

The Effects of Smoking Cigarettes, Marijuana, and E-Cigarettes on Fertility

Presented to the S. Daniel Abraham Honors Program

in Partial Fulfillment of the

Requirements for Completion of the Program

Stern College for Women

Yeshiva University

April 27, 2020

Leeroun (Lilly) Yaghoubian

Mentor: Professor Amanda Katz, Biology

Smoking, whether it be, cigarettes, marijuana, or e-cigarettes, has become extremely common in American culture. Smoking cigarettes had a large social aspect and contributed largely to social interactions and events. However, after the publication of the Surgeon General's report of the health effects of smoking, there was a big change in attitude regarding how smoking was perceived. Laws were put in place to limit and control smoking in America, especially regarding the youth. As a result, smoking cigarettes successfully decreased in adults and teenagers in America. On the other hand, the usage of marijuana has become less stigmatized and more commonly accepted within the past 15 years. Its legalization has become widespread through America and the use of recreational marijuana is no longer taboo. There are studies that claim that marijuana aids chronic pain management, however, it should not overshadow the reported health effects of marijuana such as changes in mood and impaired body function. Moreover, the use of vaping and e-cigarettes are relatively new and unregulated in America. Since there are no definitive studies that document the long term health effects associated with vaping, it is considered a more acceptable medium of smoking. Many cigarette smokers who are trying to quit divert to using e-cigarettes as a means of decreasing tobacco intake. Although there is no tobacco in e-cigarettes, it does still contain nicotine and other chemical additives that can potentially be harmful to the body as well. There are not as many organizations and laws put in place to limit the amount of vaping since its effects are still partially unknown. All three forms

of smoking. Cigarettes, marijuana, and e-cigarettes have potential negative health effects on the body. The impact of these smoking methods on fertility is an important aspect to research. Although vaping's effect on fertility isn't heavily researched, that should not discount from considering the possible long term effects on the ability to conceive and the viability of the fetus. The social and governmental regulations on smoking cigarettes, marijuana, and e-cigarettes affect the attitude people have their long term health effects.

In the mid 1900's there was a great surge of Americans who smoked. Data shows that smoking at its peak in 1963, Americans smoked 4,345 cigarettes per year, per adult. The release of the 1964 smoking and health report to the Surgeon General changed the attitude toward smoking and resulted in a dramatic decrease in American cigarette users; "Adult prevalence of cigarette smoking fell from 51.9% to 21.% among men and from 33.9% to 16.5% among women" (Burns). In 2020, it was recorded that 14.6% of adults aged between 18 and 44 years were smokers and 16.5% of adults between 45 and 64 were smokers. These statistics are considerably lower than those in 1963. The governmental attitude toward cigarette smoking changed as well, federal taxes increased for cigarettes, workplace restrictions on smoking became more stringent, and smoking started to be seen as a shameful rather than normative act. With the newfound research about the health effects of cigarette smoking, the previous social approval associated with smoking was suddenly being questioned. In 1976, media industries attacked tobacco use and advocated for tobacco control very adamantly. Antismoking messages

received about \$75 million in free airtime between 1967 and 1970, which resulted in an immediate drop in cigarette consumption. Many campaigns were created during this time such as the American Legacy Foundation that advocated for the support of reducing tobacco usage, especially in the youth. Furthermore, these organizations educated the public on the effects of cigarette smoking on lungs, overall health, and the dangers of smoking while pregnant. The Truth Initiative exposed the harmful effects of smoking and successfully decreased teen smoking from 23% in 2000 to less than 5% in 2020 (Burns).

Smoking originated as a social activity and often aided at bonding people together and forging relationships. However, as smoking in public places slowly got banned that forced people to smoke in isolation and thereby changed the social aspect of smoking. This evolution of the public perception of smoking was mainly pushed by the realization that smoking caused great harm to the body and that second hand smoke could be just as dangerous as smoking yourself. This realization convinced a lot of people to stop smoking and stay away from smokers. The government had a big role in controlling the sale of cigarettes and educating the public on its potential deadly health effects. Starting in 1967, legislation was taken by the government such as; Civil Aeronautics Board bans smoking on all commercial airline flights, the Environmental Protection Agency assessed tobacco smoke as a “Group A” carcinogen, tobacco advertisements were removed from line of sight of television cameras in sports stadiums, etc. Furthermore, it is illegal in all states for anyone under the age of 18 to purchase cigarettes. Data shows that in 1991, about 225 million packs of cigarettes were sold illegally to minors. Most importantly, the

Federal Cigarette Labeling and Advertising Act of 1965 required that the warning, “Caution: Cigarette Smoking May Be Hazardous to Your Health” should be printed on the side panels of each cigarette box. However, in 1981, it was deemed that this disclaimer provided very little public knowledge about the dangers of smoking. Congress then enacted the Comprehensive Smoking education Act of 1984, that required four health warnings to be on all cigarette packages: “SURGEON GENERAL'S WARNING: smoking causes lung cancer, heart disease, emphysema, and may complicate pregnancy. QUITTING SMOKING NOW GREATLY REDUCES SERIOUS RISKS TO YOUR HEALTH. SMOKING BY PREGNANT WOMEN MAY RESULT IN FETAL INJURY, PREMATURE BIRTH, AND LOW BIRTH WEIGHT, CIGARETTE SMOKE CONTAINS CARBON MONOXIDE” (*Policy and Legislation*).

