EBM with Doctor Variation

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8/3/2020

Doctor variation

Now let's take a doctor-centric view. Suppose that doctors (indexed by j) diagnose with a probability that depends on (1) the severity of the patient's symptoms, S_i (2) the patients demographics X_i, and (3) the parameters of their own diagnostic habits, $\boldsymbol{\theta}_j = (\beta_{0j}, \beta_{1j}, \beta_{2j})$. Explicitly, for patient i seeing doctor j,

$$D_i \sim_{iid} \text{Bernoulli}\left(\phi(S_i, X_i, \boldsymbol{\theta}_j)\right)$$

where,

$$\phi(S_i, X_i) = \frac{1}{1 + exp(-(\beta_{0j} + \beta_{1j}S_i + \beta_{2j}X_i))} - c_{x_i\boldsymbol{\theta}_j}.$$

Two types of doctors:

Recall that an ideal diagnostic model would have $\beta_1 = \infty$ and $\beta_2 = 0$, since the only feature that really matters is the symptoms, and in this world the symptoms only emerge when the disease is present. However, doctors aren't perfect at recognizing the symptoms of this disease. Instead, our doctors have two patterns:

$$\boldsymbol{\theta_A} = (-10, 20, 0)\boldsymbol{\theta_B} \qquad\qquad = (-10, 20, -10)$$

In other words, "A"-type doctors diagnose people based on the severity of their symptoms only, whereas "B"-type doctors diagnose $X_i = 0$ people at the same rate as A-doctors but diagnose $X_i = 1$ people at a lower rate. In our case, we know A-doctors will have a lower misdiagnosis rate than B-doctors.

