Patient safety and avoiding adverse events are the focus during the management of post-operative pain in the post-anesthesia care unit (PACU). The cost of related post-operative complications from potentially preventable respiratory events is estimated, for Medicare alone, to be an average of $55,502 per event. A significant burden to departmental budgets and workflow, however, comes from “close calls” and difficult to manage patients where respiratory deterioration ensues or continues undetected following transition to lower acuity environments. Existing technologies have proven adept at detecting adverse events as or after they have occurred, but have not demonstrated significant clinical impact in predicting respiratory compromise in advance of adverse occurrences. A novel, non-invasive, respiratory volume monitor (RVM) that provides continuous, real-time, measurements of minute ventilation (MV), tidal volume and respiratory rate was utilized to develop a risk stratification algorithm based on the effects of opioids on respiratory status.

### Methods

After IRB approval and consent, digital respiratory traces were collected from 114 post-surgical patients. Predicted MV (MV\text{PRED}) for each patient was calculated based on standard formulas. Measured MV (MV\text{MEAS}) was used to calculate the following:

- \text{Percent Predicted MV} = \left( \frac{\text{MV\text{MEAS}}}{\text{MV\text{PRED}}} \right) \times 100\%

Prior to opioid administration in the PACU, patients were classified as “At-Risk” (MV > 80\% MV\text{PRED}) or “Not-at-Risk” (MV ≤ 80\% MV\text{PRED}). Following opioid administration, patients were classified as “Un-Safe” and experiencing OIRD if their measured MV was less than 40\% MV\text{MEAS} for at least two minutes.

- **Sensitivity**: 93\%
- **Specificity**: 85\%
- **Positive predictive value**: 2\%
- **Potential to adjust therapy before deterioration**: 49\%
- **Potential to prevent LOS delay or complication**: 54\%

### Results

50/114 patients received opioids in the PACU. 13/18 patients classified “At-Risk” (MV > 80\% MV\text{PRED}) based on the MV\text{PRED}-guided algorithm, had MV decreases into “Un-Safe” (MV < 40\% MV\text{MEAS}) range after opioid. Pre-opioid MV as a % of MV\text{PRED} as a predictor of “Un-Safe” (MV < 40\% MV\text{PRED}) had a sensitivity of 93\%. Applying historical cost data, PACU flow-through consideration, and applying average risk for critical respiratory event post PACU discharge, data was sanitized to assess aggregate economic benefit.

### Conclusions

Data demonstrates that seemingly benign and temporal respiratory deterioration can result in significant unappreciated patient risk and added costs. “At-Risk” (MV > 80\% MV\text{PRED}) prior to opioid is a strong predictor of further respiratory decline to potentially “Un-Safe” MV (MV < 40\% MV\text{MEAS}) and possibly to significant respiratory depression for the patients continuing to receive opioids. Utilizing a point-of-care, MV\text{PRED}-guided, risk stratification algorithm can guide PACU care and facilitate flow-through for the patients at elevated risk. Early interventions based on a risk-based protocol can potentially prevent adverse events and the associated added costs in the first 24 post-operative hours. Eliminating 26\% of preventable respiratory PACU delays by providing early warning can result in $714,000 - $312,000 of savings per year for an average medical center and additional $131,000 - $5,618,000 savings from a 10-15\% reduction in the incidence of preventable adverse events. Early intervention based on a risk-based protocol could reduce PACU delays and preventable events resulting in average potential economic savings of $887,000 per year for an average tertiary care center.