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The Status of Workplace Safety in the United States and Employer Consideration of Real Time Impairment Monitoring

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Chapter 1

Abstract

Impairment in the workplace is a major issue that is often overlooked. Trucking, mining, and construction are industries that involve the use of heavy equipment and vehicles are often marked by long work days where even the slightest slip-up can lead to accidents with often fatal consequences. Operating equipment or driving for long periods of time is hard enough when fully alert, but what about when the operators are under the influence of cannabis, alcohol, drugs, or even not getting enough sleep? With modern technology, it is becoming possible to, detect impairment at the time of testing using non-invasive techniques as a way to prevent workplace accidents. This report analyzes the current state of workplace safety and the nascent impairment detection industry.

Chapter 2

Current State of Workplace Safety

Workplace safety has come a long way since the days of people falling into heavy machinery at the start of the industrial revolution. Today's workplace safety is regulated by agencies like the Occupational Safety and Health Administration (OSHA), an agency of the Department of Labor. It is important to understand the current state of how workers are kept safe in dangerous jobs to understand how impairment detection may fit into existing protocols and practice.

Mining, trucking, construction, and manufacturing have been identified as the industries most impacted by workplace safety. Out of all of the industries in the current economy, they represent the greatest harm to workers with the most potential for technology to improve safety.

2.1 Mining

Mining is one of the most dangerous jobs on the planet. From mine cave-ins, air quality issues and required equipment, the job is incredibly physically demanding and full of danger. While underground, miners have to keep constant check on the status of the atmosphere so that it has both enough oxygen to breath and no buildup of poisonous gasses. With coal mining in particular, coal dust can aerosolize and get into worker's lungs, causing pneumoconiosis (commonly referred to as black lung). Large excavation and transport vehicles are used, with the potential to cause a cave in if the structural integrity of the mine is compromised.

To combat these dangers, mines in the U.S. employ a multi-leveled safety protocol. First, workers typically must wear hard hats, safety goggles, and depending on the mine, respirators or air filters.

Mines must be lit with bright floodlights to minimize the risk of trips, falls, or other hazards. State-of-the-art air ventilation systems are used to get noxious fumes and carbon dioxide out and fresh surface oxygen in. Special devices are even capable of removing particulates and dust from the air when appropriate. Finally, extensive training is required for mining personnel on how to act safe and what to do in the event of an accident.

For the year 2020, there were 44 oil and gas-related mining fatalities and 34 other mining fatalities, for a total of 78.

2.2 Trucking

Essentially the backbone of America's logistics, trucking represents a very important industry coupled with the highly dynamic environment that is the U.S. interstate system, where safety is essential due to the hazards on the road. The biggest issue facing truck drivers is boredom and fatigue. The long hours of little action that require upmost concentration takes a toll on the driver's attention span and energy. In addition, weather can be very problematic for truck drivers. Truck drivers have to remain vigilant at all times to be safe with the other people on the road.

Because of this, there are several generally accepted safety practices that truckers engage in. First of all, there are legal limits on how long truckers are allowed to work before a mandatory rest period is allotted. This rest is important, as truck drivers need to be well rested and alert on the roads, especially when the interstates or other roads come near populated areas. Additionally, truckers have to ensure their truck is kept in good working order and be extra cautious depending on the weather report or if night driving is required. Most truckers in modern vehicles are required by federal law to keep electronic logs, using a device in the cab which collects data from the OBD port and other sensors.

For the year 2020, there were 805 transportation related fatalities, though this number also includes warehousing operations as well. According to the Department of Transportation, there were approximately 415,000 police-reporting truck crashes in 2020, and of those 101,000 involved injuries.

2.3 Construction

Construction is perhaps the industry with the most visible safety precautions, primarily because construction sites are everywhere. Construction sites expose workers to severe safety risks, including falling from heights, being injured by falling objects, dangerous materials involved in the construction process, and lots of heavy vehicle use, from forklifts, cranes, and excavators, to all types of trucks.

