashboards for huddles.

## Noradrenaline infusion data: For information and demonstration purposes only

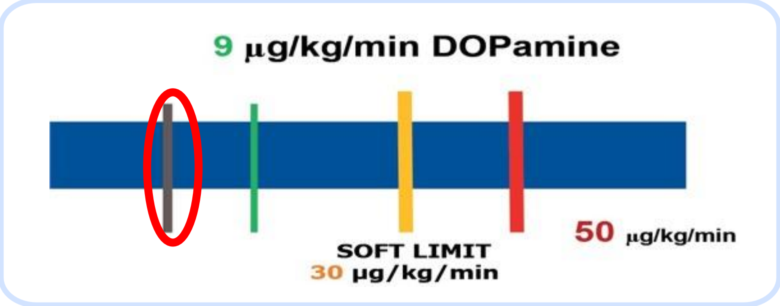


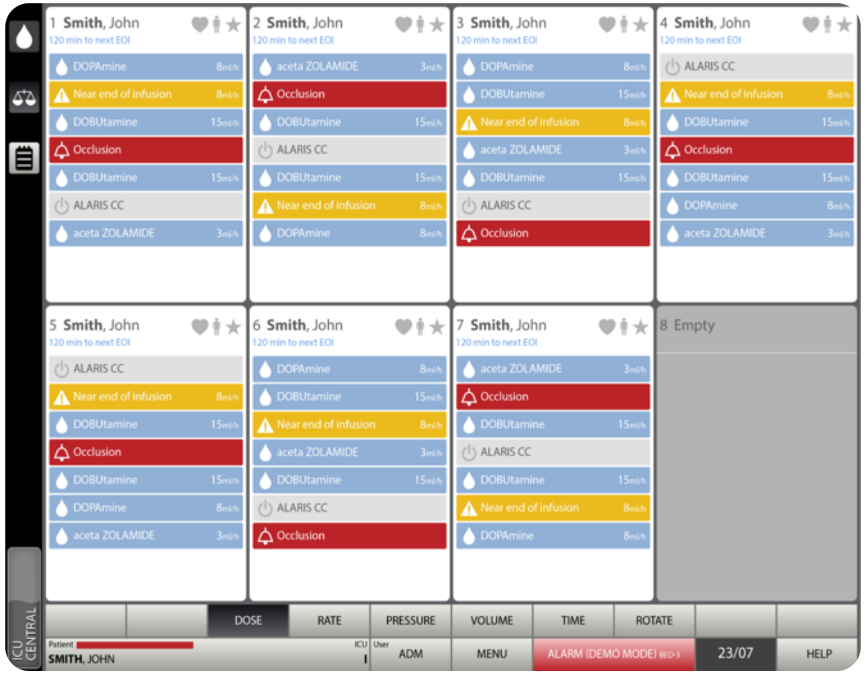




- Within soft limits
- Outside soft limits
- Outside hard limits

# So much for hard limits and Compliance with Med Safety...
# What about our VAP bundle compliance?

- The Minimum Soft Limit? Any Value?
- Yes, displayed in both AIC and ACE
- Real-Time Audit of Sedation Holiday
- ACE Dashboard can be filtered for Soft limits




