Breathalyzers
Erik, Rich, and Roy
Overview

- How do breathalyzers work?
- How “don’t” many current consumer breathalyzers work?
- How can we augment existing technology using mobile devices?
Alcohol is absorbed from the mouth, throat, stomach and intestines into the bloodstream.

As blood goes through the lungs, alcohol is exhaled through the alveolar air.

2,100:1 ratio of breath to blood alcohol.

Example - 0.08 BAC means 0.08 grams of alcohol per 100ml of blood.
Alcohol found in alcoholic beverages is ethyl alcohol (ethanol)

The OH (O – H) group makes it an alcohol

Strip hydrogen from the right carbon to get acetic acid

The ethanol $\rightarrow$ acetic acid oxidation produces 2 protons and 2 electrons
How the MQ-3 works

1) The coil is heated up and ceramic tube becomes semiconductor

2) Alcohol molecules meet the electrode

3) Ethanol burns into acetic acid, protons and electrons created

4) Current produced proportional to the alcohol in the air
How the MQ-3 works

- Current is measured by microcontroller, and BAC calculated
- Frequent calibration is important!!!
- Margin of error always present (temp and humidity)
An Evaluation of the Accuracy and Reliability of Popular Consumer Breathalyzers as compared to their Marketing Statements (2010)
Consumer Breathalyzers

- How are they regulated by the FDA?
- How accurate are current consumer products?
- How does this affect how they should be marketed?
The FDA & Breathalyzers

- Public health & safety
- 510(k) “screeners”
- “FDA approved” or “FDA cleared”
How the FDA tests consumer breathalyzers

- 20 tests at .000 BAC, .008 BAC, and .032 BAC

<table>
<thead>
<tr>
<th>BAC Test Level</th>
<th>Allowable Failures</th>
<th>Required Passes</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.000</td>
<td>1 test &gt; .000</td>
<td>19 tests = .000</td>
</tr>
<tr>
<td>0.008</td>
<td>1 test &gt; .020</td>
<td>19 tests &lt; .020</td>
</tr>
<tr>
<td>0.032</td>
<td>1 test &lt; .020</td>
<td>19 tests &gt; .020</td>
</tr>
</tbody>
</table>
Testing protocol

- Tested for range 0.08-0.10
  - Individualized doses (Alcohol Administration Protocol from Rutgers University Center for Alcohol Studies)
- Participant consumed 3 drinks 5 minutes apart over a 15 minute period
Testing protocol

- **Test Period 1**, 30 minutes post-dosing
  - 3 readings each for 3 devices

- **Test Period 2**, 45 - 60 minutes post-dosing
  - 1 reading from each of the 5 devices
  - Blood sample

- **Test Period 3**, 75 minutes – 105 minutes post-dosing
  
  “Each of the breathalyzers was tested 4 times by each of the 57 subjects producing a total of 228 test samples for each breathalyzer. One blood sample was also obtained from each of the 57 subjects.”
“Device readings ranged from 30% lower up to 65% higher than the test subjects mean BAC at the time of the testing.”

“In an average 180 pound male this margin of error is roughly equivalent to the difference between 1 drink per hour up to 2.5 drinks per hour.”
Exhibit 1

Mean Accuracy of Semiconductor Breathalyzer Test Results VS. 0.084 BAC Mean Blood Test

<table>
<thead>
<tr>
<th>Device</th>
<th>Mean BAC%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bac Track B70</td>
<td>0.110 BAC%</td>
</tr>
<tr>
<td>Alcohawk Slim</td>
<td>0.126 BAC%</td>
</tr>
<tr>
<td>Alcomate Premium</td>
<td>0.073 BAC%</td>
</tr>
<tr>
<td>Alcohawk Pro</td>
<td>0.139 BAC%</td>
</tr>
<tr>
<td>Bac Track S50</td>
<td>0.127</td>
</tr>
</tbody>
</table>

% BAC
Exhibit 2

Standard Deviation of Test Results at .084 Ave. BAC

<table>
<thead>
<tr>
<th>Make/Model</th>
<th>BAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bac Track S50</td>
<td>0.143</td>
</tr>
<tr>
<td>Alcohawk Pro</td>
<td>0.123</td>
</tr>
<tr>
<td>Alcomate Premium</td>
<td>0.107</td>
</tr>
<tr>
<td>Alcohawk Slim</td>
<td>0.118</td>
</tr>
<tr>
<td>Bac Track B70</td>
<td>0.128</td>
</tr>
</tbody>
</table>

Exhibit 3

<table>
<thead>
<tr>
<th>Model</th>
<th>Correlation Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>BACTrack B70:</td>
<td>.28</td>
</tr>
<tr>
<td>Alcoscan:</td>
<td>.81</td>
</tr>
<tr>
<td>Alcohawk Pro:</td>
<td>.76</td>
</tr>
<tr>
<td>Alcohawk Slim:</td>
<td>.73</td>
</tr>
<tr>
<td>BACTrack S50:</td>
<td>.49</td>
</tr>
</tbody>
</table>
The marketing claims