Construction is probably the most visibly regulated industry, with signs and fences to protect civilians from the workplace. Most construction personnel have to also wear hard hats, safety goggles, and high visibility vests. In addition to this, there is stringent training required to operate vehicles like forklifts or excavators. Finally, construction workers have mandated breaks and lunch to combat fatigue at the workplace. Despite the focus on safety, for the year 2020, there were 1,008 construction fatalities.

2.4 Manufacturing

Manufacturing, including chemical plants, refineries, factories, and processing plants for food have a fair share of risks. Even though the building is likely designed for safety, workers still have to be vigilant about machinery and other workers. Additionally, there might be vehicles traveling on the floor or large machines with the potential to injure or kill.

In addition to safety equipment, one of the biggest aspects of safety is training and workplace culture. Employees are trained to promote a safe environment and how to deal with accidents to prevent serious injury. Additionally, machines have guarding and safety equipment to prevent workers from engaging parts of the machinery to prevent any serious damage from occurring. Despite all of the efforts on workplace safety, for the year 2020, there were 304 manufacturing fatalities.

Chapter 3

Current State of Impairment Science

Impairment science is still evolving, however, there has been research conducted on the effect of specific substances and activities on the performance and safety of employees and how to detect said impairment effectively and non-invasively.

3.1 Current Accepted Workplace Practices

Across the various aforementioned industries, there are several practices which are already used to promote and improve workplace safety:

- Safety Glasses
- Dust Masks or other Ventilation Equipment
- Working in pairs or in teams to promote checking
- Signs and labels for safety
- Lockouts on electrical panels and doors while working
- High Visibility Vests
- Hard hats
- Training and instruction on how to safely perform duties

3.2 Policy Suggestion

An article sponsored by the Transportation Research Board (Fell et al. 2016) examined how the impairment detection industry has stagnated in the past thirty years and proposed a change of laws to help deal with the issues facing industry. These policies were primarily focused on alcohol, and included:

- Additional taxes on alcohol to discourage purchasing and consumption
- Lowering the illegal threshold for blood alcohol content (BAC), which would promote more temperate consumption of alcohol and thus less impairment
- The use of detection systems, which did not exist as much at the time of publishing but would be needed to ensure enforcement of any impairment-related policy
- A public awareness campaign to increase discussion and research into solutions for the problem.

The National Safety Council (NSC) also conducts research and makes policy recommendations.

3.3 Methodologies

There currently exist two broad categories that successful impairment detection devices use:

3.3.1 Eye-Based Measurements

Devices based on the eyes typically come in the format of a large headset similar to virtual reality goggles. There are a few different types of detection here but both use involuntary eye movement. Some devices track eye movement over a period of time while others use pupillary light reflex (PLR). The benefit here is these methods are fast, accurate, and require no voluntary action from subjects, making them easy and helping to prevent fraud.

3.3.2 Cognitive and Motion Video Game/App

The other primary method used by current devices is based on essentially a test framed as a game. These have varying science backing the actual test, but usually involve a cognitive aspect to measure

the person's ability for higher-order thought, which typically is diminished when impaired. This is combined with a balance or reflex motor test using the smartphone's or tablet's sensors, as motor skills also suffer when impaired. These tests match with the biggest hazard an impaired person poses to the workplace, that is a lack in sound judgment and not having good motor control of equipment.

3.3.3 Wearable Technology

Another category of technology to consider here are wearables, such as watches and glasses, which allow more sensors to be used in a more convenient format. One such device, which is examined later, is the Optalert which consists of glasses to record the trucker's alertness and connect to a central unit.

3.4 Technologies

In addition to the above listed overarching categories for impairment detection, these are some recurring technologies also present in many devices:

3.4.1 Truck Cab Interlink

These types of devices use the ODB2 port (a standard port present on all modern vehicles that allows external devices to read data from and manipulate the onboard driving computer) to get very accurate driving performance data from the truck itself. Devices that integrate this can detect drifting, strange acceleration and deceleration patterns, lazy swerving, among other things to detect impairment and help alert the driver. This technology is more apt for general fatigue or drowsiness rather than drug-induced impairment, but will detect most precursors to driving fatalities. Models have been developed to map the ODB2 port data into actionable impairment data (Thomas A. Dingus 1987).

