**Project Title:** Predicting respiratory decompensation in Pediatric ICU

**Problem Statement**: Mechanical ventilation is a life sustaining therapy, but patients remain at risk for further decompensation, either due to the primary disease or complications such as ventilator lung injury or ventilated associated infection. Early warning of decompensation could trigger investigations and interventions that minimize this risk. We hypothesize that it is possible to predict decompensation by integrating patient data (high resolution physiologic data, ventilator data, and laboratory data) into a prediction model.

**Project Team:**

Faculty Mentor: Jim Fackler, MD (Pediatric Critical Care Attending), Mela Bembea, MD, PhD (Pediatric Critical Care Attending).

Co-mentor: Jules Bergmann, MD (T32 clinical research fellow).

**Background**: There is a large body of prior and active work on developing early warning systems, primarily in sepsis. TREWScore (Henry 2015 from Saria’s lab), identification of pre-sepsis states (Liu 2019 from Winslow’s lab), AWARE at Mayo (Harrison 2016), and Dascena (Calvert 2016). There is smaller body of work for respiratory failure, including UVA (Politano 2013, Moss 2016) and Philips (Ennett 2008). Much of this progress has been driven by the availability large datasets (especially MIMIC Johnson et al 2016) and the advance of machine learning techniques capable of handing these large datasets. Finally, there is benefit to being able to predict respiratory decompensation early, so that investigations (radiography, cultures) and appropriate interventions (respiratory clearance, increase settings, antibiotics, diuretics) may be given.

**Potential Solution:**

At the end of this project, students will develop a prediction model for respiratory decompensation that could provide a clinically significant early warning (on the order of 6 hours) to allow investigations and interventions to take place. This model will use multiple streams of patient data, such as demographics, physiologic signals, laboratory measurements, medications, fluid status, and other observations. Ideally the model would give some justification for predictions.

**Preliminary Data**

We’ve examined the incidence of VACs (ventilator associated complications – an infectious disease surveillance definition that is a reasonable label for decompensation while on mechanical ventilation (Cocoros 2016)) in our PICU and found they are significantly associated with increased mortality. The broad definition of VACs captures decompensation on the ventilator from both infectious and non-infectious causes, making it an ideal prediction target.

**Relevant Experience**:

Dr. Fackler is an experienced pediatric intensivist, anesthesiologist, and informaticist with deep insight into respiratory physiology and ventilator management and considerable experience in applying technology to clinical problems. He has mentored BME 680 groups for the past 7 years.

Dr. Bembea is an experienced pediatric intensivist with expertise in ECMO and research interests including development of predictive models for multi-system organ failure based on biologic and physiologic markers.

Dr. Bergmann is a current T32 clinical research fellow and recent PICU fellowship graduate interested in optimizing ventilator management through better use of data. He has a background in computer engineering prior to medicine and is excited to help students apply their technical expertise to clinical concepts.

**Data Set Identification**: This project will require detailed data on PICU/ICU patients that includes demographics, physiologic monitor data (from waveforms to medium, ventilator data, laboratory values, medication administrations, and nursing/RT flowsheets.

Students will use the following datasets:

* MIMIC-III and e-ICU datasets (Johnson 2016, Pollard 2018) – publicly available datasets for primarily adult ICU patients that contain these elements (except no high/medium resolution ventilator data)
* JHH PICU dataset #1 – Internal dataset for Pediatric ICU patients from Jul 2016 through Jan 2018 that contains these elements with the following limitations (subset of laboratory data, no waveform data, no high/medium resolution ventilator data)
* JHH PICU dataset #2 – Internal dataset for Pediatrics ICU currently being developed from the Precision Medicine Analytics Program that includes medium (q1s to q1m) resolution data for some ventilated patients.

**References:**

* Calvert et al. Computational approach to early sepsis detection. CIBM 2016;74:69-73.
* Cocoros et al. VAE in Neonates and Children. Crit Care Med 2016; 44:14-22.
* Ennett, et al. Predicting Respiratory Failure in the ICU. IEEE EMBS 2008.
* Harrison et al, Development and implementation of sepsis alert systems, Clin Chest Med 2016;37:219.
* Henry et al TREWScore, STM 2015;299.
* Johnson et al. MIMIC-III. Scientific Data 2016;3:160035.
* Liu et al Pre-Shock States predict Impending Septic Shock in the ICU. Scientific Reports 2019;9:6145
* Moss et al, Signatures of Subacute Potentially Catastrophic Illness in the ICU, CCM 2016;44:1639.
* Politano et al Predicting the need for urgent intubation in SICU. Surgery 2013;154:1110.
* Pollard et al. eICU Collaborative Research Database. Scientific Data 2018;5:180178.
* Ravishankar et al, Early Respiratory Distress Detection with Markov Models, IEEE EMBS 2014.