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An Assessment of the Effects of Medical Marijuana on the Quality of Patient Life

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This Honors thesis entitled

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Kori L. Bullard

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meets the criteria for acceptance
and has been approved by the undersigned readers.

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CARL GOODSON HONORS PROGRAM
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AN ASSESSMENT OF THE EFFECTS OF MEDICAL MARIJUANA ON THE QUALITY OF PATIENT LIFE

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ABSTRACT

An Assessment of the Effects of Medical Marijuana on the Quality of Patient Life

Kori L. Bullard

America is known as the land of opportunity. People attempting to better their lives tend to see America as an opportunity to do so. This statement remains true for the American medical field. Americans are known as advanced in treatment options for various diseases. With this being said, there are few diseases that still bring forth complete fear in the minds of the people of America. In spite of this, "You have been diagnosed with cancer" is a statement that generates this fear. Cancer is one of the leading causes of death worldwide. Current treatments for cancer are invasive, expensive, and disheartening for patients. There is a true need for help in the prevention, diagnosis, and treatment of this horrific disease. The medical world has begun turning its attention to marijuana to help fill this gap between cancer and cure. My interest is not on the politics of marijuana, but rather on the potential to improve patients' quality of life. Through the construction and future application of a medical marijuana questionnaire, a qualitative assessment will be made on the effectiveness of medical marijuana. If quality of life for patients is seen to improve with use of medical marijuana, I would like to advocate for the patients and provide them a voice in the medical marijuana discussion. The null hypothesis to this study is that medical marijuana has no effect on a patients' quality of life. My research with Ewing's sarcoma and current literature review on patients' experiences with marijuana and its related cannabinoids lead me to conclude that the null hypothesis is invalid. I believe medical marijuana has the ability to improve the quality of life of patients to which it's prescribed.

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ACKNOWLEDGEMENTS

I would like to thank the Ouachita Baptist University Carl Goodson Honors Program for the ability to pursue an honors degree while in undergraduate. The benefits have far outweighed the challenges during this pursuit. The memories I have made and the lessons I have learned will help me throughout my future endeavors. Without the honors program, the amazing time I had writing this thesis would not of been made possible. I would like to thank my thesis mentor, Dr. Elizabeth Kelly, for keeping my journey of writing a thesis both possible and thoroughly enjoyable. I would like to thank Dr. Nathan Reyna and Dr. Margarita Pintado for also playing huge roles in the completion of this thesis, without both of your ideas, time in the revision of this paper, and constant motivation I could not have completed this work. I would like to thank the J.D. Patterson Summer Research Program and Dr. Lori Hensley for the opportunity to work in the Hensley Lab the summer of 2017, which ultimately lead to my interest in medical marijuana. I would like to thank my family and friends for motivating me not only through the completion of my honors program experience, but through my whole life and every challenge I have faced along the way. Without these people mentioned and the many more who played a part in my journey, I would not have made it to where I am standing today. Thank you, from the bottom of my heart.

Background

As I spent my first day shadowing at a medical marijuana clinic, the first question I heard from a patient was not "Will this make me feel better?" or even "What are the potential side effects?" The patient's very first question was "Am I going to get arrested?" This question was quickly followed by, "What will my preacher think?" I came to the sad realization that there are many patients who severely need new medication for their diseases, but many of these patients will not explore the world of medical marijuana due to societal judgment. I was in a room with a person who has been battling a chronic disease for many years, who is close to giving up hope due to being on 20-30 prescription pills a day with little to no sign of improvement, and who is too afraid of society to get the help they need. The medicine available to help them is not only frowned upon by many members of the American society, but is also still federally illegal. Why? Pot is for the lazy and the uneducated, isn't it?

The Hippocratic Oath and I

Writing a thesis potentially advocating for the use of medical marijuana, while studying at a private, liberal arts, Christian university might seem to have conflicting interests. To introduce and understand the purpose of this thesis, and why this thesis is just for a Christian to explore, I should first tell you my future personal goals. I am accepted as a medical school student to University of Arkansas for Medical Sciences, where I intend to continue my education and earn my Doctor of Medicine (MD). As a future physician, I intend to advocate for patients for the rest of my life. Hippocrates, often referred to as the "Father of Medicine," is credited as the first person that viewed medicine as a science rather than magic or superstition (Hippocrates, 2017). He believed

that disease was naturally occurring. Hippocrates created the Hippocratic oath, which is known in today's society as a binding commitment between physicians and patients.

Figure 1. The Hippocratic Oath

There are now many different versions of this document. Figure 1 (Miles, 2013) is a traditional version. When I take the Hippocratic Oath, and read off, "I swear to fulfill, to the best of my ability and judgment, this covenant: . . . I will apply, for the benefit of the sick, all measures [that] are required," I have bound myself to the good of my patients, not to the good of myself.

If I have knowledge that could improve the quality of my patients' lives, it becomes my duty as a physician to share this knowledge and fight for my patients' rights to have access to new, advancing medical discoveries. As a Christian, I believe that God created the earth, and He created man to use what is on the earth. God made mankind in His image and gave man the ability to tbink and adapt to our changing world. Marijuana is not the first drug to switch from illegal to legal, or vice versa. Pain-killing drugs called opiates have been used for thousands of years, both medically and recreationally. Opiates

are derived from the opium poppy (Nevius, 2016). Opiate drugs include morphine, codeine, laudanum, and heroin. Beginning in 1620 with the coming of the Mayflower to America, opiates have been used medically. Up until 1905, opiates were legal medically and recreationally in the United States. The severe problem with opiates arose with the increased recreational use. As more people used opiates, more people became dependent on opiates. An opioid epidemic began to take place. People became dependent on the dulled sense of pain, and increased use of opioids to a dangerous level. As their pain-tolerance went up, as did the amount of opioids they took. In 1906, the federal government passed the Pure Food and Drug Act, a law that required addictive drugs to be labeled (Nevius, 2016). Recreational use of opiates slowed, but doctors were still allowed to prescribe opiates when necessary. This medical use left the loophole open for addiction to continue. In this case, history seems to repeat itself. An opioid epidemic is occurring again in American today. Despite humans adapting and opiates being illegal recreationally, synthetic opiates, such as hydrocodone and oxycodone, are still being prescribed to treat pain. Opiates are still being misused and the opioid epidemic is at an all-time high.

Humans adapted and changed laws in the case of opiates, and the same adaptations need to be considered for marijuana. God gives us the knowledge and ability for this adaptation. If medical marijuana proves to be a better treatment option or suppressor of symptoms than the treatments currently available, then I find it my duty as a future physician to share this medical knowledge with all those who may benefit. My status as a Christian ties me to live a life of compassion and care, and administering the best care to my knowledge is following through with that promise. Understanding my

beliefs as both a future physician and as a believer in the compassionate side of Christianity is vital to understanding why I find the topic of this thesis one that needs to be discussed with the people of the world.