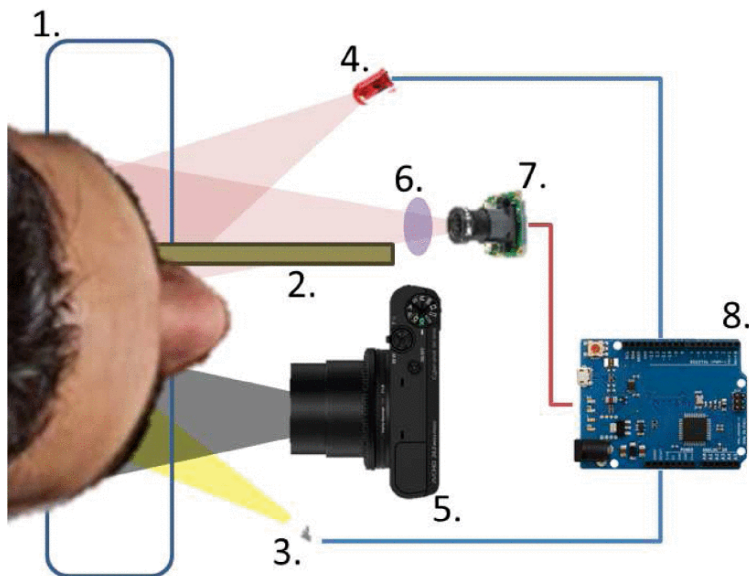
3.5 Current Research

3.5.1 Pupillary Light Reflex

One of the most promising methods to detect impairment is pupillary light reflex (PLR). PLR essentially works by pointing an optical sensor at someone's eye, and then over a period of thirty seconds to two minutes measures characteristics of the pupil. These include time to change size, initial size, rate of change, and amount of time to return to base, among other things. Systems like these have been proven to be very accurate at detecting impairment as the current science shows that all of these characteristics will be slowed or change when under the influence of any drug, including alcohol, marijuana, and even sleep deprivation. An example system is shown in figure 3.1. (Amodio et al. 2019)

This research was significant in that it produced high quality algorithms and formulas that are used by the system to determine impairment given the raw sensor values. Later commercial products would end up with systems very similar to this, but fleshed out to work in the real world. Some commercial examples of this process include SoberEye, which tracks PLR using an iPhone in a headset.

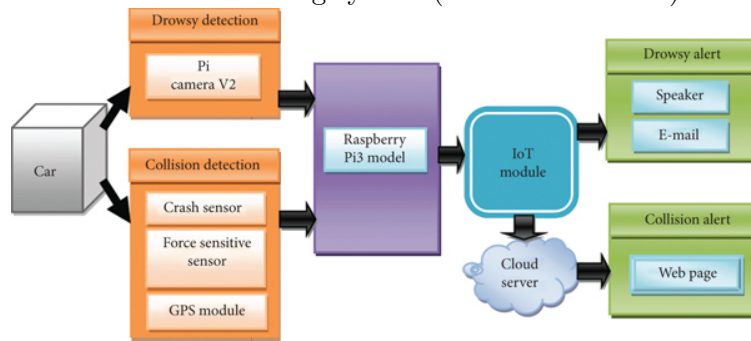
Figure 3.1: A diagram showing how a PLR-based impairment detection system would work (Amodio et al. 2019)



3.5.2 Car Monitoring System

Another eye-based system that shows promise is the whole car monitoring system. In these implementations, eye movement and direction is paired with sensors tied into the car's OBD2 port. A processor aggregates all of the data from the cameras, car, and other sensors, as shown in figure 3.2. If the driver is impaired or crashes email and text alerts can be sent as well as audible alerts in the cab. (Biswal et al. 2021)

Figure 3.2: A flowchart showing the information flow in an Internet of Things *IoT*-based system to detect impairment from a car monitoring system (Biswal et al. 2021)



3.5.3 Wearable Technology

Yet another system researchers are looking into is wearable technology. In a system like this, the driver, operator, or employee wears a piece of technology on his person, such as glasses, a watch, or some other sensor. This sensor then gathers information in a more accurate manner than an external system. This also has the added benefit of being easier to use and harder to forget. However, this also has privacy and potentially legal implications.

Chapter 4

Current Perception of Impairment

Impairment is a complicated subject, primarily because of the different stakeholders involved. Employees are the ones who cannot be impaired at work less an accident occur. Employers have a responsibility to ensure a safe workplace and keep productivity up. The impairment detection industry and scientists work to make it easier to prevent accidents at the workplace. And finally, politicians make laws that impact the other stakeholders.

4.1 Employees

Perhaps the greatest affected group is employees, as they have to deal with the consequences of both impairment and impairment detection. On one hand, if they or one of their coworkers on the job is impaired, it could result in an accident, especially when considering industries like mining, trucking, construction, manufacturing, all of which involve dangerous and heavy machinery. A detection of impairment could impact their livelihood, resulting in loss of pay or even the loss of their job. Impairment detection technology devices are quite new, so there isn't a lot of data on how employees view these devices in the workplace. However, it is key to avoid them being placed into the same category as drug tests. If this happens, the push back will be too great due to the perception of drug tests as trying to catch someone in the act. In addition, these devices only capture a snapshot of their fitness for duty, as opposed to any drug use over a set period of time in the past. As a result, use of real time impairment technology could be framed as a necessary and standard piece of safety equipment, like a hard hat at a construction site or a hydrogen sulfide

detector at an oil refinery. Items like these are not even questioned anymore and a basic impairment detection device should be framed like this to keep the workplace as safe as possible.

4.2 Employers

Employers have challenge in dealing with workplace impairment, as they bear the burden of dealing with any accidents or fatalities that may occur. In addition, they have to keep their employees satisfied and not seem like they are going too far with impairment detection. Finally, employers have a big legal burden due to the amount of laws and regulations they have to comply with is immense and overbearing. There are several laws that intersect and prevent employers from effectively keeping the workplace safe. The best bet is to frame an impairment detection solution as another routine piece of safety equipment, like a high-visibility vest or safety glasses.

4.3 Safety Industry

The safety industry is pushing everyone forward. This includes companies researching and developing technology to prevent workplace injury or at least mitigate it, businesses looking to lower their insurance burden and overall improve morale and safety in the workplace, and regulatory and trade organizations which tie the two together. They build the devices which enable employers to detect impairment easily and frame it correctly as well. Additionally, they apply the researched science from academia with their own research and development to produce high quality devices or apps which can determine impairment in under two minutes. Not only do these companies have to produce a high quality product to entice employers to spend money on them, but they also have to create a product employees will find palatable.

4.4 Scientists and Academics

Scientists and academics play an important role of researching methods the industry can use to build devices to effectively and more importantly accurately detect impairment. Researchers have discovered methods which avoid testing for a specific drug, which is important if the perception of impairment devices is to not be lumped in with routine drug testing. In addition, scientists have

found methods to detect impairment very quickly and accurately. Sometimes these take the form of dedicated machines the user interacts with, such as a large box with eye sensors or a smartphone, and sometimes it is done with wearable technology, using devices similar in form-factor to VR goggles that measure eye movement or existing devices like a FitBit or Apple Watch that are used to monitor activity and health.

4.5 Regulatory and Legal

These quasi-politicians have the ability to set stringent rules on how industries can operate, and thus have the ability to stop impairment detection in its tracks. A few examples of these agencies include the U.S. Department of Labor, which may be for or against these newer devices. On one hand, departments like the Occupational Safety and Health Administration (OSHA) would probably prefer having a non-invasive way to keep accidents from happening, while other departments of the Department of Labor having to do with employee protections and unions may want to restrict the use of these devices.

4.6 Politicians

Finally, politicians have a key role to play here as well, as they make laws both directly and indirectly related to impairment and drugs. One of the biggest problems in this sphere right now is that as some states have legalized recreational marijuana and have made it illegal to test for cannabis in the workplace. This makes it much harder for employers to keep workplaces safe. Additionally, the impairment detection industry is still in its infancy, so most politicians are wholly unaware of its existence or implications and thus think of it in terms of routine drug testing.

