Clinical Resource Engine (Healthcare) — Surge Capacity Risk Forecasting

1. Problem Statement

Healthcare systems in the U.S experience recurring short-term capacity stress driven by fluctuations in patient demand, particularly during respiratory illness seasons. Public reporting from the U.S. Department of Health and Human Services (HHS) shows that hospital admissions and ICU utilization vary substantially over days and weeks at the state level, with respiratory illness waves frequently pushing utilization toward critical thresholds. Persistent nursing shortages further limit hospitals' ability to absorb these demand shocks, increasing operational risk.

The goal is to identify near-term periods (1-7 days ahead) of elevated hospital capacity stress at the state level using publicly available admissions and utilization data, and evaluate whether proactive capacity adjustments reduce overload events compared to reactive baseline strategies. Capacity stress is defined operationally using utilization-based thresholds(e.g., ICU utilization exceeding a critical level).

Change**

Because above goal slightly blurs **prediction** vs **evaluation**.

The goal is to **predict near-term periods (1–7 days ahead) in which a state is at elevated risk of hospital capacity stress**, defined operationally as ICU utilization exceeding a critical threshold, using publicly available admissions and utilization data.

The system evaluates whether **proactive capacity interventions triggered by early risk signals** reduce the frequency and duration of overload events compared to reactive baseline strategies.

2. Context

Short-horizon demand fluctuations are operationally significant because hospitals operate with limited staffing buffers, a constraint exacerbated by persistent nursing shortages documented in HRSA workforce projections (HRSA 2025 Report). When baseline utilization is already high, even modest increases in admissions can rapidly increase the likelihood of capacity stress.

Respiratory illnesses such as influenza and COVID-19 are treated as primary demand drivers rather than prediction targets. Both exhibit episodic and seasonal patterns, generate sharp increases in hospital admissions over short time windows, and draw on shared hospital resources including inpatient beds, ICU capacity, and nursing staff. As a result, respiratory admissions provide a practical and operationally relevant signal for assessing near-term capacity risk.

3. Criteria for Success

- Identifies elevated hospital capacity risk 1–7 days in advance using state-level data
- Demonstrates a measurable reduction in overload days under simulated proactive interventions relative to reactive baseline strategies
- Improves intervention efficiency measured as (overload days avoided/intervention day)
- Produces interpretable daily risk scores and decision thresholds suitable for operations
- Learned capacity risk patterns remain informative when applied to other states

4. Scope of Solution Space

- State-level, daily respiratory-related hospital admissions
- Hospital capacity and utilization (inpatient beds and ICU)
- Short-horizon capacity risk forecasting
- Counterfactual evaluation of decision timing under fixed intervention constraints

5. Constraints

- Analysis limited to publicly available, state-level data
- Interventions evaluated through simulation rather than observed policy changes
- Capacity adjustments modeled as temporary percentage increases in effective capacity, rather than explicit staffing counts
- Variability in reporting completeness across states and time periods

6. Stakeholders

- Hospital operations leaders responsible for capacity decisions
- Healthcare system planners and administrators
- Public health agencies focused on system-level surge preparedness

7. Data Sources

HHS Protect – COVID-19 Reported Patient Impact and Hospital Capacity by State
Source: U.S. Department of Health and Human Services (healthdata.gov)
Granularity: State-level, daily (2020–2024)

Provides daily hospital demand and capacity signals, including influenza and COVID-19

admissions, inpatient bed utilization, ICU utilization, and total capacity counts. Data collected during the COVID response period, but still supports broader hospital capacity risk modeling.

8. Analytical Approach (High-Level)

- Define capacity stress using utilization thresholds
- Estimate near-term overload risk from admissions and utilization signals
- Trigger proactive interventions when predicted risk exceeds a threshold
- Evaluate outcomes by comparing earlier action versus waiting under identical intervention limits
- Compare outcomes against reactive baseline strategies

9. Deliverables

- GitHub repository containing documented analysis code
- Written report summarizing methodology, results, and operational implications
- Visualizations for predicted capacity risk, intervention timing and counterfactual outcomes