# Hidden harm?[1]

| Therapy type | Moderate totals n. (% vs. DERS infusions) Magnitude: Times max. rate/dose | Catastrophic totals n. Magnitude: Times max. rate/dose | | | | All catastrophic totals n. (% vs. DERS infusions) |
|---|---|---|---|---|---|---|
| | 1.5 - 9.999 | 10 | 10 - 99.999 | 100 | 100+ | |
| IV fluids | 35,572 (1.1758) | 23 | 259 | 4 | 9 | 295 (0.0098) |
| Simple analgesia | 10,844 (0.3584) | 62 | 641 | 4 | 53 | 760 (0.0251) |
| Antivirals, general antibiotics and antifungals | 20,277 (0.6702) | 84 | 950 | 33 | 67 | 1,134 (0.0375) |
| Blood products | 35,830 (1.1843) | 325 | 20 | 0 | 4 | 349 (0.0115) |
| Chemotherapy and cytotoxics | 11,422 (0.3775) | 37 | 166 | 4 | 31 | 238 (0.0079) |
| Anticoagulants | 2,688 (0.0888) | 12 | 305 | 24 | 60 | 401 (0.0133) |
| Insulin | 313 (0.0103) | 31 | 77 | 6 | 37 | 151 (0.0050) |
| Electrolytes ($K^+$ and $Mg^{2+}$) | 17,918 (0.5922) | 114 | 725 | 0 | 18 | 857 (0.0283) |
| GI system | 5,688 (0.1880) | 153 | 1,187 | 5 | 11 | 1,356 (0.0448) |
| Labour and delivery meds | 111 (0.0037) | 6 | 33 | 0 | 5 | 44 (0.0015) |
| Aminoglycosides | 2,286 (0.0756) | 13 | 179 | 0 | 5 | 197 (0.0065) |
| Diuretics | 549 (0.0181) | 34 | 63 | 4 | 38 | 139 (0.0046) |
| Steroids | 24 (0.0008) | 0 | 0 | 2 | 0 | 2 (0.0001) |
| Total all adult | 143,522 (4.7439) | 894 | 4,605 | 86 | 338 | 5,923 (0.1958) |

**More alerts in ICU mean more near-miss errors.**

**This is a fallacy that we are beginning to uncover as we apply DERS across whole facilities via wireless transfer and obtain continuous server capture of CQI 'good save' evidence.**

**Results:** Catastrophic errors averted at a rate higher than that seen in ICU despite lower compliance.

**Conclusion and Relevance:** The study identified an incidence rate above those in many published studies; this may be because we 'cast the net wider'.

The presence of insulin, potassium preparations is in line with other studies.

1. Aljaber R, Waterson J. Hidden harm? Assessing magnitude and costs of intravenous therapy administration errors via smart pump reports. Eur J Hosp Pharm: 10.1136/ejhpharm-2022-eahp.325. March 2022.