Chapter 5

Current State of the Impairment Detection Industry

5.1 Available Solutions

As recent report conducted by the National Safety Council (Stroer et al. 2022), on impairment lists several products available on the market.

5.1.1 AlertMeter

AlertMeter is a smartphone game based solution, which is based on the Psychomotor Vigilance Test developed by NASA, as shown in figures 5.1 and 5.2. The app must first gather a personal baseline to compare results against before impairment results can be effectively delivered. The test takes approximately sixty seconds and only requires a standard smartphone in addition to the app. Additionally, a cursory look appears to show that there is broad industry usage for this product.

5.1.2 Druid

Druid is a smartphone app that resembles a casual mobile game, as shown in figures 5.3 and 5.4. The game is designed based on conducted research and claims to use cognitive, reflex, and balance based testing to determine an individual's impairment level in approximately three minutes. The only requirement upon employers is a standard smartphone and the service itself, not requiring custom or

Figure 5.1: Welcome page for AlertMeter testing app (*AlertMeter - Apps on Google Play* 2022)

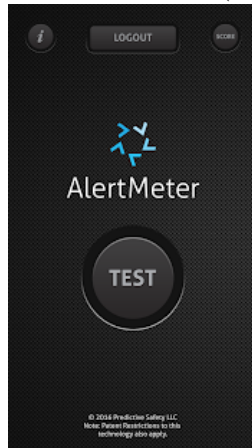
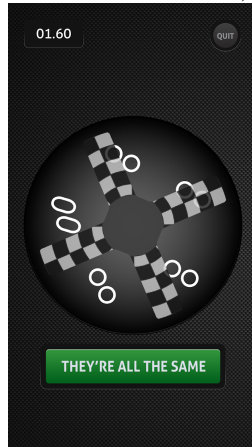


Figure 5.2: Specific example of a cognitive test taking place in the app to measure spatial and visual reasoning (*AlertMeter - Apps on Google Play* 2022)



bespoke hardware. Additionally, one of its standout features is offering a metric equivalent to Blood Alcohol Content (BAC) allowing supervisors to make subjective judgments about impairment.

Figure 5.3: Introductory page for Druid application describing tests to take place (*DRUID - Apps on Google Play 2021*)

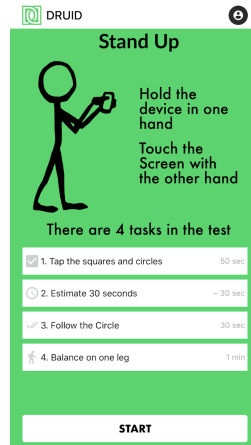
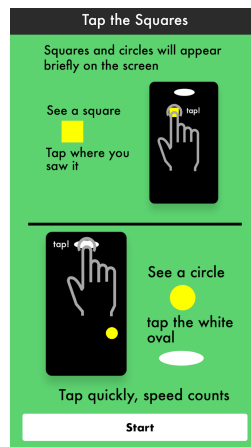


Figure 5.4: Instructions for a specific cognitive test in Druid application (*DRUID - Apps on Google Play 2021*)



5.1.3 Optalert

Optalert is a vehicle-based system, where a custom designed computer is mounted inside the cab to aggregate signals from sensors. The sensors include a link into the truck’s OBD2 port to get high quality data about driving performance. Additionally, the driver wears modified glasses which measure eye movement and head motion, as shown in figure 5.5. Unlike most other competitors, the focus is on drowsiness from the work itself rather than an external impairment. Finally, it offers a numeric measurement similar to Druid called the Johns Drowsiness Scale (JDS) which enables different responses based on severity.

Figure 5.5: Glasses worn as part of the Optalert system. These include sensors for eye and head movement and connect back to the central base station (*Scientifically designed glasses* 2022)



5.1.4 SafetyScan

SafetyScan is an eye movement based testing solution instead using a form factor of a desk device, as shown in 5.6. A custom headset with cameras aimed at the subject's eyes is used to measure involuntary eye movement over a period of thirty seconds. There is less readily available information about SafetyScan, which may be due to it not being based in the United States.