- **Alcohawk Slim**
  - “Operating on a single button, simply blow into the folding mouthpiece for an **accurate BAC reading in seconds**.” [Sam’s Club website](#)
  - “The AlcoHAWK Slim contains a software upgrade to allow the unit to track if an uneven alcohol concentration is detected in the sample. This cutting-edge technology provides another method of ensuring breath sample integrity.” [Wal-Mart website](#)
The marketing claims

- **BACtrack S50**
  - “Why guess your alcohol level when you can easily test with the professional and remarkably affordable BACtrack Select S50.”
  - “The BACtrack Select S50 uses law enforcement technology to provide trusted results”
  - “The BACtrack Select S50 is FDA 510(k) cleared for consumer use.”

Costco Website
What this means for our project

- Testing protocol
- Additional information -> greater accuracy
The Kinetics of Ethanol Absorption and Elimination in Twins and Supplementary Repetitive Experiments in Singleton Subjects

M. Kopun** and P. Propping

European Journal of Clinical Pharmacology

1977
Testing what affects alcohol absorption

- 40 twin pairs
- 25 Identical (avg 23 years old)
- Catagorized by
  - drinking habits
  - smoking habits
  - Had to been non-medicated for the past month
  - have functioning kidneys
1. No food for dinner before

2. Arrive at institute at 8:00am

3. Eat 2 ham sandwiches (or not for later comparison)

4. Drink (1.2 ml per kg of body weight) of ethanol mixed in orange juice

5. Have blood samples drawn every 30 minutes for the next 4.5 hours
- For 4 cases

- Solid line = Had breakfast

- Dashed line = No breakfast
## Results

**Table 4. Relationship of alcohol intake and smoking habits to ethanol elimination rate**

<table>
<thead>
<tr>
<th>Category</th>
<th>Number of subjects</th>
<th>Mean ± s. d. for ethanol elimination rate (mg/ml × h)</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-drinkers</td>
<td>9</td>
<td>0.133 ± 0.029</td>
<td>3.535</td>
<td>&lt;0.005</td>
</tr>
<tr>
<td>Drinkers (minimum 60 g ethanol/day)</td>
<td>9</td>
<td>0.179 ± 0.025</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-smokers</td>
<td>22</td>
<td>0.151 ± 0.039</td>
<td>2.085</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Smokers (more than 25 cigarettes/day)</td>
<td>9</td>
<td>0.181 ± 0.029</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Individuals who neither drank nor smoked</td>
<td>4</td>
<td>0.125 ± 0.003</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Individuals who drank and smoked</td>
<td>5</td>
<td>0.180 ± 0.030</td>
<td>3.558</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>
Ethanol degradation rate formula

\[ \text{EDR} = \beta_{60} \times r \times 10^3 \frac{\text{mg}}{\text{kg} \times \text{h}} \]

\( \beta_{60} \) represents ethanol disappearance from the blood in \( \frac{\text{mg}}{\text{ml} \times \text{h}} \), which is approximately linear after termination of absorption. Widmark’s \( r \) factor was calculated from the formula:

\[ r = \frac{A_0}{p \times C_0} \quad A_0 = \text{ethanol ingested (grams)} \]

\( p = \text{body weight (kilograms)} \)
\( C_0 = \text{theoretical blood alcohol concentration at zero time (mg/g)} \)

Diagonal table:

<table>
<thead>
<tr>
<th></th>
<th>Mean ± s. d.</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \beta_{60} ) ( \frac{\text{mg}}{\text{ml} \times \text{h}} )</td>
<td>0.161 ± 0.043</td>
<td>0.073 − 0.255</td>
</tr>
<tr>
<td>EDR ( \frac{\text{mg}}{\text{kg} \times \text{h}} )</td>
<td>104.53 ± 21.51</td>
<td>57.6 − 147.6</td>
</tr>
<tr>
<td>Widmark’s ( r ) factor</td>
<td>0.664 ± 0.086</td>
<td>0.490 − 0.972</td>
</tr>
<tr>
<td>absorption rate ( \frac{\text{mg}}{\text{ml} \times 30 \text{min}} )</td>
<td>0.611 ± 0.256</td>
<td>0.20 − 1.12</td>
</tr>
</tbody>
</table>

\( \beta_{60} = \text{ethanol elimination rate; EDR} = \text{ethanol degradation rate} \)
To accurately predict blood alcohol level change over time we’ll need:

- Body weight of person
- Whether person drinks or smokes often
- Whether food was eaten before alcohol
- How much alcohol was drank
- Previous BAC level