Cancer and Current Treatments

Cancer is a collection of more than 200 diseases that are all characterized by abnormal cells in the body uncontrollably dividing. Types of cancer range from the most deadly, such as lung and colon cancer, to the less deadly, such melanoma and thyroid cancer (American Cancer Society, 2018). Many types of cancer result in death not because of the primary tumor, but because of metastasis, spreading to other areas of the body. Tumors that have the ability to spread to other areas of the body are also known as malignant tumors, while those without the ability are known as benign tumors. Different degrees of metastasis are seen in different types of cancer. Cancer arises from many different causes such as environmental factors (sunlight), lifestyle choices (smoking), and genetic variations (mutations) (Doll & Peto, 1981). Cancer is one of the leading causes of death worldwide, responsible for approximately 9 million deaths in 2017. This number is a scary wake up call to many patients and families, and one of the reasons why interest in cancer and its potential treatments has grown greatly in today's society.

Current treatments of cancer are very expensive, ranging in cost from $4,500 to $10,000 per month (Kantarjian, Fojo, Mathisen, & Zwelling, 2013). According to the American Society of Clinical Oncology, new cancer drugs cost an average of $10,000 per month with some therapies maxing out above $30,000 (Glover, 2015). In a report for the President's Cancer Panel, it was stated that approximately 41 percent of Americans will be diagnosed with cancer at some point during their lifetime and about 21 percent of

these people will die from cancer (41 Percent of Americans will get Cancer, 2010). Without treatment options available to patients, this percentage would be even higher. The most common types of cancer therapies are surgery, chemotherapy, radiation therapy, targeted therapy, and immunotherapy.

Surgery is the oldest and most invasive cancer therapy. Surgery is the active removal of cancerous tissue from the body via incision. Due to the very invasive nature of surgery, there are limitations. A physician must be very careful during surgery to avoid taking healthy tissue out when attempting to remove all cancer. For this reason, many patients must undergo multiple surgeries to safely remove all the cancer from the body. Common side effects of surgery are pain, drowsiness, bruising, bleeding, and loss of appetite. In addition, surgery is a very expensive option and often leaves the patient in financial ruin after the long battle through cancer should be over.

According to the American Cancer Society, chemotherapy is the use of chemical substances to treat disease (Mcgee & Benson, 2014). Chemotherapy is determined based on the type of cancer the patient has, the age of the patient, and the over-all health of the patient. Typically, chemotherapy is given intravenously, meaning it is given into a vein. Chemotherapy targets rapidly dividing cells throughout the body. The problem with this is that chemotherapy can also affect healthy, rapidly growing cells in the body such as cells dividing to grow hair. Patients undergoing chemotherapy can experience side effects such as loss of hair, fatigue, nausea, vomiting, and loss or gain of weight.

Radiation therapy, the use of high energy x-rays or other particles to kill cancer cells, kills and damages cancer cells in a confined area, typically the area of the primary tumor. Radiation therapy has fewer side effects than chemotherapy due to the fact that

radiation is administered in a small, targeted area where the cancer was found while chemotherapy cannot be administered in such a way. Patients undergoing radiation therapy have reported that they experience dry mouth, soreness at the site of the radiation therapy, and nausea (Dearnaley, et al., 1999).

Two less common cancer treatment options are targeted therapy and immunotherapy. Targeted therapy is the use of drugs to block the growth and spread of cancer by interfering with specific molecules ("molecular targets") that are involved in the growth, progression, and spread of cancer. Immunotherapy targets cancer through substances that stimulate the immune response. The immune response targets foreign substances and attacks them. Sometimes a person's immune system does not recognize cancer cells are foreign because the cells are normal cells that begin to divide uncontrollably. This flaw is a big limitation in immunotherapy. Some people use one cancer therapy independently, but more often people use a combination of therapies to combat the disease.

A common cancer treatment plan will include undergoing surgery, chemotherapy, and radiation therapy. While undergoing treatment, cancer patients are often very sick and do not have a good quality of life. Throughout treatment patients often feel pain, depression or emotional instability, nausea, anxiety, inability to sleep, and severe loss of appetite. A sad realization is that many of these hindrances continue for a significant amount of time after treatment stops due to chemical substances remaining in the patient's body. Help is needed in preventing, diagnosing, and treating this horrific disease. Current medications are not giving the results and satisfaction that patients deserve.. Medicine has turned its attention to marijuana to be said help. My outlook is

that cancer treatments that utilize the use of medical marijuana will show less of the mentioned side effects and increase the quality of the patients' lives.

Marijuana and its Uses

Is marijuana the same substance as all the slang terms that are used in today's society, such as weed, hemp, pot, or Mary Jane? Cannabis is the common term for drugs produced from plants belonging to the genus, *Cannabis* (Small and Cronquist, p.406). Marijuana is the most well-known name for the plant, but when legal issues arose and the public was trying to keep the buying, selling, and use of marijuana away from public knowledge, many slang terms for the plant came up, including names such as weed, pot, or bud. Many of these slang names are still around today, but essentially they are all talking about the cannabis plant, commonly called marijuana.

Marijuana is a versatile plant with widespread uses ranging from making paper to salad dressing. My focus is on its role as a drug. As a drug, marijuana is used both recreationally and medically. Many people do not understand the difference between recreational marijuana and medical marijuana. Marijuana is composed of 113 known cannabinoids, chemicals responsible for giving marijuana its recreational and medicinal effects. Two of the most commonly known cannabinoids are Δ9-tetrahydrocannabidiol (THC) and cannabidiol (CBD). These compounds interact with receptors in the body and give marijuana properties for recreational and medicinal use. THC is the active, psychotropic component of marijuana, in other words it is the compound that gives users a sense of euphoria. Euphoria is defined by an exaggerated feeling of physical and mental well-being, especially when not justified by external reality (Euphoria, 2003). The state of euphoria is more commonly known as "being high." Marijuana plants can be grown to

contain a higher content of the cannabinoids with the desired effects. Recreational marijuana is typically grown to be high in THC content so users can reach this sense of euphoria. Marijuana's natural THC content is one of the main reasons why it is not widely accepted for medicinal use. CBD does not produce any psychoactive effects, such as euphoria (Burstein, Karst, Schneider, & Zurier, 2004). CBD is recognized for its health benefits, including help with inflammation, pain, anxiety, and seizures. Medical marijuana is typically grown to be high in CBD content and low in THC content so users can get the benefits without feeling the sense of euphoria.

Medical use of marijuana has dated back approximately 5,000 years (Randall and O'Leary, p.29). Patients can smoke from either a joint or a pipe, vape, eat edibles, apply patches, drink as tea, or rub on the medicine as a topical. As medical marijuana is becoming more common, more options to consume it are becoming more available. If marijuana has these named benefits, then why did the legality of marijuana ever become an issue? The answer can be found in the Great Depression of the 1920s and 1930s.

The Great Depression was the worst economic downturn of United States history. There was widespread unemployment, poverty, and hunger that reached way past just the borders of America. The Great Depression was felt around the world. People began looking to place the blame of the downfall of the economy on something. A man by the name of Harry Anslinger placed this blame on marijuana, stating that marijuana was a drug that caused addiction and evil. He stated that the marijuana caused users to become lazy and satisfied with their status, which was reducing the amount of work they were contributing to the economy (Nicholas & Churchill, 2012). Anslinger and the Federal Bureau of Narcotics convinced the U.S. Congress that marijuana needed much tighter

controls, and they received their wishes. In 1937, marijuana became illegal not only recreationally, but also medically (Burnett & Reiman, 2014). This illegal status suddenly meant that patients who were using medical marijuana to treat ailments of many sorts had to turn their attention to other treatments, many of which were much more expensive and invasive.

The long-term effects of marijuana are still being studied, which is another reason why the medicinal use of marijuana is still up for debate. There are two categories of long-term effects of marijuana. The first category deals with the effects of chronic smoking. It is thought that marijuana smoke may cause many of the same effects as cigarette smoke, including, but not limited to, various cancers and an increased risk of heart attack. The second category deals with effects of THC. The dependence on the psychotropic effects of THC is of great concern. A person's dependency on marijuana to remain high may cause substance abuse and could potentially even lead to the use of other, more severe drugs to gain that high. This idea is where marijuana gained the nickname "gateway drug." Marijuana introduces users to the realm of drugs, and when that euphoria is no longer enough satisfaction, users go through the gateway into other drugs to reach that euphoria.

My Interest in Marijuana

In late 2016, I experienced the fear of losing a loved one for the first time. My grandfather suffered symptoms of a heart attack. Two stints were put in his heart in December of 2016. To further the issue, he became ill again in January of 2017 and was diagnosed with cancer of the thyroid. When I first learned of these two health issues, I was unaware how negatively they would impact each other. The heart stints lead to many

complications with the cancer diagnosis and treatments. My grandfather's cardiologist would not allow him to quit taking Plavix, a blood thinning medication designed to prevent blood clots that can create complications with stints, long enough to run cancer screening tests in other areas of his body, such as his prostate. Fear was obviously in my grandfather's mind, as he knew there was potential for undetected cancer to spread to other parts of his body. Debates went on for weeks about what actions needed to be taken for my grandfather, but my grandfather wanted help faster than the doctors seemed able to give him. He researched and took interest in medical marijuana, more specifically in CBD oil. I was aware of my grandfather's interest, but I had never heard of the substance and could not give much input of my opinion. This lack of opinion changed dramatically when I was given the opportunity to conduct independent research through the J.D. Patterson Summer Research Program in the summer of 2017, as an undergraduate at Ouachita Baptist University. How does my personal summer research tie into my grandfather's medical history? When listening to the research options of each lab involved in the summer program, Dr. Lori Hensley mentioned the letters CBD and caught my attention. Her lab studied the effects of cannabinoids on a type of a pediatric cancer called Ewing's sarcoma. I took an immediate interest in this lab, and after speaking with Dr. Hensley more in depth about the details of her studies I found what I wanted to do all summer.

The Hensley Lab

The cancer of interest during my summer research project was Ewing's sarcoma, a highly aggressive pediatric cancer with a 30% five-year survival rate after metastasis (Cotterill, et al., 2000). This survival rate is horrifying for any family who gets this

diagnosis. I worked with a Ewing's sarcoma cell line known as TC-71 cells, which are especially high in metastatic potential. Our lab focused on the potential use of cannabinoids, specifically CBD and ajulemic acid (AJA) as novel treatment options for tumors in the Ewing's family. Data previous to my work in 2017 demonstrated the abilities of cannabinoids to reduce metastatic potential in vitro through decreased migration and invasion of tumor cells, decreased migration of endothelial cells, and decreased angiogenesis in aortic ring assays, but the cellular mechanisms responsible had not been elucidated. The main topic of my research was to elucidate this cellular mechanism of how cannabinoids are working in the body. Specifically, I looked at exosomes, small extracellular vesicles associated with cell-to-cell communication and transferal of molecules between cells, to see if they played a role in the metastatic potential of Ewing's sarcoma.

Exosomes contain cargo consisting of proteins, lipids, and RNA that can be delivered to cells in other locations of the body and can alter their phenotypes. Our hypothesis believed that exosomes were increasing the metastatic potential of cancer. Cancer was using these extracellular vesicles to travel throughout the body. We believed that if we treated exosomes with cannabinoids, we could potentially reduce this metastatic occurrence. Migration and invasion of these cells were assayed through Boyden Chambers.

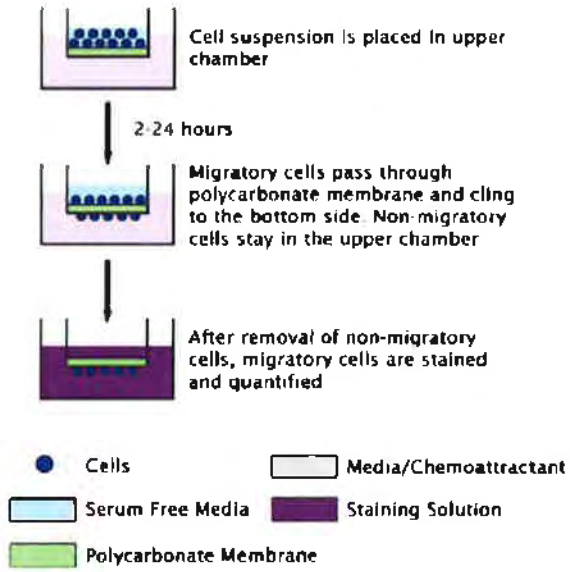

Figure 2. Boyden Chamber Migration Assay to Assess Metastatic Potential.

The exosomes of untreated, CBD-treated, and AJA-treated Ewing's TC71 cells were collected and isolated. These exosomes were then added back to either tumor cells or endothelial cells. The cells were placed in a cell suspension in the upper chamber of a Boyden Chamber. Cells with metastatic potential have the ability to migrate through the polycarbonate membrane into the lower chamber of the assay. We were able to quantify how many cells had this ability to migrate through, therefore allowing us to assess the metastatic potential of cells that were treated with exosomes isolated from untreated TC-71 cells, treated with exosomes isolated from CBD-treated TC-71 cells, and treated with exosomes isolated from AJA-treated TC-71 cells. Our treatment concentration was 32μM. Migration was measured 18 hours post-treatment.

