Dr. Daniela Thorin, the Chief of Medicine at Mirkwood General Hospital (MGH) is very enthusiastic about leveraging powerful machine learning algorithms for healthcare and personalized medicine. She heard that you are taking the MLHC short course and immediately invited you to visit MGH to talk with the attending physicians about some problems that MGH is facing and suggest data-driven solutions.

Q0: Download the following data files from the Physionet website:
   - https://physionet.org/challenge/2012/set-a.zip (per-patient data)
   - https://physionet.org/challenge/2012/Outcomes-a.txt (outcomes/labels)
You will also find it useful to look at the descriptions of the features, available here:
   - https://physionet.org/challenge/2012/#general-descriptors

Your first meeting is with Dr. Dwalin, the chief of internal medicine. He explains that one of the most pressing issues that the hospital is facing is that the adult ICU is short staffed. Right now, physicians rely on the Simplified Acute Physiology Score (SAPS) to prioritize which patients are in need of immediate attention. The SAPS score takes into account a handful of patient characteristics to estimate patient severity and risk of death.

Dr. Dwalin believes you could do better with a learned risk estimate. He tells you that they have demographic information, vitals, lab results and date of death if available for all their ICU patients during their entire stay. His main question boils down to:

“How do we leverage EHR data to make optimal use of the MD’s time and effort? What outcome should we choose? Which data should we include in our risk estimation?”

Q1: Discuss the advantages and disadvantages of the following setups. Discuss whether or not these setups are well-suited to answer Dr Dwalin’s question, and if not, what are situations in which these setups would be useful? Discuss any other problems with these setups from a medical or algorithmic perspective.

- Outcome = 1 year mortality; data = data collected in the first 48 hours
- Outcome = 1 year mortality; data = data collected throughout the entire visit.
- Outcome = In-hospital mortality; data = data collected in the first 48 hours

Q2: You decided to go with in-ICU mortality with data collected in the first 48 hours. Run an L2 regularized logistic regression to predict the in-hospital mortality using the data collected on admission and the data collected during the first 48 hours of the ICU stay. You should partition the data into a train, validate, and test set (60/20/20). Compute the AUROC on the test data and comment on the model’s performance. Look at the top 5 risk factors of mortality and the lowest 5 and explain what they mean.
Hint: In order to compare the coefficients of the features included here regardless of their scale, it is useful to standardize the non-binary variables.

Q3: Next, Dr. Thorin asks you to meet with MGH’s senior administration to discuss how machine learning could be used more broadly to improve clinical care at the hospital. They were particularly excited to read all the press surrounding Google’s recent paper on deep learning with electronic health records (see below for link to main paper and supplementary material). Dr. Thorin asks you to look through the paper and to help them tease apart hype from promise. Specifically, she asks for an executive summary with bullet points addressing the following:

1. How could these algorithms be best used to improve clinical care at MGH?
2. What are possible limitations of the approach described? What failure modes might the prediction algorithms have when deployed?
3. How much better is deep learning compared to the simpler supervised learning methods that the hospital may already be using? Is it worth it?
4. What are the most important questions should MGH ask to the authors of this paper?

Scalable and accurate deep learning with electronic health records
Rajkomar et al., Nature Digital Medicine, 2018
Paper: https://www.nature.com/articles/s41746-018-0029-1
Supplementary: