



Evaluating the Strength of Evidence in DUI Cases Presented in North Carolina



Rebecca Law¹, Brady Melton¹, **Marcus Hill²**, Fan Wu¹, and Dr. Eric Laber¹
¹North Carolina State University Dept of Statistics, ²**Marcus E Hill Attorney At Law**

Background

Purpose: To explore the strength of evidence presented by breathalyzer measurements in North Carolina DUI cases.

- ▶ Criminal penalties depend on estimated Blood Alcohol Content (BAC)
 - ▷ Ex. A BAC above 0.08 is considered legally impaired
- ▶ Breathalyzer readings are subject to measurement error (ME)
 - ▷ Reliability of readings is dictated by ME variance
 - ▷ Breathalyzer readings are truncated
 - ▶ Ex. Two BAC readings of 0.0823 and 0.0879 → 0.08 and 0.08
 - ▶ Complicates the estimation of ME variance
 - ▶ Two readings of 0.07 do not necessarily indicate a true BAC of 0.07

Data

The data comprise all breathalyzer tickets in closed DUI cases from Jan 2011-June 2014 from the Orange County Courthouse in Hillsborough, NC.

Parameter Estimates from the Real Data

Using the likelihood, we found estimates of θ , τ , and σ from our data and chose 8799 as the representative breathalyzer machine.

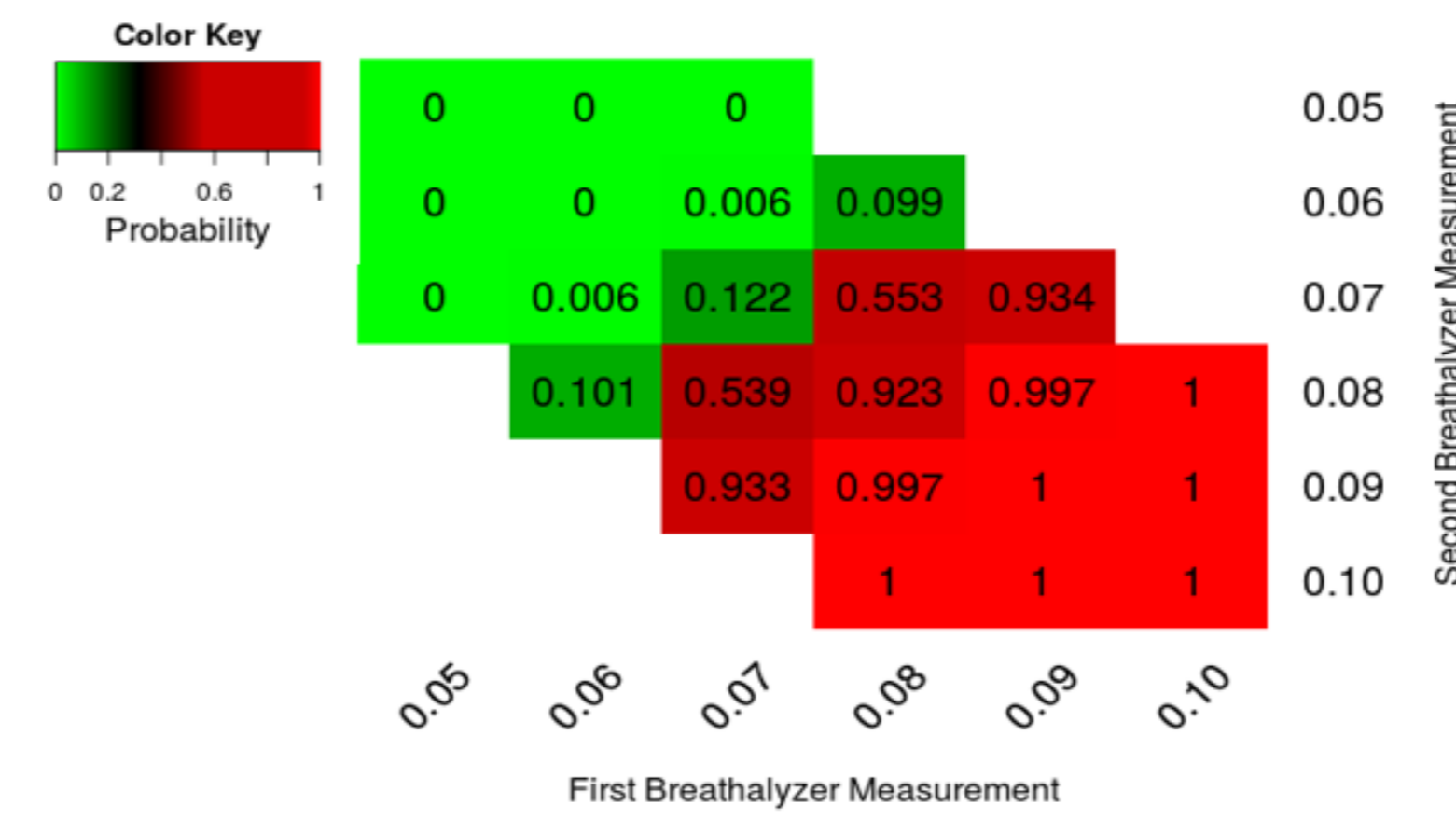
Parameter Estimates x 100 By Machine

Machine	Obs.	$\hat{\theta}$	$\hat{\tau}$	$\hat{\sigma}$
8799	386	15.52	4.88	0.46
8839	236	16.59	4.66	0.61
8856	317	16.16	5.26	0.47

Inference for True BAC

We used the estimated conditional models for machine 8799 to illustrate inference for an individual's true BAC.

Estimated Probability that True BAC is above 0.08



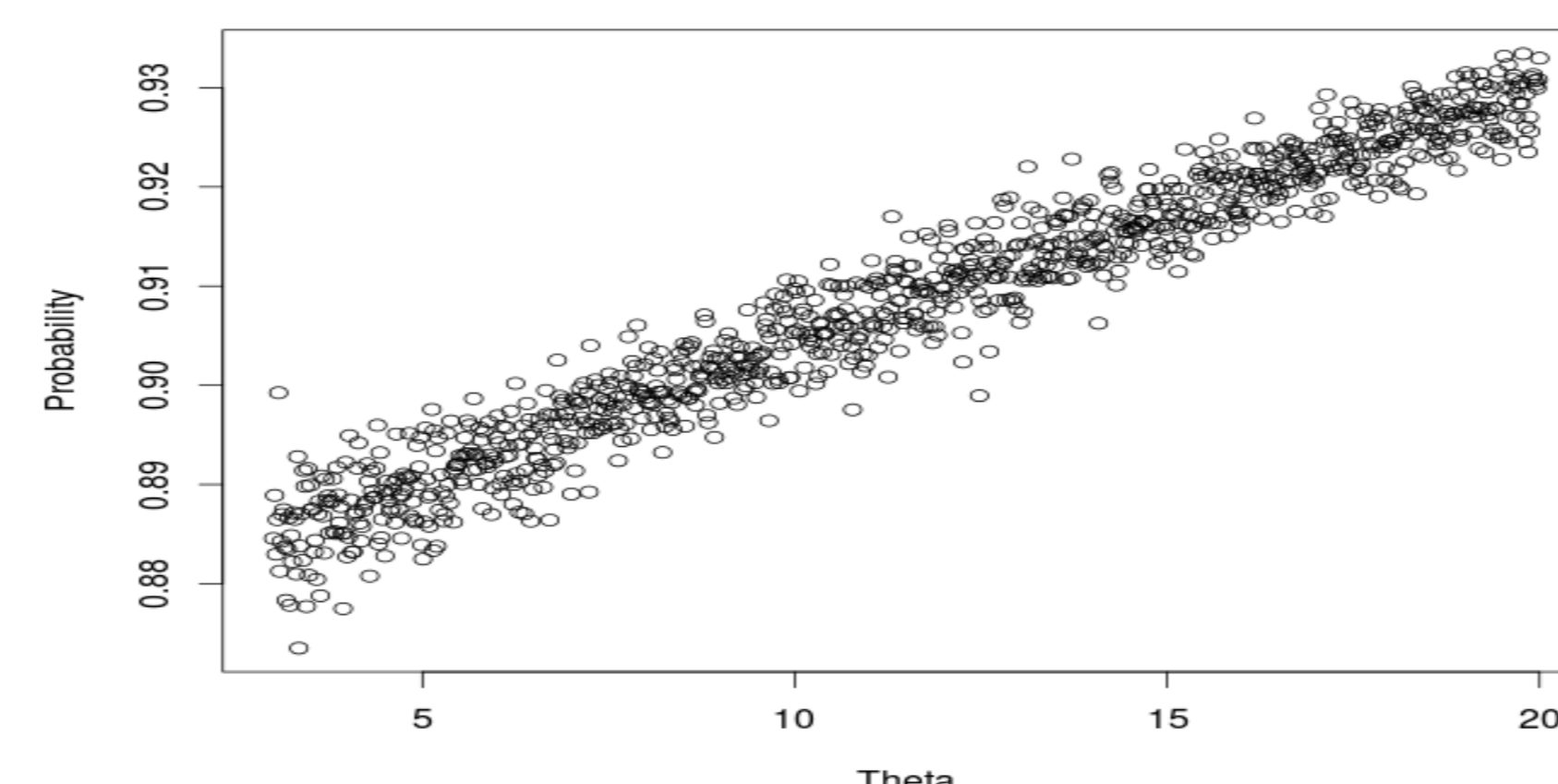
$P(\mu \geq 0.08 | Y_1, Y_2)$

Prediction Intervals

		First Breathalyzer Measurement (y_1)					
		0.05	0.06	0.07	0.08	0.09	0.10
Second Measurement (y_2)	0.05	(0.048, 0.063)	(0.053, 0.068)	(0.059, 0.073)			
	0.06	(0.053, 0.068)	(0.058, 0.073)	(0.063, 0.078)	(0.068, 0.082)		
	0.07	(0.058, 0.072)	(0.063, 0.078)	(0.068, 0.083)	(0.073, 0.088)	(0.078, 0.092)	
	0.08		(0.068, 0.082)	(0.073, 0.088)	(0.078, 0.093)	(0.083, 0.098)	(0.088, 0.102)
	0.09			(0.078, 0.092)	(0.083, 0.098)	(0.088, 0.103)	(0.093, 0.108)
	0.10				(0.088, 0.102)	(0.093, 0.108)	(0.098, 0.113)

We calculated 95% prediction intervals for the true BAC given breathalyzer readings; boxed portion indicates intervals with lower bounds above 0.08.

Dependence on Theta (Population Mean)



$P(\mu \geq 0.08 | Y_1 = 0.08, Y_2 = 0.08)$ as a function of $\theta \times 100$

Based on our model, as θ increases, so does the conditional probability that the true BAC will exceed 0.08, given both readings are 0.08.

Probability of a False Positive

An alternative is to assume innocence and calculate the probability of a false positive (Reported BAC ≥ 0.08).

Estimated Probability of Breathalyzer Readings Given True BAC of 0.079
 $P(Y_1 \geq y_1, Y_2 \geq y_2 | \mu = 0.079)$

		First Breathalyzer Measurement (y_1)					
		0.05	0.06	0.07	0.08	0.09	0.10
Second Measurement (y_2)	0.05	1.00	1.00	0.97			
	0.06	1.00	1.00	0.97	0.41		
	0.07	0.97	0.97	0.95	0.40	0.01	
	0.08		0.41	0.40	0.17	0.00	0.00
	0.09			0.01	0.00	0.00	0.00
	0.10				0.00	0.00	0.00

Assuming a true BAC of 0.079, the boxed off region contains the probabilities of readings that would result in a false positive.

Differences in 1st and 2nd BAC Readings

χ^2 goodness of fit:

$$H_0: P(BAC1 > BAC2) = P(BAC1 < BAC2)$$

$$H_a: P(BAC1 > BAC2) \neq P(BAC1 < BAC2)$$

χ^2 Goodness of Fit Test

Machine	BAC1 > BAC2	BAC1 < BAC2	χ^2	df	p-value
8799	106	65	9.8304	1	0.0017
8839	81	41	13.1148	1	0.0003
8856	95	61	7.4103	1	0.0065

Problems and Policy Recommendations

- ▶ The value of θ , the estimated population mean BAC, for Orange County is well above 0.08 and therefore raises the $P(\mu \geq 0.08 | Y_1 = 0.08, Y_2 = 0.08)$, increasing an innocent defendant's chance of being convicted. We are looking into ways to work around this dependence.
- ▶ The first and second breathalyzer measurements from our data are significantly different which indicates other problems to be further explored.
- ▶ Law enforcement should be aware that blowing two identical BAC measurements (i.e. 0.08 and 0.08) does not indicate that the readings are the individual's true BAC.
- ▶ North Carolina courts can utilize our look-up tables to determine the strength of evidence presented in DUI cases

Future Work

Future Work:

- ▶ Incorporate dependence in ϵ_1 and ϵ_2
- ▶ Factor calibration, temperature, and humidity into our model