Exploring Methods to Enable Responsible Alcohol Consumption in Social Environments

By

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Bachelor of Science in Mechanical Engineering

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ABSTRACT

With the recent rise in alcohol related incidents and deaths in the United States we have seen new technologies and tools to try to reduce the number of these occurrences. Apps such as Uber are only a click away from being able to pick up an intoxicated person at a party and there is research being done at Washington University on an application to communicate with your friends that you are too drunk while at a party based on Transdermal Alcohol Content (TAC).

This thesis presents an idea and initial feasibility experiments for an affordable one-night-use wristband that would be able to change colors based on your TAC and encourage wearers to be aware of how much alcohol they have actually consumed throughout the night, with the goal of reducing the number of incidents and deaths.
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Introduction

Many undergraduates arrive at college having never been exposed to alcohol and or alcohol poisoning. Couple this with the limited number of people that know how to correctly respond to intoxication leads to many situations that could easily be avoided if people only had a way of knowing how intoxicated the person was or if the person drinking would have stopped drinking once their blood alcohol content (BAC) was above a safe threshold. With college campuses being the one to shoulder the blame for students’ actions it is no surprise that they react with trying to cut down on parties and limit the availability of alcohol on campus. While this proactive approach does help prevent some future incidents it also increases the likelihood that students will simply find other venues to consume alcohol. As a member of a fraternity during my entire time as an undergraduate at MIT, I have seen many efforts at alcohol risk management from my own fraternity and other living groups. If the fraternity system is to stay in place at MIT in the future they will have to continue to strive to look for new ways to improve on the safety of parties because there have been multiple deaths and near deaths within the last decade.

Current rules on risk management is for people over the age of 21 to wear a wristband to identify themselves as someone who can drink. Once the person takes a drink they get a mark on their wristband and are not allowed to go over a set number of drinks. This practice works well in theory. However, it does not take into consideration the high number of people that arrive at parties already drunk from other venues.

During college I spent time as a bartender and I came to realize that it was never an exact science to figure out if a person had too much to drink prior to getting the next one from the bar. It is also huge liability being the one dispensing drinks. The biggest issue was that while
working bar there were frequently times where the bartender was pouring as fast as they could and partygoers would be grabbing drinks just as fast. In this time there is only a split second to make sure that the person in front of you is not too intoxicated. There have been many times when the assessment of the customer could be compromised because the bartender is trying to meet the demand. One way to help with this is to have more bartenders. However, there is limited space behind the bar to work so number of bartenders is limited to decrease the bottleneck. So, there needs to be a better system for the bartender to make the decision on a person’s alcohol level.

I researched ways to monitor people that were drunk and the prevalent way is to monitor BAC. Realistically, no one is going to carry around a breathalyzer in a frat or club to check if the person is too intoxicated. This got me thinking that instead of going with the high tech wristbands that are used to monitor transdermal alcohol content and are capable of notifying friends where you are, similar to the strategy used by another team of researchers from the University of Washington. The wristbands could be very inexpensive like the disposable “over 21” wristbands and are really good at one function which is once the person is above a threshold that is considered safe it changes colors or does something to notify the people around them that the person should not be allowed more drinks till their BAC goes down. This would effectively reduce the time necessary for the bartender to make the decision and reduce bottlenecks at the bar.

If the person were to be belligerent then the bar would also have a metric to be able to say you have had too much and can call the person a taxi or have them use an Uber to get home reducing the liability of the establishment. In informal interviews with stakeholders, a common concern about the wristband was the possibility that bad actors might use the wristband to prey
on drunken individuals. While this is a valid concern one would hope the intoxicated person’s friends or the party staff would step in and help before anything happened.

The rest of this thesis will describe studies of patterns of user behavior in a club setting and experiments to identify possible low cost, low overhead ways to detect intoxication.
Chapter 2 Background

Alcohol Use and Your Health

According to the CDC excessive alcohol use leads to about 88,000 deaths in the United States each year, and shortens the life of those who drink by almost 30 years. The study was done from 2006-2010[2]. Further, excessive drinking cost the economy $249 billion in 2010. While helping the economy is a good side effect it is not the main focus of this experiment. The focus is to help people and save people from engaging in dangerous activities.