# WFPICCS 22.

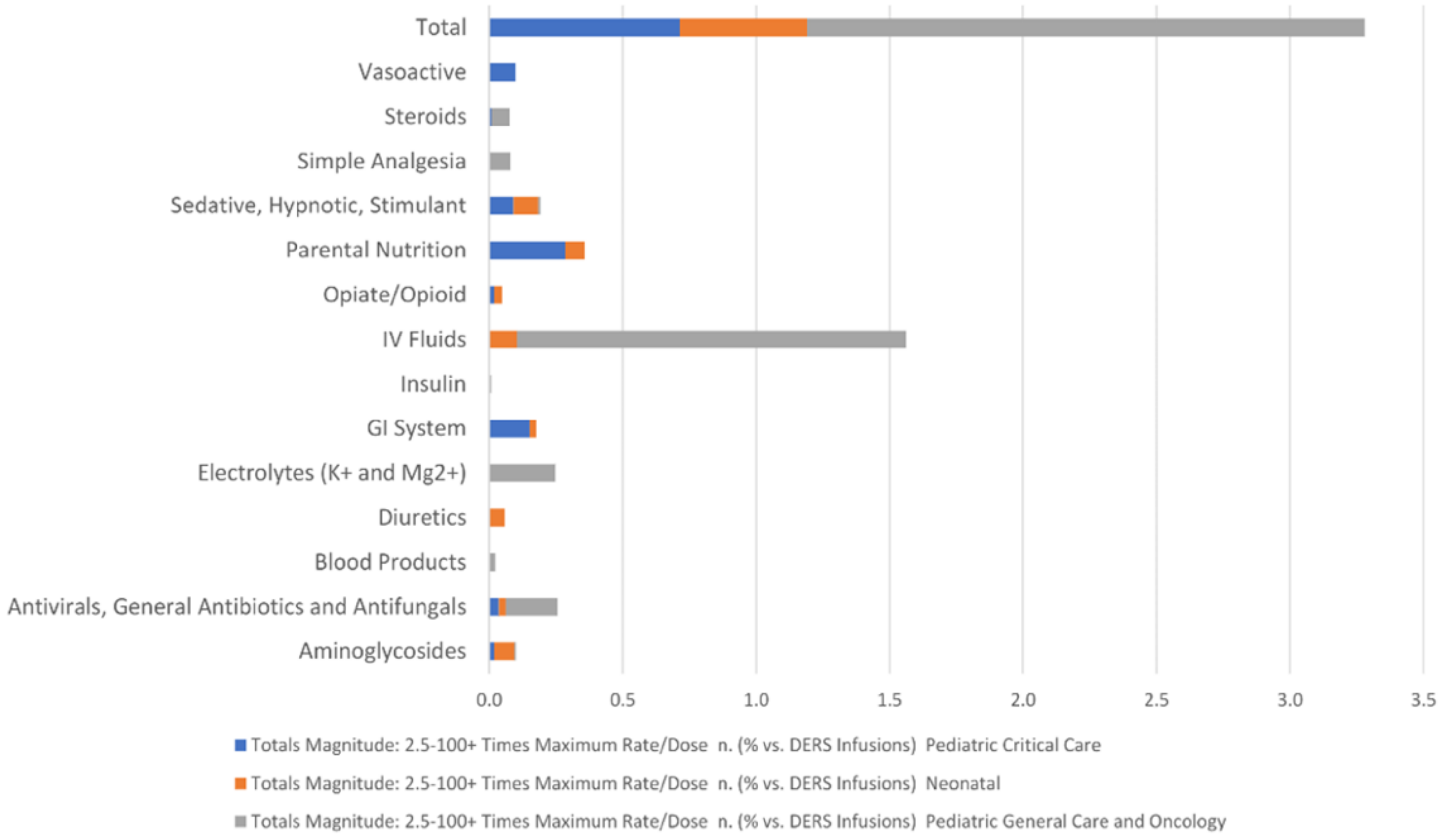
| Medication group | Moderate Totals Magnitude: 2.5-9.999 Times Maximum Rate/Dose n. (% vs. DERS Infusions) | | | Catastrophic Totals Magnitude: 10-100+ Times Maximum Rate/Dose n. (% vs. DERS Infusions) | | | Totals Magnitude: 2.5-100+ Times Maximum Rate/Dose n. (% vs. DERS Infusions) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Pediatric Critical Care | Neonatal | Pediatric General Care and Oncology | Pediatric Critical Care | Neonatal | Pediatric General Care and Oncology | Pediatric Critical Care | Neonatal | Pediatric General Care and Oncology |
| Aminoglycosides | 67 (0.0135) | 313 (0.1328) | 22 (0.0093) | 29 (0.0058) | 70 (0.0296) | 0 (0) | 96 (0.0193) | 383 (0.1625) | 22 (0.0095) |
| Antivirals, General Antibiotics and Antifungals | 104 (0.021) | 105 (0.0446) | 668 (0.2895) | 74 (0.0149) | 17 (0.0072) | 303 (0.1313) | 179 (0.0361) | 123 (0.0522) | 971 (0.4208) |
| Blood Products | 0 (0) | 0 (0) | 108 (0.0468) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 108 (0.0468) |
| Diuretics | 0 (0) | 279 (0.1184) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 279 (0.1184) | 0 (0) |
| Electrolytes ($K^+$ and $Mg^{2+}$) | 0 (0) | 0 (0) | 882 (0.3822) | 0 (0) | 0 (0) | 355 (0.1539) | 0 (0) | 0 (0) | 1,237 (0.5361) |
| GI System | 717 (0.1445) | 0 (0) | 0 (0) | 37 (0.0075) | 0 (0) | 0 (0) | 754 (0.1519) | 123 (0.0522) | 0 (0) |
| Insulin | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 32 (0.0139) | 0 (0) | 0 (0) | 32 (0.0139) |
| IV Fluids | 0 (0) | 0 (0) | 6,657 (2.8851) | 0 (0) | 523 (0.2219) | 570 (0.2470) | 0 (0) | 523 (0.2219) | 7,228 (3.1325) |
| Opiate/Opioid | 90 (0.0181) | 105 (0.0444) | 0 (0) | 7 (0.0015) | 35 (0.0148) | 0 (0) | 97 (0.0196) | 139 (0.0592) | 0 (0) |
| Parental Nutrition | 1,411 (0.2843) | 349 (0.148) | 0 (0) | 7 (0.0015) | 0 (0) | 0 (0) | 1,418 (0.2857) | 349 (0.1480) | 0 (0) |
| Sedative, Hypnotic, Stimulant | 434 (0.0874) | 453 (0.1922) | 43 (0.0186) | 22 (0.0045) | 0 (0) | 0 (0) | 456 (0.0919) | 453 (0.1922) | 43 (0.0186) |
| Simple Analgesia | 7 (0.0015) | 0 (0) | 205 (0.0888) | 0 (0) | 0 (0) | 183 (0.0793) | 7 (0.0015) | 0 (0) | 388 (0.1682) |
| Steroids | 37 (0.0075) | 0 (0) | 333 (0.1443) | 0 (0) | 0 (0) | 11 (0.0048) | 37 (0.0075) | 0 (0) | 344 (0.1491) |
| Vasoactive | 493 (0.0993) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 493 (0.0993) | 0 (0) | 0 (0) |
| Total | 3,360 (0.677) | 1,603 (0.684) | 8,918 (3.8647) | 178 (0.0358) | 645 (0.2736) | 1,454 (0.6301) | 3,538 (0.7128) | 2,372 (1.0067) | 10,373 (4.4955) |
| Infusion Events, DERS and Infusions | Total All Hard Limit Events | | | Total DERS Infusions | | | Total Infusions | | |
| | 19,905 | 9,451 | 10,690 | 496,355 | 235,642 | 230,741 | 1,079,262 | 351,560 | 917,129 |
| % DERS Compliance | Pediatric Critical Care | | 38.82 | Neonatal | | 48.64 | Pediatric General Care and Oncology | | 30.82 |