A simple doctor population

Now let's imagine we have a population of 100 A-doctors and 100 B-doctors. Each doctor sees 200 patients a year. A histogram rates of correct diagnosis of disease patients for each doctor is shown below, first as an aggregate, then subsetted by X.
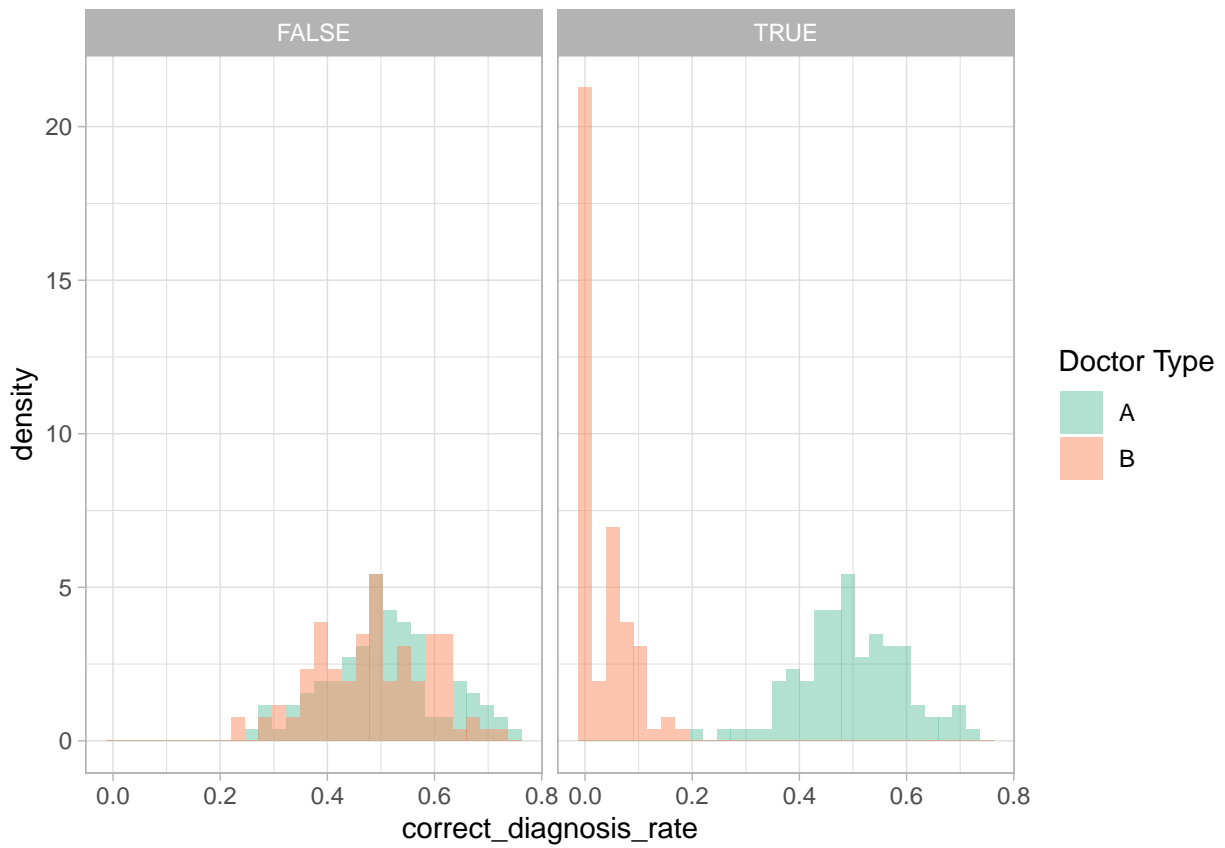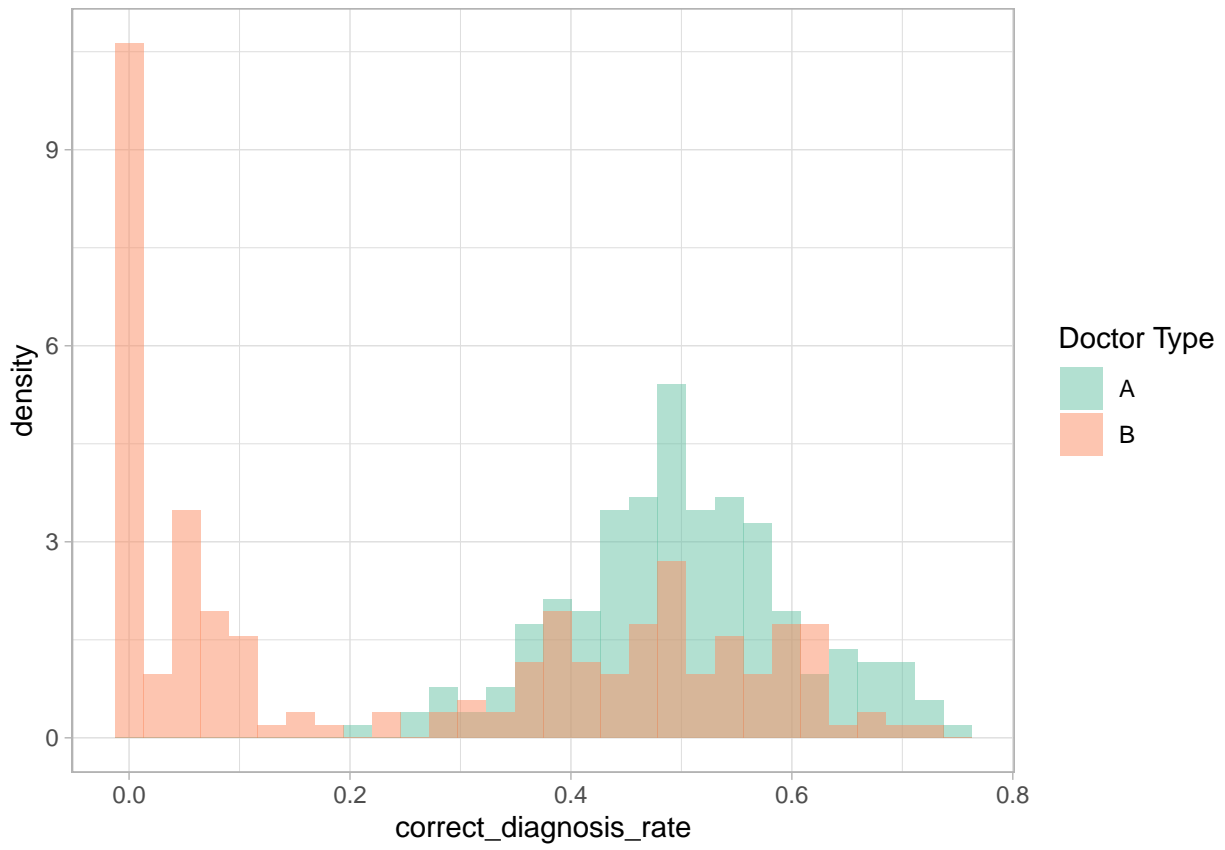
As expected, the doctors have similar diagnosis patterns when $X = 0$, but type B doctors perform much more poorly when patients with $X = 1$ are considered.

A data-driven diagnostic model

```
##
## Call:  glm(formula = diagnosed ~ x + severity, family = "binomial",
##     data = rbind(df_A, df_B))
##
## Coefficients:
## (Intercept)        xTRUE      severity
##      -5.849       -2.450        11.219
##
## Degrees of Freedom: 59999 Total (i.e. Null);  59997 Residual
## Null Deviance:        26160
## Residual Deviance: 6160   AIC: 6166
```

What happens over time

Now we imagine that this is part of a learning healthcare system. Every year, a new batch of patients comes to the hospital, and is diagnosed (or isn't). Every year, the researchers retrain their model based on the previous year's diagnoses.