Simulation evaluation of Bayesian borrowing techniques in estimating biomarker cutoff for diagnosing or predicting a binary response

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Background

- Determining a cutoff value for a continuous biomarker in a continuous diagnosis test to classify patient population is challenging

- Most common current methods (ROC–based methods) do not provide information on the diagnostic accuracy of the test at an individual level (Vradi et al. 2018)

- The learning of one study from predictive modeling for diseases/non-disease or responders/non-responders is rarely utilized in the exercise for the next study

Scope of Project

- Explore Bayesian borrowing methods such as mixture prior (Vradi et al. 2018) and power prior, for estimating the cutoff of a continuous biomarker assay
- Design adaptive strategies to select the weight parameters
- Compare performance of the two priors and frequentist approach for determining cutoff
- Extend the method to include multiple cut point determination

Model

$$Y|X \sim Bernoulli(p)$$

$$p(x) = P(Y = 1|X = x) = \begin{cases} p_1 = P(Y = 1|X \leq cp), & \text{for } x \leq cp \\ p_2 = P(Y = 1|X > cp), & \text{for } x > cp \end{cases}$$

The p1 = 1- NPV expresses the probability of response given X is below the cutoff value cp and p2 = PPV expresses the probability of response given that X is greater than cp

Model

$$p_1 \sim Unif(0, 1) \quad \text{and} \quad p_2 \sim Unif(p_1, 1)$$

$$cp = w\, g_1 + (1 - w)\, g_2 \qquad w \sim Beta(1, 1)$$

An example

Rahmati et al. (2023) :

- Determination of elevated thyrotropin (TSH) cutoff for prediction of preterm-birth
- Combine informative and non-informative prior with mixture prior
- PPV (positive predictive value) and NPV (negative predictive value) are clinical utility measure of a diagnostic test
- Have better PPV and NPV performance compared to predictive summary index(PSI), the frequentist approach

	Total pregnant women (n = 1,538)		
Parameter	Bayesian method Estimate (95% CI)	Youden Estimate (95% CI)	PSI Estimate (95% CI)
Cutoff	3.97 (3.95, 4.0)	3.14 (3.01, 3.22)	9.17 (8.42, 9.38)
PPV	0.84 (0.80, 0.88)	-	0.5 (0.21, 0.79)
1-NPV	0.08 (0.06, 0.09)	-	0.08 (0.02, 0.42)