Glycaemic Control in ICU: Stable Patients Tend to Remain Stable
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Background
Stress-hyperglycaemia is a common complication in intensive care patients. Glycaemic control (GC) has shown improved outcomes but was proven difficult to achieve safely, increasing risks of hypoglycaemia.

STAR is a model-based GC protocol with proven safety and performance. It uses a cohort-based 2D stochastic model of model-based, patient-specific insulin sensitivity (SI). Given current SI, it predicts likely future distribution of SI values to dose insulin and nutrition based on specified risk of hypoglycaemia (Figure 1).

Objectives

- Could we make the SI range prediction more patient-specific? → Using more information can give additional information on future likely SI.
- What separates different kinds of patients? → Metabolic (SI) variability: more variable patients are harder to control than more stable patients.
- How do the new models compare to the current GC algorithms?

Methods
Metabolic data from 3 clinical ICU cohorts (819 episodes and 68629 hours of treatment) are used in this study (Table 1).

| SI variability (%ΔSI) is defined as the hour-to-hour percentage change in SI: |
| [%ΔSI] = 100 × \frac{SI_{i+1} - SI_{i}}{SI_{i}} |

Data triplets (ΔSI, SI, SI_{i+1}) are created and grouped together in bins of size %ΔSI = 10% and SI_{i} = 0.5e-4. CDFs are computed in each bin where data density reach 100 data triplets.

Outcomes are:
- The percentage change in the 90% CI prediction width.
- The predictive power (median [IQR] per-patient percentage prediction within the 5th–95th or 25th–75th percentile range).

Results

- The 2D model is over-conservative for 77% of hours mainly where %ΔSI is within an absolute 25% change (Figure 1).
  → Indicates patients are stable more than 75% of the time.
  → Stable patients tend to remain stable.
  → 51871 conservative hours vs. 13180 non-conservative hours.
- The percentage change in the 90% CI width in conservative regions is reduced by 25-40% (Figure 2).
  → More aggressive dosing allowed for these patients.

- Similar predictive power for both models, but closer to ideal value of 90% for 3D stochastic model (Figure 2).
  → Greater patient-specificity.
- Significant percentage reduction of the 90% CI predictive range (Table 2, Figure 4).

Conclusions

- By reducing prediction range for 77% of hours, predominantly where SI is stable, the new 3D model shows stable patients tend to remain stable in terms of %ΔSI, refuting the idea they are always very variable.
- The 3D model better characterises patient-specific response to insulin, allowing more optimal dosing while ensuring safety.