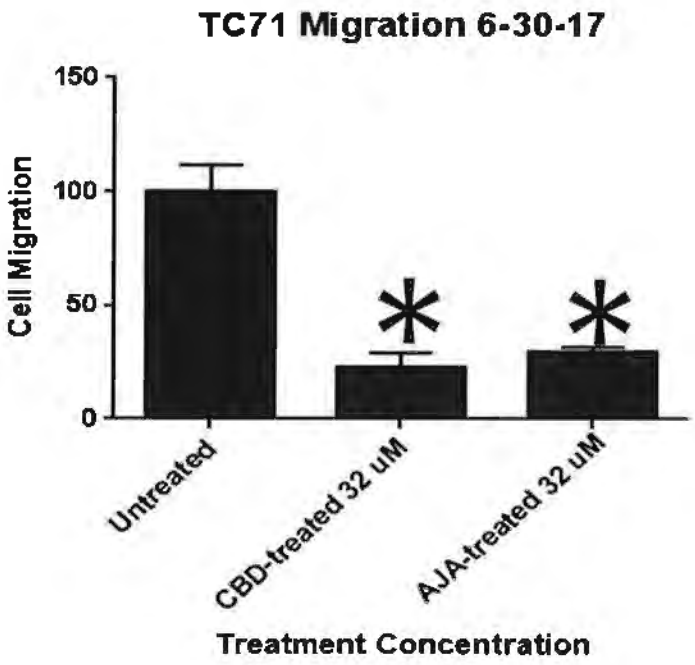

Figure 3. Cannabinoids Decrease Ewing's Sarcoma Cell Migration. (Asterisks indicate a p-value < 0.05)

Figure 3 is a graph of a migration assay I conducted on June 30th, 2017. Treating cells with CBD or AJA before isolation of exosomes reduced the metastatic potential significantly. Recent studies have shown that cannabinoids can increase the quality of patient life, and our conclusions elucidate that this improvement in life may be due to decreased metastasis of cancer (Sarfaraz, Adhami, Syed, Afaq, & Mukhtar, 2008). Seeing a decrease in metastatic potential of such an aggressive cancer filled me with hope, as my interest in CBD was not only to gain knowledge of the current medical topics but also a personal one for my grandfather. Through these findings, my interest in medical marijuana spread to the clinical and patient realm. If I was showing decreased migration and invasion of a very aggressive cancer cell such as Ewing's sarcoma in vitro, does that mean actual patients could be impacted by research such as my own? I became inspired to research patients who have taken medical marijuana as a cancer treatment option and

assess the impact medical marijuana had on their lives. Medical marijuana is a relevant debate in today's society, and the questionnaire developed in this thesis aims to get a patient's perspective on the issue.

Previous Studies

Studies on marijuana and its medicinal benefits have been going on for years. Marijuana use is expanding throughout America and people from all age ranges have begun using the drug. With increased use, in-depth studies of greater quantity are made possible. Previous studies have shown that cannabinoids found in marijuana can be taken as analgesic (painkilling) treatments. Various studies have been conducted to attempt to verify if cannabinoids could be the link to a more pain-free battle of cancer and various other conditions.

In 1971, Dr. Robert Hepler and the University of California in Los Angeles conducted studies on marijuana's effects on patients with glaucoma. One of the problems with glaucoma is that the intraocular pressure in the eye becomes extremely high, which can put pressure on the optic nerve and potentially lead to permanent vision loss. After marijuana was smoked, subjects in the study saw a drop in this intraocular pressure, not only reducing risk of vision loss but also reducing pain. The conclusions of the study were that marijuana is shown to have a favorable (beneficial) impact on glaucoma (Randall and O'Leary, p.29). Many studies on various other conditions have found similar results. It is hopeful that medical marijuana could help patients with an assortment of ailments, not only cancer.

In 2003 and 2004, a study conducted on Australians using marijuana for medical purposes received convincing results. There were 147 adults screened by phone and 128

participants whose data were used to formulate conclusions. Of those 128 participants, marijuana was being used for various conditions, including chronic pain (57%), depression (56%), arthritis (35%), persistent nausea (27%), and weight loss (26%). Respondents were asked to rate the overall effects of marijuana from "I feel a lot worse" to "gives me great relief." The response that cannabis provided "great relief" overall was given in 86% of surveys and the other 14% stated they felt a little relief. Not a single respondent believed that marijuana worsened their conditions. In addition, 62% of respondents claimed they were able to decrease use of other medication when they started using marijuana (Swift, et al., 2005). One issue with this study is the small sample size of respondents. This study has results that are very convincing.

In a study published by the JAMA Network in 2015, 79 trials reaching a total of 6462 participants assessed the use of cannabinoids in treating various conditions in comparison to typical treatments. In this study, nausea and vomiting due to chemotherapy, appetite stimulation in HIV/AIDS infection, chronic pain, spasticity due to multiple sclerosis (MS) or paraplegia, anxiety disorder, sleep disorder, psychosis, and glaucoma were all assessed. The results of the study stated, "Most studies suggested that cannabinoids were associated with improvements in symptoms, but these associations did not reach statistical significance in all studies. Based on the GRADE approach, there was moderate-quality evidence to suggest that cannabinoids may be beneficial for the treatment of chronic neuropathic or cancer pain…and spasticity due to MS…there was low-quality evidence suggesting that cannabinoids were associated with improvements in nausea and vomiting due to chemotherapy…weight gain in HIV…sleep disorders…and Tourette syndrome…and very low-quality evidence for an improvement in anxiety as

assessed by a public speaking test…there was low-quality evidence for no effect on psychosis…and very low-level evidence for no effect on depression" (Whiting, 2015).

All of these studies were conducted on different scales (many participants and few participants) and they all assess different conditions with different symptoms. Despite these differences, the results of the studies all elucidate towards the same conclusion—that cannabinoids show potential to improve patients' quality of life.

Biological Pathway of Marijuana

The three main cannabinoids of my interest are THC, CBD, and AJA. All three compounds, THC, CBD, and AJA, exert similar medical benefits, including decreasing nausea, pain, anxiety, and inability to sleep. The potential medicinal value of CBD and AJA, without the undesired psychoactive effects that THC exerts, was the topic of my summer research. Pharmaceutical companies have turned their attention to these two compounds as potential treatment options. It becomes apparent how these very similar compounds can produce different effects with a little understanding of how our endocannabinoid system works.

There are two types of cannabinoids. The cannabinoids found in marijuana that give it recreational and medicinal value are called exogenous cannabinoids because they are not produced naturally in the body. Examples of these exogenous cannabinoids are THC, CBD, and AJA. The other types of cannabinoids that are naturally produced in our bodies are known as endogenous cannabinoids or endocannabinoids. Marijuana acts in our bodies through the endocannabinoid system, which consists of endocannabinoids and cannabinoid receptors. There are two different types of cannabinoid receptors: CB1 and CB2. CB1 receptors are typically found in the brain and they help to initiate a response to

the THC in marijuana, producing the psychoactive effects. CB2 receptors are found throughout the body and they help to initiate a response causing biological functions, such as medicinal benefits (What Are Cannabinoids, 2017). An example where many of these CB2 receptors are found is in immune cells and in some neurons (Thirumoorthy, p.184). Through either the ingestion of cannabinoids or the interaction of naturally occurring endocannabinoids, CB1 and CB2 receptors become activated in the human body and are responsible for a wide range of functions.

Figure 4 (Making) shows that the structure of THC consists of 21 carbons that form a combination of rings and straight chains. Oxygen molecules are found throughout the structure. Figure 5 (Making) and Figure 6 (National) display a similar structure, which could explain the similar effects these three compounds exert. The structures of CBD and AJA contain 21 and 25 carbons, respectively. Each structure also exhibits carbon rings and straight chains as well as oxygen molecules, similar to the structure of THC.

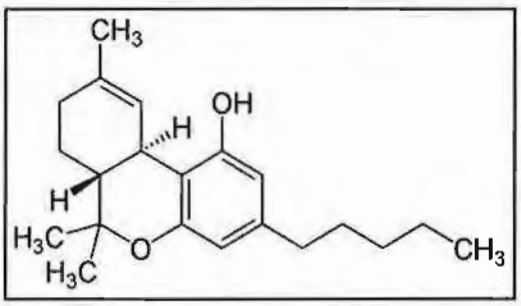

Figure 4. Structure of Δ9-Tetrahydrocannabinol (THC)

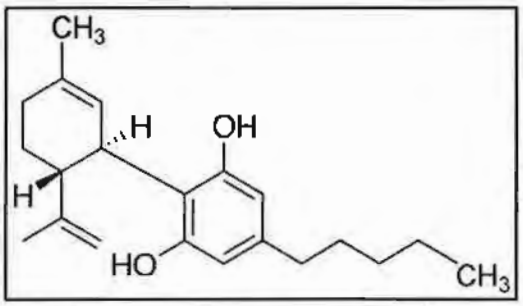

Figure 5. Structure of Cannabidiol (CBD)

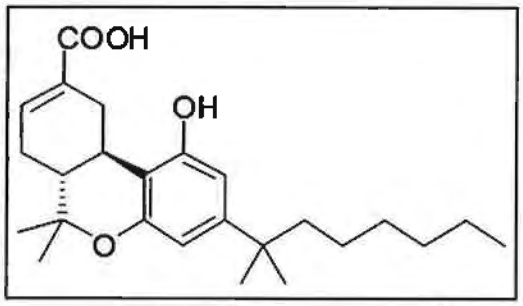

Figure 6. Structure of Ajulemic Acid (AJA)

Cannabinoids interact with cannabinoid receptors in a lock-and-key mechanism (What Are Cannabinoids, 2017). Upon the intake of marijuana or production of natural encocannabinoids, these receptors receive a signal after the compound binds and work to initiate a response. Depending on the receptor and type of compound that binds, the response can affect memory, coordination, and/or sensory functions. This mechanism is extremely sensitive to small details in the structure of a compound. THC, CBD, and AJA have the potential to act on CB2 receptors and produce many of the same medicinal benefits; however, CBD and AJA do not interact with the CB1 receptors of the brain to produce the euphoria associated with recreational marijuana. The small changes in structure allow these differences.

The Intersection of Law and Medicine

Medical marijuana is classified as a Drug Enforcement Administration (DEA) Schedule 1 drug. These drugs are known as the most serious category of illegal drugs that are unauthorized for any production, buying, or selling. Furthermore, along with recreational use being illegal, they are stated to have "no accepted medical use" (Schedule, 2017). In 1972, petitions began when the National Organization for the Reform of Marijuana Laws (NORML) wanted marijuana to be rescheduled from a DEA Schedule 1 drug to a DEA Schedule 2 drug. While a DEA Schedule 1 drug cannot be

used medically, a DEA Schedule 2 drug can be, which would allow physicians to legally prescribe it. Many states have long advocated for the legalization of medical marijuana. Despite current evidence that marijuana may serve medical purposes, it is still listed as a DEA Schedule 1 drug. Even further, cannabidiol, a marijuana extract that does not get a person high, but still shows the same medicinal benefits as marijuana, is also specified as a DEA Schedule 1 drug alongside drugs such as heroin, lysergic acid diethylamide (LSD), and ecstasy.

The Food and Drug Administration (FDA), a federal agency of the United States Department of Health and Human Services, controls the development and approval of new drugs. The FDA has strict guidelines before a new medicine can be approved for use on human patients. The company that wants to legalize a drug must submit a statement showing the drug is safe for both short and long term use. Drug safety is often demonstrated through intense laboratory research and large numbers of clinical trials showing the drugs success. Current scientific studies are investigating the potential use of marijuana or its chemicals as a treatment for various conditions or symptoms, but these studies are ongoing. For this reason, medical marijuana remains illegal nation-wide in America.

While recreational use of marijuana is still not widespread across America, many individual states are fighting for its legalization. Currently, eight states and the District of Columbia have laws legalizing marijuana for recreational use. These states include Alaska, California, Colorado, Maine, Massachusetts, Nevada, Oregon, and Washington. It is often misunderstood what this means, however. People living in these states can still be drug tested at the workplace. Employers still have every right to fire an employee for

using on the job or for failing a drug test, although the latter is becoming less common because it is legal to use marijuana away from the workplace and marijuana stays detectable for days or even weeks after use. Marijuana is still to be consumed with caution in these states. Warnings such as "do not consume and drive" are still in place and enforced by law.

The fight for the legalization of medical marijuana is more widespread. States that have legalized medical marijuana include Arizona, Arkansas, Connecticut, Delaware, Florida, Illinois, Louisiana, Maryland, Michigan, Minnesota, Montana, New Hampshire, New Jersey, New Mexico, New York, North Dakota, Ohio, Oregon, Pennsylvania, Rhode Island, Vermont, Washington, and West Virginia. The medical marijuana legalization in many of these states is a very limited legalization, meaning that there are strict guidelines determined by the state on what conditions make use acceptable. One of the largest issues in the marijuana debate is state rights versus national rights. As it stands today, even in states where use of marijuana is legal, whether recreationally or medicinally, the national government can still arrest anyone growing, selling, buying, or using marijuana. Since marijuana is on the list of the DEA Schedule 1 drugs, physicians who prescribe it can lose their license indefinitely. Even in states where medicinal marijuana is legal, physicians cannot legally prescribe it, instead they may only write letters of recommendation for a patient to obtain the drug from a dispensary. The dispensary is a completely separate business from the physician's clinic.

My Medical Card, Compassionate Care Clinic

Medical marijuana has made recent headlines in Arkansas. In the 2016 election, medical marijuana became legalized with a vote of 53.2% to 46.8% (Arkansas Issue 6 -

Medical Marijuana Amendment - Results: Approved, 2017). There are strict requirements for a medical marijuana card in Arkansas. The Arkansas Department of Health came up with a list of qualifying medical conditions to get a marijuana card, including cancer, glaucoma, immune deficiency syndrome, hepatitis C, amyotrophic lateral sclerosis (ALS), Tourette's syndrome, Crohn's disease, ulcerative colitis, post-traumatic stress disorder (PTSD), severe arthritis, fibromyalgia, Alzheimer's disease, cachexia or wasting syndrome, peripheral neuropathy, intractable pain, severe nausea, seizures, or persistent muscle spasms (Arkansas Department of Health - Medical Marijuana FAQ's). The only way to receive a medical marijuana card in Arkansas is if a physician confirms the patient has at least one of the qualifying conditions. The restrictions are very enforced.

My Medical Card, Compassionate Care Clinic was the first freestanding medical marijuana clinic in Arkansas. The clinic is owned and operated by four physicians, Dr. Randy Hill, M.D., Dr. David Slay, M.D., Dr. Kyle Roper, M.D., and Dr. Greg Whorton, M.D. in Hot Springs, Arkansas. The clinic opened on January 5th, 2018 and had seen 187 patients as of March 10, 2018 when I visited and got to speak with Dr. Kyle Roper, M.D., during a typical day at the marijuana clinic.

Dr. Roper and his team see medical marijuana as a compassionate bridge between hopelessness and hope. Many of their patients, such as the one I got to sit in with a visit on, have been battling chronic, painful diseases for many years. Many of these patients take pill after pill into their body daily and still feel little to no relief. As stated best by Dr. Roper, "There is an opioid epidemic in America today. The use and often abuse of pills is seen very often. There have been many examples where a person is on 15-20 pills a day and with the help of marijuana can reduce this amount to 1-2 pills or even stop use

of pills altogether." Dr. Roper believes marijuana could help to stop the opioid epidemic that is currently occurring in America.

Many patients who visit My Medical Card, Compassionate Card Clinic have already done their research and know they have an Arkansas Department of Health qualifying condition. The patients are asked to bring their medical history to the clinic for the physician to review and confirm. In Arkansas, even patients who are approved for a medical marijuana card are currently still unable to obtain marijuana because Arkansas currently has zero dispensaries open. Dispensaries are expected to open in June or July of this year, 2018.

With the federal government still classifying marijuana as illegal, it is important for clinics such as My Medical Card, Compassionate Care Clinic to separate their clinic from the federal government. This means the clinic cannot accept any type of federal funding, including Medicare, Medicaid, or even private insurances, and must operate on a cash only basis. Also, it is important for clinics to keep their clinic and the actual dispensing of marijuana separate since a physician cannot legally prescribe marijuana. A physician can only confirm you have a qualifying medical condition and are eligible to receive a medical marijuana card. Patients who are approved for a medical marijuana card by the doctors at My Medical Card, Compassionate Care Clinic must sign a medical marijuana disclosure. This disclosure is to protect the doctors and the company from any legal issues that arise due to the use of marijuana (Compassionate Care Clinic | Hot Springs Arkansas, 2017).

Medical Marijuana Disclosure

My doctor has discussed possible addictive nature of medical marijuana, possible adverse reactions including worsening schizophrenia and suicidal thoughts, and possible drug interactions (antidepressants and blood thinners)

I understand that having a medical marijuana card does not make it acceptable to have a positive drug test at work. It is my responsibility to make sure having a
medical marijuana card and using medical marijuana will not interfere with any other responsibilities I have in my daily life.
I understand that I cannot drive a motor vehicle while under the influence of medical marijuana.

I understand that many edible forms of medical marijuana may look like candy. Special care should be taken with all forms of medical marijuana, especially with edible forms. Accidental overdoses have happened, especially with children

In reliance on my statements and medical records, my doctor is certifying that I have a qualifying medical condition for medical marijuana. The benefits of medical marijuana possibly outweigh the risks of its use, and I (the patient) assume any risks that may be associated with the use of medical marijuana.

Printed Name **Patient Signature**

Figure 7. My Medical Card, Compassionate Care Clinic Medical Marijuana Disclosure. This disclosure belongs to My Medical Card, Compassionate Care Clinic. This figure or the statements made on it are not to be duplicated.

I believe clinics such as this one are demonstrating courage and compassion to their community. I only got to see one patient, but the hope in their eyes that this might finally be the answer to their pain and suffering was enough to show me the medical marijuana issue is one that has so much potential. The doctors at My Medical Card, Compassionate Care Clinic are exemplifying to me what true doctors are supposed to portray. The marijuana industry still has many legal issues to work out, but these doctors

were willing to put this aside and serve their community, offering hope and answers to many people of the community.

Introduction to Experiment

Through the combination of reading literature on the medicinal benefits of marijuana, my personal research in the Hensley lab showing decreased metastatic potential of Ewing's cells with use of CBD, and witnessing real patients feeling hope again that their condition or symptoms can be improved through use of medical marijuana, I want to take part in the movement towards answering if medical marijuana is the right answer. I believe marijuana has the potential to be a better treatment option for patients to suppress their symptoms than the options that are currently on the market. I believe the use of medical marijuana could help patients feel less pain, nausea, and anxiety than current treatments. The main goal of this thesis is to create a tool to help confirm whether or not medical marijuana can improve patients' lives. I constructed a questionnaire that will allow a qualitative assessment to be made on the effectiveness of medical marijuana to improve patients' quality of life. Through the future application of a questionnaire, I hope that patients such as the one I witness will get a voice in the legal debate of marijuana.

Null Hypothesis: Medical marijuana has no effect on patients' quality of life.

Alternative Hypothesis: Medical marijuana will improve patients' quality of life.

Materials and Methods

I constructed a survey to measure the success of medical marijuana in suppressing the symptoms of disease and to compare it to the success of chemotherapy and radiation, common current cancer treatments. I wanted to make this specific comparison for many

reasons. Chemotherapy and radiation are very commonly used cancer treatments today, so the identification of patients who use these treatments would be relatively easy. Chemotherapy and radiation are considered to particularly negatively impact quality of life, so I would like to assess the difference medical marijuana seems to make in comparison.

Successful Construction of a Questionnaire

A survey needs to be simple, yet acquire enough information from the respondents' answers to draw conclusions and inferences beyond the data. For the best results of this survey, the sample size needs to be as large as possible. Since this questionnaire is measuring the effect of medical marijuana on the quality of patients' lives, the questionnaire only needs to be given to those who have used or are currently using marijuana for medical reasons. We also intend to find patients who have used both medical marijuana and other cancer treatments such as chemotherapy and radiation in order to compare the differences between the two. Our hope is to contact physicians across various states with legalized medical marijuana use and have patients from each physician fill out the questionnaire. This method will give us a large and diverse sample size to give us the opportunity for the best results.

A questionnaire must be reliable and valid (Boynton, 2004). Reliability is the use of consistent questions to receive consistent answers. I constructed a survey that was consistent with asking scaled questions on how satisfied patients were with their pain suppression, emotional stability, nausea, anxiety, sleep patterns, and appetite. It is important to keep a consistent format to reduce the directions the patients would have to read, therefore reducing possible errors. A lengthy survey with many directions would

cause the patient to be frustrated and could skew their effort in the latter parts of the survey and potentially alter the accuracy of the results. The validity of the survey describes how the answers we obtain correspond with the hypothetical answers. It is important to verify that what you are claiming to measure is what you are actually measuring.