U.S. Standard Drink Sizes

<table>
<thead>
<tr>
<th>12 ounces</th>
<th>8 ounces</th>
<th>5 ounces</th>
<th>1.5 ounces</th>
</tr>
</thead>
<tbody>
<tr>
<td>5% beer</td>
<td>7% Malt Liquor</td>
<td>12% wine</td>
<td>80 proof liquors</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Binge Drinking</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 drinks in one occasion</td>
<td>4 drinks in one week</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Heavy Drinking</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 drinks in one week</td>
<td>8 drinks in one week</td>
<td></td>
</tr>
</tbody>
</table>

Excessive alcohol use has immediate effects that increase the risk of many harmful health conditions. These are most often the result of binge drinking. Over time, excessive alcohol use can lead to the development of chronic diseases and other serious problems. Even though this study will focus on the short-term health risks because it is more preventable than changing a long term behavior it is also worthwhile to know the long term issues with drinking excessively.
This way if you notice a pattern in someone’s drinking habits you can say something with facts as to why their behavior should change.

Short-Term Health Risks

<table>
<thead>
<tr>
<th>Injuries</th>
<th>Violence</th>
<th>Alcohol poisoning</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Motor vehicle crashes</td>
<td>• Homicide</td>
<td></td>
</tr>
<tr>
<td>• Falls</td>
<td>• Suicide</td>
<td></td>
</tr>
<tr>
<td>• Drownings</td>
<td>• Sexual assault</td>
<td></td>
</tr>
<tr>
<td>• Burns</td>
<td>• Intimate partner violence</td>
<td></td>
</tr>
</tbody>
</table>

Reproductive health

• Risky sexual behaviors
• Unintended pregnancy
• Sexually transmitted diseases, including HIV
• Miscarriage
• Stillbirth
• Fetal alcohol spectrum disorders (FASDs)

Long-Term Health Risks

<table>
<thead>
<tr>
<th>Chronic diseases</th>
<th>Cancers</th>
<th>Social problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>• High blood pressure</td>
<td>• Breast</td>
<td>• Lost productivity</td>
</tr>
<tr>
<td>• Heart disease</td>
<td>• Mouth and throat</td>
<td>• Family problems</td>
</tr>
<tr>
<td>• Stroke</td>
<td>• Liver</td>
<td>• Unemployment</td>
</tr>
<tr>
<td>• Liver disease</td>
<td>• Colon</td>
<td></td>
</tr>
<tr>
<td>• Digestive problems</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Learning and memory problems

• Dementia
• Poor school performance

Mental health

• Depression
• Anxiety
Chapter 3 User observation

After learning about alcohol and some of the effects it has on the body short term and long term I decided it was time for me to go out into venues and observe people in the environments where it is being consumed. I watched for lines forming around the bar, how often people were getting drinks, activity level, and approximate intoxication level from observation level and whether or not based on the serveSafe model [7] the person should have another drink or if they should wait a while and sober up. I went to a small local establishment, House of Blues Boston and La Caverna in New York. Listed below in Figures 1, 2 and 3 are rough floor plans of the clubs and an assessment of ease moving around to get to where you wanted to be in the club. I chose to look at floorplans of these establishments to help get a sense of how users would interact with the wristbands.

Figure 1: The small local establishment
Figure 1 shows an example of a dancefloor with flow issues getting to the dance floor and the bar area being too close to where the dance area is to allow simple flow into the establishment.

Figure 2: La Caverna New York
Figure 3: House of Blues Boston
Having the bar anywhere near the dancefloor reduces dance space and requires people to maneuver around the people that are around the bar waiting for drinks or just hanging around the bar drinking. As a dancer it is very cumbersome to carry your drink around with you while you are trying to dance because the drink could spill or someone bumps into you and makes you spill. Due to the close proximity of the dance floor to the bar on a packed night getting bumped is very likely. Yet if the bar were moved to another room revenue from the dancers would decrease as they would have to move away from the dance atmosphere to go to the bar to order more drinks. In hybrid bar and club establishments the dance area is more defined and smaller so the dancers have their space and the drinkers can drink in peace.

La Caverna in New York uses an island style bar in the middle of the club and has seating on the sides which is nice for the people that use it as a bar only however on a packed Saturday night when it is used more as a club the space runs out before 11 and generates a long line outside to get in. The space feels more cramped than it actually is because the bar being in the middle requires people to stand at either side of the bar to be served which eliminates the problem of bumping into people dancing but creates a problem of walkways to the dance floor. Other than the initial problem of getting to the dance floor the club does a great job of creating a space that is closed off and encourages dancing and keeps dancers there until closing as it is difficult to leave through the crowd around the bar.

At House of Blues it provides an interesting take on a club area as the dance floor is gigantic and does not interfere with where the bar area is. It also has its drawbacks due to there being so much space it actually discourages the slightly shy dancer from starting to dance. In terms of venues it depends on what the patron is looking for as to what is acceptable for the space and patrons tend to go back to the ones that they feel fit what they expect from an
establishment. Therefore, before the establishment has been in use they have already determined the clientele for the club.