Smoking cigarettes causes more than 480,000 deaths each year in the United states. Smoking cigarettes is considered “the leading cause of preventable death in the United states.” Smoking causes 90% of lung cancer deaths and 80% of all deaths from chronic obstructive pulmonary disease. Those who smoke are 2 to 4 times more at risk for coronary heart disease and stroke. Smoking is known to cause cancer almost everywhere in the body such as in the bladder, blood, esophagus, stomach, trachea and lung. Very alarmingly, smoking can affect fertility in men and women. Smoking while pregnant or while trying to conceive can result in birth defects and miscarriage. More specifically, smoking affects fertility in men and women and can lead to birth defects (*Health Effects of Cigarette Smoking*). This data was very instrumental in curbing

smoking rates because it showed people that smoking could harm more than just yourself and can have effects in fetuses.

Smoking, although is not as common as it was in the 1960s is still prevalent in men of reproductive age. Men of reproductive age (20-39 years) make up about 46% of smokers. 8% of couples worldwide experience infertility, and a male factor contributes to 30-35% of all cases (Harlev, et al.). A single cigarette contains 400 chemical compounds, some of which are toxic and carcinogenic. Nicotine, carbon monoxide, tar, arsenic, ammonia and hydrogen cyanide, are the ingredients in cigarettes, which additionally can contribute to heart and lung injury. These substances have a great impact on the human reproductive system (Cooper). Smoking is so harmful to sperm because it increases the presence of reactive oxygen species, resulting in oxidative stress (OS) which has negative effects on sperm parameters: viability, morphology, impairs sperm function. Cigarette smoking has been correlated with increased seminal OS markers as shown by an increase in ROS (reactive oxygen species) levels, and a decrease in total antioxidant capacity. Spermatozoa are particularly prone to damage caused by excessive ROS due to the large amount of polyunsaturated fatty acids in the plasma membrane and the low concentrations of enzymes in their cytoplasm (Harlev, et al.). This is important to acknowledge because damage to sperm can result in trouble conceiving and possible infertility.

Infertility affects more than 15% of people in the world. Half of infertility problems are attributable to a male factor. It is still unclear whether the harmful effects of cigarette smoking on

sperm characteristics and infertility are due to nicotine. A study conducted by Oyeipo, et al., investigates the effects of orally administered nicotine on sperm characteristics and libido in adult male albino rats. This experiment consisted of 45 male rats that were divided into 5 groups and were treated for 30 days with low dose of nicotine and high dose per body weight while the control rats received saline. The fourth and fifth groups were given low dose and high dose as well but were left untreated for 30 days to serve as the recovery groups. A sperm analysis, fertility study, litter weight and size were determined of the rats. The experiment showed that both sperm motility and count significantly decreased and percentage of abnormality increased in both treatment groups. There was a insignificant decrease in the viability and semen volume of the treated groups. The results showed a reduction in libido in male rats, in addition to, a reduction in litter weight and number of rats delivered in the female rats (Oyeyipo, et al). However, parameters affected by oral nicotine were improved following 30 days of cessation, suggesting a component of reversibility to these effects. This study concluded that there is a link between nicotine use and fertility, which can allow us to infer that these are long term effects of e-cigarette use since it contains high levels of nicotine.

An April 2016 study from *European Urology* produced a meta analysis on the effect of smoking cigarettes on semen. It included 20 studies on 5,000 men across Europe. Results showed that smoking was associated with decreased sperm count, decreased sperm motility, and poor sperm morphology. Male smokers were associated with decreased IVF success rates and

miscarriage rates. Furthermore, it was inferred that secondhand smoke can harm the female partner's fertility as well (Gurevich).

Researchers looked at the effect of male smoking on the rate of IVF with ICSI treatment. ICSI treatment is the process of taking sperm and directing it straight into the egg in order to result in successful fertilization. Researchers found that male smoking had an effect on the success of this treatment. Women with partners who didn't smoke had a success rate of 38%. Those who had partners that did smoke, the success rate was 22% (Gurevich).

Smoking is associated with an accumulation of cadmium and lead in seminal plasma, reduced sperm count and motility, and fewer morphologically normal spermatozoa. A study was conducted on adult male mice exposed to tobacco smoke. The result displayed significant increase in sperm DNA mutations and aberrations in sperm chromatin structure in the adult male mice. These DNA mutations can lead to many different cancers and diseases. The International Associated For Research on Cancer has recently declared that men who smoke while trying to conceive have a high risk of having a child that will develop leukemia. This suggests that smoking can induce genetic or epigenetic changes that are transferred to the child. Studies show that children of men who are smokers are at higher risk for, "childhood cancers, asthma, birth defects, congenital heart disease, spina bifida" (Jenkins, et al.). In the experiment conducted by Jenkins, et al., semen samples were collected from patients being evaluated for couple infertility and from men from the general population There was a smoking and non smoking group and

each group consisted of 21 men from the general population and 57 men who were experiencing couple infertility. This study used alkaline single cell gel electrophoresis assay to determine if there was sperm DNA damage. The presence of a visible comet tail determined whether or not the spermatozoa was normal or damaged. The results showed that there was a significant decrease in several semen parameters, “semen volume, total sperm count, total progressively motile sperm count in men who smoked compared to non smokers in addition to an increase in sperm DNA damage in smokers” (Jenkins, et al.).