Waterson, J, Al Jaber, R. Looking in the wrong place? assessing magnitude of intravenous therapy administration errors across pediatrics via smart pump reports. Pediatric Critical Care Medicine 23(Supplement 1 11S):, November 2022.

# Looking in the wrong place? Assessing magnitude of intravenous therapy administration errors across pediatrics via smart pump reports

## Total magnitude 2.5-100+ X max. rate/dose (% vs. total DERS infusions): Note the preponderance of 'good saves' in general paediatric care and oncology

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**Background and aim:** Most reviews of pediatric intravenous therapy administration error are undertaken in critical care. In our study wireless pumps gave access to smart pump therapy library log data from lower acuity areas of care such as pediatric general and oncology units. We aimed to compare and contrast pediatric intravenous therapy administration errors outside of critical care with those inside the intensive care unit.

**Methods:** A review of 2,347,951 infusions of pediatric units inside and outside of critical care across the Middle East for the volume of averted dose/duration errors was undertaken, and a recognised grading of 'moderate' and 'catastrophic'[1] was applied.

**Conclusion:** The study identified an incidence rate above those in many published studies, this may be because we 'cast the net wider' and because in the areas studied there was limited clinician experience of administration of some of the medications. Competency is difficult to maintain with limited exposure to a task. Frequency of averted moderate and catastrophic error was substantially higher outside of critical care. The presence of insulin, analgesics, and potassium preparations in our results is in line with other studies. The data may assist pediatric critical care outreach teams in risk-scoring and frequency of review for patients receiving IV-therapy outside of the PICU.



1. Manrique-Rodríguez et Al. Implementing smart pump technology in a pediatric intensive care unit: a cost-effective approach. Int J Med inform. 2014 Feb;83(2):99-105.

# Aims of integrated solutions

## Connected care in all areas of Critical care and the OR

Job demands most consistently associated with elevated burnout: Workload

TISS: Infusion. ≈24%
Medications: 40% of nursing time

Identify with certainty which drugs, diluents, and volumes were used

ML Predictor models
need data to feed them

Response times to critical short half-life infusion interruption outliers

NVA vs. VA

# Thank you