Figure 5.6: Subject being tested using the SafetyScan system. Near the top of the machine is the camera system to measure eye movement (Staples 2018)



5.1.5 Sobereye

Sobereye is a visor based solution that uses an iPhone as a platform to measure the pupillary light reflex (PLR) of the person under test. PLR is a natural reflex where the pupil adjusts its size in response to light. Sobereye requires a ten day baseline period where an individual's characteristics

are measured to help determine if there is impairment due to any cause. The test only takes a few minutes to complete, and it returns a yes or no impairment result.

Figure 5.7: Headset used by SoberEye system for impairment test (*Workplace Safety / SOBEREYE 2022*)



5.2 Comparison of Current Solutions

Company Name	Baseline Time	Test Time	Data Output	Cost	Methodology	Equipment	Headquarters
Sobereye	10 Days	**	Pass/Fail	**	Pupillary Light Reflex	Smartphone-Based Headset	California, US
Druid	12 Minutes	3 Minutes	P/F and BAC	**	Field Sobriety Test	Smartphone Game	Massachusetts, US
SafetyScan	**	30 Seconds	Pass/Fail	**	Involuntary Eye Mvmt.	Custom Headset	Canada
Zxerex	**	**	**	**	Involuntary Eye Mvmt.	**	Arizona, US
Optalert	**	Continuous	P/F and JDS	**	Head & Vehicle Sens.	Glasses & Base Station	Australia
AlertMeter	**	60 Seconds	Pass/Fail	**	Cognitive / Reflex Test	Smartphone App	Denver, CO

5.3 Failed Solutions

In stark contrast to the solutions listed above, there have been many product offerings that offer limited if not unviable solutions. The same National Safety Council (Stroer et al. 2022) report contains several examples.

5.3.1 Failure to Startup

The problem here is companies either running out of capital or failing to acquire enough sales or revenue in a timely fashion to keep the business afloat. This is unfortunate as these business usually have a solid business model or promising product. These include products such as Zxerex Safe and WIT, perhaps these products will succeed with additional time and funding.

5.3.2 Bad Technology

The other side of the coin is companies whose product is lackluster compared to what is available now. One example of this is a company that requires a physical unit the size of an arcade cabinet to be installed, which then takes longer than other devices to measure impairment. Why would an employer use a product that costs more and does less? Devices like these can be studied and learned from as to what not to do in the industry. Just like any industry, products must remain competitive in the market to survive. These include products such as F2D2, WIT, ExceleRate, and PVT. Usually, the mark of a bad technology is very long time to test coupled with expensive custom hardware or a subscription.

5.4 Hurdles to Adoption

5.4.1 Legal Barriers

One of the biggest challenges for an employer considering implementing an impairment detection system is the changing legal environment related to drugs. In the state of California, due to recent legislation surrounding recreational and medical marijuana usage, it is illegal for employers to test for and fire based upon marijuana usage. In addition, employers must have a reasonable suspicion to order a drug test on a specific employee, and having random drug tests frequent enough would

be cost prohibitive. Most of the devices mentioned above work around these issue by detecting impairment instead of a specific drug. Impairment is defined more generally as a state of mind more prone to error, which can be caused by drug usage but also from sleep or distraction. Again, impairment detection devices should be positioned as safety equipment instead of drug testing devices.

5.4.2 Employer/Employee Perception

Another aspect a potential user of impairment detection devices must consider is the perception of the products and their use in the business. Employees may perceive the devices as management out to catch people in the act of drugs. Alcohol and other recreational drugs are common in hard jobs such as mining and trucking, which is unfortunate and thus efforts must be made to determine when an employee is impaired and prevent the operation of dangerous machinery in such a state. Thus, employers are nervous about the perception that having mandatory daily impairment checks has. Fortunately, these devices can instead be positioned as essential safety equipment, akin to safety glasses, hard hats, and high visibility vests and thus be made more palatable to the general public. Indeed, these devices are not intended to be punitive mechanism but instead are designed to prevent workplace accidents and fatalities before they happen.

Chapter 6

Analysis of Impairment Detection Industry

6.1 Summary of Current State

A lot of very promising products are starting to be developed and released that have the potential to radically change how workplace safety works. On the flipside, this also means that the legal landscape hasn't quite caught up with the technology, nor will it until key issues are flagged that prompt a legal reaction. As such, given that these devices do not usually classify as drug tests they are essentially unregulated. This presents a unique opportunity to position them as key pieces of workplace safety.