The Marijuana Questionnaire

Patients' lives have to be evaluated before, during, and after treatment with marijuana in order to draw any conclusions that it was marijuana that produced any changes in quality of life. The questionnaire I designed does so. Our questionnaire begins with a statement that is required to gain Institutional Review Board (IRB) approval. An IRB ensures that patient anonymity and confidentiality will be maintained throughout the entire process of collecting data and ensures that a patient is in no risk of being harmed by the design of the questions. The questionnaire is then divided into two sections. The first section begins with demographic questions so we can assess if age, sex, race, ethnicity, or socioeconomic status may influence the opportunity to receive treatment or the quality of treatment received. The questionnaire then asks questions relevant to treatment with medical marijuana. The second section is designated for only the people who have also used chemotherapy and/or radiation, to compare the treatment options. This design will allow us to gather whether or not a patient's quality of life is altered with use of marijuana and whether or not marijuana is a potential better treatment option than chemotherapy and/or radiation.

Marijuana Questionnaire

Thank you for your participation and willingness to complete this questionnaire on medicinal marijuana (also referred to as medical cannabis). Please understand that this survey is for statistical use only, and your participation does not register you for any present or future participation in trials

on medical marijuana. Please complete the questionnaire to the fullest of its extent by marking the appropriate answer for each question or by writing in the correct information. If there is any portion of the survey you wish to leave blank, for any reasons, you may do so. Your answer and identity will remain completely anonymous. If you have any questions about the survey or its purpose, please contact _____ with Ouachita Baptist University at (__)-__-___ or by email at _____@obu.edu.

Date completed: _____

1. What is your age?
___ 18-28 years
___ 29-39 years
___ 40-50 years
___ 51-61 years
___ 62-72 years
___ 73 years or older
___ Prefer not to answer

2. What is your sex?
___ Male
___ Female
___ Prefer not to answer

3. What is your race?
___ Caucasian
___ Black or African American
___ Hispanic
___ American Indian or Alaska Native
___ Other (please briefly describe): _____
___ Prefer not to answer

4. What is your ethnicity?
___ Hispanic, Latino, or Spanish origin
___ Native American
___ Asian or Pacific Islander
___ Other (please briefly describe): _____
___ Prefer not to answer

5. What is the highest level of schooling you have completed? If currently enrolled, please indicate the highest degree you have already received.
___ No schooling completed
___ Preschool to 8th grade
___ Some high school, no diploma received
___ High school graduate, diploma, or equivalent (GED)
___ Some college credit, no degree received
___ Associate degree
___ Bachelor's degree
___ Master's degree
___ Professional degree
___ Doctoral degree

6. What is your current income level?
___ Less than $14,999
___ Between $15,000-$29,999
___ Between $30,000-$44,999
___ Between $45,000-$59,999

___ Between $60,000-$74,999
___ Between $75,000-$89,999
___ $90,000 or more

7. What type(s) of cancer(s) have you been diagnosed with? (please check **all** that apply)
___ Bladder cancer
___ Breast cancer
___ Colon/rectal cancer
___ Endometrial cancer
___ Kidney cancer
___ Leukemia
___ Liver
___ Lung cancer
___ Melanoma
___ Non-Hodgkin Lymphoma
___ Pancreatic cancer
___ Prostate cancer
___ Thyroid cancer
___ Other (please briefly describe): _____

8. What type(s) of marijuana have you used? (please check **all** that apply)
___ Smoked as a cigarette (joint)
___ Smoked through a pipe
___ Used as a vaporizer
___ Eaten
___ Drunk (tea)
___ Other (please briefly describe): _____

9. How often do you (did you) use marijuana?
___ Several times a day
___ 6-7 days a week
___ 3-5 days a week
___ 1-2 days a week
___ 1-2 times a month
___ Very rarely
___ As needed or other (please briefly describe): _____

10. Please indicate which treatment you were MOST satisfied with. (please check **one** only)
___ I have only used one treatment
___ Smoked as a cigarette (joint)
___ Smoked through a pipe
___ Used as a vaporizer
___ Eaten
___ Drunk (tea)
___ Other (please briefly describe): _____

11. Has the dosage of marijuana you have needed to take to suppress your symptoms changed over time?
___ Not applicable, I have only taken marijuana for a short amount of time
___ No, I take the same amount of marijuana now as when I began
___ Yes, I must take more marijuana now to feel the same relief
___ Yes, I must take less marijuana now to feel the same relief

12. Are you still using marijauna for any reason?
___ Yes, for medical reasons

___ Yes, for recreational reasons
___ Yes, both for medical reasons and recreational reasons
___ No

IF NO, please indicate why you stopped usage. (please check **all** that apply)
___ It did not work
___ It stopped working
___ Because it is illegal
___ Because it is too expensive
___ Undesirable side effects
___ Other (please briefly describe): _____

13. After insurance, approximately how much did you spend per month to obtain medical marijuana?
___ Less than $999
___ Between $1,000-$4,999
___ Between $5,000-$9,999
___ Between $10,000-$14,999
___ Between $15,000-$19,999
___ More than $20,000

14. On a scale of 1 to 10, how satisfied were you with the suppression of your PAIN with marijuana used?
(**NOTE**: an answer of 1 indicates **LEAST** satisfaction and an answer of 10 indicates **MOST** satisfaction).

no effect 1 2 3 4 5 6 7 8 9 10

15. On a scale of 1 to 10, how satisfied were you with the suppression of your DEPRESSION/EMOTIONAL INSTABILITY with marijuana used?
(**NOTE**: an answer of 1 indicates **LEAST** satisfaction and an answer of 10 indicates **MOST** satisfaction).

no effect 1 2 3 4 5 6 7 8 9 10

16. On a scale of 1 to 10, how satisfied were you with the suppression of your NAUSEA with marijuana used?
(**NOTE**: an answer of 1 indicates **LEAST** satisfaction and an answer of 10 indicates **MOST** satisfaction).

no effect 1 2 3 4 5 6 7 8 9 10

17. On a scale of 1 to 10, how satisfied were you with the suppression of your ANXIETY with marijuana used?
(**NOTE**: an answer of 1 indicates **LEAST** satisfaction and an answer of 10 indicates **MOST** satisfaction).

no effect 1 2 3 4 5 6 7 8 9 10

18. On a scale of 1 to 10, how satisfied were you with the ability of marijuana to help your SLEEP DEPREVATION.
(**NOTE**: an answer of 1 indicates **LEAST** satisfaction and an answer of 10 indicates **MOST** satisfaction).

no effect 1 2 3 4 5 6 7 8 9 10

19. On a scale of 1 to 10, how satisfied were you with the ability of marijuana to help your LOSS OF APPETITE.
(**NOTE**: an answer of 1 indicates **LEAST** satisfaction and an answer of 10 indicates **MOST** satisfaction).

no effect	1	2	3	4	5	6	7	8	9	10

Please continue this portion of the survey **ONLY** if you have ever underwent chemotherapy and/or radiation treatments.