- Dancers -- most active on the dance floor and may stop to grab a drink but they will sweat out most of their intake throughout the night from being active. That does not mean that a person that is a heavy drinker may not wind up out on the dance floor but the dancers spend more of their time dancing than getting drunk.

- Light drinkers -- will spend a small amount of time at the bar but will not make frequent trips back and forth to the bar. Orders a drink about once an hour.

- Observers -- are going to be the ones sitting in the corner crowd watching and seeing how the night unfolds. Relatively inactive so if they do have drinks their BAC is more likely to go up.

- Heavy Drinkers -- is the target group as they order drinks at a very high rate can be as high as once every 15 - 20 minutes.
It was upon observing the heavy drinkers that I decided to do testing based on them as they were the most likely to have alcohol poisoning and other issues related to binge drinking. I chose to test using pH due to its ease in accessibility, low cost, and to see if there was a strong correlation between pH and alcohol consumption.

First Testing Procedure

1. 1 Blue Moon 5.4% by volume alcohol every 15 minutes
2. Test pH of mouth and sweat prior to consuming beer
3. Test using pH strips orally immediately after consumption of beer
4. Record pH of sweat
5. Record pH using photos
6. Record observations in changes in bodily function and behavior

Results of the first test:

Initially there was some surprise that the pH of the beer that was chosen was acidic due to ethanol being slightly on the basic side of the spectrum. Then it made more sense with carbonation and everything that goes into making beer and keeping it from being flat that it would have a lower pH. In this experiment five people were used of similar body types to test if the strips and sweat theory would work.

The reading for saliva was as expected with an average ph of 7.4±.3 after brushing teeth and drinking water to cleanse out residue in the mouth prior to drinking. I then recorded the pH of sweat before the subjects started to drink recorded an average of 6.2±.2 After the subjects finished the beer and found that the pH was out of the spectrum of the saliva pH strips that I had
bought for this purpose however with the other strips that were purchased showing the full scale of pH I did determine the pH went to the area above 8 and below 9. At four beers behavior changed and it was obvious that the subjects were high enough BAC to where they should not be driving so I ended the test there to let them sober up before driving home. The test subjects never produced enough sweat after four beers in an hour to produce a pH test of that so I went to testing hard liquor. I chose hard liquor to do the second test because hard liquor gets into the bloodstream faster per volume.

Second Testing Procedure

1. 1 shot of Fireball 33% by volume alcohol every 15 minutes
2. Test pH of mouth prior to consuming alcohol
3. Test using pH strips orally 1 minute after consumption of alcohol
4. Test using pH strips orally 14 minutes after consumption of alcohol
5. If sweat is present get a sample using pH
6. Record pH using photos
7. Record observations in changes in bodily function and behavior

Results of the second test:

This time I had the same five subjects as before repeat the preparation and the results were the same for one minute after the consumption of alcohol. The initial pH of Fireball was below the threshold of the saliva strips but was approximately 4.0 using the larger range pH strips. For the 1 minute after taking the shot it once again shot the pH out of the range of the testing strip and continued to hover above that threshold after more shots. However, once we waited 14 minutes before the next shot to measure the pH went down with the number of shots
and eventually got to the edge of the saliva strips accuracy of 5.5. I increased the number of shots from 4 in an hour to 8 in two hours to hopefully see sweating from alcohol and was not able to detect any using pH despite making everyone in the test group drunk.

The most disappointing thing was there was not enough sweat produced from just drinking to garner real data on if pH could actually be used as an indicator for transdermal alcohol content as it was the real goal of the experiment. Test subjects did experience the warming sensation that is associated with getting intoxicated however either the frequency was too low at 1 per 15 minutes or it required more activity while drinking. Due to this I would not use pH as a means to detect transdermal alcohol content and using it to detect BAC orally is easier if you know the persons baseline pH and what they have been drinking but is still not a good indicator as there are too many other factors such as if they have eaten something acidic or taken a tums that would drastically change the results.
Chapter 4 Future Experiments:

Even though subjects in the experiment experienced the flushing that goes along with excessive alcohol it was not enough to experience sweating till after people went to sleep. Some experienced night sweats and at that point it would be too late to prevent them from getting them the drink that put them over the edge. I would like to see if being active during the test makes the sweat more noticeable and therefore an easier method to detect.

Seeing as there is already technology to detect it using electronics so there is likely a way to get the electronics out of the picture using the correct enzyme to detect the aromatic ring that goes through the skin. Getting that to act like pH strips and change colors will be the next challenge for scientists. However, I believe it will continue to be a novelty item and will just be an app on a smartwatch or fitbit that will alert friends instead of alerting the person serving.
Bibliography