Additionally, the science behind the technology is very promising and only getting better. Earlier devices were limited in what could be accomplished, but modern devices using PLR or cognitive/reflex based testing are accurate at detecting impairment, which is what matters when preventing a workplace tragedy. Some devices even combine these methods to present a complete solution to safety at work.

6.2 Key Issues

There are several key issues the industry will need to overcome in order for impairment detection devices to become a mainstay in workplace safety:

6.2.1 Perception compared to Random Drug Testing

One of the biggest issues, as previously stated, is that there is a big potential for impairment detection devices to be juxtaposed to random drug testing, which would be very bad for the industry. Random drug testing carries both the legal ramifications of having to be regulated. The best way to avoid this connection is to frame these new devices as something that just has to be done on the workplace, like wearing a hardhat at a construction site.

6.2.2 Cannabis and the Legal Landscape

Cannabis legalization is posing a huge burden to employers as well as society at large. Cannabis impairment results in decreased mental function and less inhibition. A recent study found that recreation marijuana legalization at the state level could be connected to a 6.5% increase in traffic crash rates (Farmer, Monfort, and Woods 2022). In addition, even when cannabis isn't causing a crash, it is definitely impacting driving behavior (Hartman and Huestis 2012). When under the influence of cannabis, people become less inhibited, and it becomes harder to focus on tasks. Additionally, people tend to have a slower reaction time, decreasing the chance of successfully navigating a critical situation. Cannabis legalization and the laws that make it illegal to test for marijuana has led to dangerous situations where employees cannot be stopped from working in dangerous workplaces even though they are in no condition to do so. The impairment detection industry needs to ensure that their devices are not banned under this new legislation and also lobby state governments for less liberal cannabis laws as the safety impact is immense.

6.2.3 Pricing and Initial Expense

Another issue some of the newer competitors to the industry face is the higher price tag compared to both traditional drug testing and to doing nothing. Traditional drug testing suffers from the issues mentioned in the previous section, and thus the higher cost can be justified. Additionally, investing in impairment detection hardware or the service needed to run it in the cloud is an ongoing value, as opposed to a one-time disposable product. Perhaps the best comparison is against doing nothing, as seemingly it should be very hard to convince employers to spend potentially thousands of dollars when they don't think they need the product. However, the best way to work around this

is to consider the cost of an accident or even fatality on the workplace. Compared to the insurance costs, medical costs, regulatory burden, and even more indirect costs, even the thousands of dollars for bespoke impairment detection hardware will look like a drop in the bucket.

According to a report on the topic, pricing for SoberEye, for a 50 employee company is approximately \$16,500 per year. This is compared to traditional drug testing for the same company which is \$2,480 (Emery and Solomonides 2021). These numbers may seem steep for initial pricing, but the whole system eventually becomes more reasonable when considering the cost of insurance and other traditional safety measures. Additionally, these numbers are nothing compared to the potential cost of an accident.

6.2.4 Broad Market Appeal

Finally, many of the companies examined seemed to suffer with gaining broad market appeal. For some devices, such as Optalert, this actually works to their favor as they can add custom functionality to the product (via the OBD2 port) to specifically target the trucking industry and thus beat out competitors that only offer a generic solution. However, for those companies that offer a generic solution they must frame their product such that industries outside their initial scope are also in the target audience, to increase the customer base. Right now companies like SoberEye and AlertMeter target only the most dangerous of industrial jobs, such as mining, oil rigs, trucking and construction. While these segments of the market will definitely benefit from these products, it would be very beneficial to also market towards segments with less danger, such as chemical and manufacturing plants, electrical, HVAC, and plumbing trades, and even potentially white-collar jobs where stakes and stress are high and a mistake could be very costly.

Chapter 7

Conclusion

In conclusion, several new products and technologies are coming soon which will greatly impact the workplace safety landscape. However, there are many considerations both employers and industry experts will need to make at the intersection of safety, legality, and technology.

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