1. Which treatment did you undergo? (please check ALL that apply)
___ Chemotherapy
___ Radiation

2. After insurance, approximately how much did you spend per month to obtain chemotherapy and/or radiation treatments?
___ Less than $999
___ Between $1,000-$4,999
___ Between $5,000-$9,999
___ Between $10,000-$14,999
___ Between $15,000-$19,999
___ More than $20,000

3. On a scale of 1 to 10, how satisfied were you with the suppression of your PAIN with chemotherapy and/or radiation used?
(**NOTE**: an answer of 1 indicates **LEAST** satisfaction and an answer of 10 indicates **MOST** satisfaction).

no effect	1	2	3	4	5	6	7	8	9	10

4. On a scale of 1 to 10, how satisfied were you with the suppression of your DEPRESSION/EMOTIONAL INSTABILITY with chemotherapy and/or radiation used?
(**NOTE**: an answer of 1 indicates **LEAST** satisfaction and an answer of 10 indicates **MOST** satisfaction).

no effect	1	2	3	4	5	6	7	8	9	10

5. On a scale of 1 to 10, how satisfied were you with the suppression of your NAUSEA with chemotherapy and/or radiation used?
(**NOTE**: an answer of 1 indicates **LEAST** satisfaction and an answer of 10 indicates **MOST** satisfaction).

no effect	1	2	3	4	5	6	7	8	9	10

6. On a scale of 1 to 10, how satisfied were you with the suppression of your ANXIETY with chemotherapy and/or radiation used?
(**NOTE**: an answer of 1 indicates **LEAST** satisfaction and an answer of 10 indicates **MOST** satisfaction).

no effect	1	2	3	4	5	6	7	8	9	10

7. On a scale of 1 to 10, how satisfied were you with the ability of chemotherapy and/or radiation to help your SLEEP DEPREVATION.
(**NOTE:** an answer of 1 indicates **LEAST** satisfaction and an answer of 10 indicates **MOST** satisfaction).

no effect 1 2 3 4 5 6 7 8 9 10

8. On a scale of 1 to 10, how satisfied were you with the ability of chemotherapy and/or radiation to help your LOSS OF APPETITE.
(**NOTE:** an answer of 1 indicates **LEAST** satisfaction and an answer of 10 indicates **MOST** satisfaction).

no effect 1 2 3 4 5 6 7 8 9 10

9. If you had multiple treatments, please indicate which treatment you are overall most satisfied with OVERALL:
___ Chemotherapy and/or radiation
___ Marijuana
___ Other (please briefly describe): _____

THANK YOU sincerely for your time in completing this questionnaire.

Figure 6. Marijuana Questionnaire

Future Application of Questionnaire

Since the debate on medical marijuana is more prevalent than ever before, the current application of this questionnaire is not possible. Approximately 30 physicians were contacted in regards to administering this survey to current patients and each phone call lead to the same conclusion- that the physicians are in a bind and will not allow patients to participate in a survey of sorts. Physicians fear having their name associated with a federally illegal substance and fear the same for their patients. We recognized some real issues with the medical marijuana process. While medical marijuana has been legalized in certain states, it has yet to be legalized nation-wide, meaning that prescribing physicians could still potentially get in trouble with the national government. For their own and their patients' protection, all physicians we contacted told us they would not partake in giving the survey out until legal aspects of the medical marijuana debate become settled.

Our ultimate goal is the future application of this questionnaire. Future application will require an IRB approval at OBU as well as an approval of any participating institution. Part of the IRB process ensures that the identity of physicians, patients, and any other participant in the process of the questionnaire remains anonymous. This is a vital step in the process of any survey given to the public. The next step in actual application of this questionnaire is identification of physicians and patients that are willing to participate in the distribution and answering of the questionnaire. Our hope is to create a pool of respondents to give a variety of answers to the questionnaire, which will help us form conclusions of whether or not medical marijuana can improve patients' quality of life.

Discussion

This questionnaire is relevant to not only cancer patients but also to all tax-paying Americans. Over $100 billion is spent yearly on cancer medicine and roughly an additional $5 billion spent annually on cancer research (Kantarjian, Fojo, Mathisen, & Zwelling, 2013). Cost of treatment is often one of the greatest fears of cancer patients. They fear that they will not only fall into debt that cannot be overcame but also that they will cost their loved ones significant amounts of money. There are potentially less invasive, less painful, and less expensive therapies to suppress the symptoms cancer patients suffer from. The voice of a patient is often overlooked in debates of the legality of a new drug in comparison to the loud voices of pharmaceutical companies who benefit financially from patients taking 15-20 pills a day. Studies and surveys such as this one can create a bridge with quantified proof that medical marijuana does or does not improve the quality of life for patients, whether it is through symptom suppression or

through quality of life such as cost. The voices of patients can become louder if proof is obtained.

While previous studies indicate strong evidence that marijuana can improve patients' quality of life, there are still many questions that have not been answered. Until larger, more in-depth studies are conducted on both the positive and negative effects of marijuana, the debates on whether or not it should become completely legal will continue. Until these debates are settled, I believe it is important to recognize that patients' lives continue every day while legislation decides what action to take. People who could be living pain-free with the help of marijuana are still feeling pain every day. Even in states where recreational use of marijuana remains illegal, legalizing medical marijuana, even in a very limited, defined sense, can show compassionate towards those patients in dire need.

Summary and Conclusions

1. CBD has the ability to reduce the metastatic potential of Ewing's sarcoma cancer cells, in vitro.

2. A potentially less invasive, less painful, and less expensive treatment for cancer can not only significantly improve the quality of life for cancer patients, but also could reduce the expenses that Americans face (through taxes or personal medical bills) due to the current cancer treatment options.

3. Before legalization and widespread use of marijuana as medicine, significant studies and trails need to be done on not only the short-term effects of the treatment, but also the potential long-term effects such as addiction.

Future Aspects of Research

Besides the desired application of this questionnaire and quantification of the responses, there are many other avenues of research to do with the topic of marijuana that I would like to look into. Working in the Hensley lab helped me to appreciate the biology behind the disease. I began some research on exosomes in the summer of 2017. With recent research elucidating that exosomes may enhance the metastasis of cancer, I would like to look into exosomes secreted by cancer cells and see what is being carried inside these vesicles. I would like to isolate exosomes from untreated Ewing's sarcoma cells and sequence the ribonucleic acid (RNA) inside the exosomes. Figuring out what the RNA is coding for could elucidate to the exact role the exosomes are playing in the metastiatic potential of cancer. I would be interested to compare the sequencing of exosomes secreted by untreated Ewing's sarcoma cells to exosomes secreted by CDB or AJA-treated Ewing's sarcoma cells. If treating Ewing's sarcoma cells with cannabinoids before isolating the exosomes has shown to reduce the metastatic potential, then something within the exosomes themselves are being altered. I would like to elucidate what exactly is being altered. Before treatments of cancer can be perfected, the mechanism of the disease must be completely elucidated. I would like to continue this research in an attempt to discover the cellular mechanism that cannabinoids uses to produce desired responses in our bodies.

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