Ramalu-Hansen, et al. did a cross sectional analysis of 2542 healthy men from 1987-2004 and found that cigarette smokers had lower semen volumes, sperm counts, and percentage of motile sperm compared to men who didn't smoke (Ramalu). A study done by Kunzle et al demonstrated that smoking decreases sperm density by 15.3%, total sperm count by 17.5%, and total motile sperm by 16.6% (Kunzle, et al.). Furthermore, Liu et al., studied 147 Chinese men and researched the association between seminal zinc levels and semen parameters. The authors found that smokers had lower seminal zinc levels than nonsmokers- associated with a decrease in sperm concentration, motility, and morphology, suggesting that zinc concentrations could play a role

It is scientifically proven that women who are exposed to secondhand smoke take longer to get pregnant. Every cigarette smoked increases the risk of miscarriage by one percent. In addition, smoking increases a woman's risk of having an ectopic pregnancy. If men quit

smoking, it doesn't matter how long he has smoked for, as soon as he stops smoking, his sperm will become healthier. Men who quit at least 3 months before conception will have much healthier sperm because it takes about three months for sperm to mature. On the other hand, if women quit, some of the effects of smoking can be reversed within a year of quitting ("Smoking"). A study with 225 women undergoing IVF/ICSI found that women exposed to secondhand smoke had a 12.0% implantation rate compared to unexposed women who had a 25% implantation rate. The pregnancy rate was 20% vs. 48.3% (Neal, et al).

A study named, *The Effects of Smoking on Ovarian Function and Fertility during Assisted Reproduction Cycles* was done on 499 women. Ovarian function characteristics and pregnancy rates were compared among current smokers, past smokers, and non smokers. Current and past smokers were found to have reduced gonadotropin-stimulated ovarian function. Gonadotropins include LH and FSH which are produced by the pituitary gland and stimulate the ovaries to produce a follicle that contains an egg/oocyte. Increased tobacco exposure was associated with decreasing estradiol concentrations, number of retrieved oocytes, and numbers of embryos. Women who smoked during their treatment cycle had a 50% reduction in implantation rate and ongoing pregnancy rate. Women who quit before their treatment cycle had the same pregnancy rate as non smokers, indicating some sort of reversibility (Voorhis, et al).

Furthermore, an experiment tested cigarette smoke extract on ovulation, oocyte morphology, and ovarian gene expression. The mice in the experimental group were given a cigarette smoke extract (CSE) solution orally daily. The control group was given DMSO. It was

found that the CSE group had a reduced diameter of zona pellucida free oocyte and a morphologically misshaped first polar body. Smoking increases the production of reactive oxygen species which can result in DNA fragmentation and irreversible damage of mitochondrial DNA. (Mai, et al). These results teach us that smoking can have a great effect on women's fertility and the damage on mitochondrial DNA can also harm the potential fetus as well.

Less than 15 years ago, marijuana was considered a social taboo and no state in the United States legalized marijuana for recreational purposes. A survey was conducted in 2015 regarding the legalization of marijuana. 53% of people favored its legalization, 59% of democrats favor it as well. Marijuana legalization has been an issue that had the country divided for many years. Republicans and Democrats constantly debated the positive and negative effects that coincide with legalization of marijuana. Despite this, lawmakers are finally finding common ground policy regarding marijuana. More and more states have legalized marijuana for personal use backed by the claims that legalization, "reduces crime, raises tax revenue, lowers criminal justice expenditures, improves public health increases traffic safety, and stimulates the economy" (Dills). Although there are critics that argue that legalization is harmful for public health, nonetheless, it seems that America is slowly moving in the direction of complete legalization of marijuana for recreational use in all 50 states (Dills).

The persistent lobbying for the legalization of marijuana has resulted in 15 states legalizing recreational marijuana use, meaning that more than a quarter of the US population

lives in states that allow for the use of marijuana for non medical purposes. Advocates for the legalization of marijuana argue that its use is effective for cancer patients and those who suffer from chronic pain. Furthermore, medical cannabis has been a source of pain relief and used popularly with disorders such as dementia, MS, parkinson disease, anxiety, depression, cancer etc. (Gundersen et al.) On the other hand, opponents claim that there is no scientific data to prove that marijuana is more helpful than harmful and should not be legalized. Although there are many recorded health benefits of using marijuana, there are also many physical and psychological negative effects. Marijuana is a drug that directly affects the part of the brain that is responsible for memory, learning, attention, decision making, and emotions. Furthermore, 10% of marijuana users will become addicted and may also experience issues with attention, memory, and learning. Marijuana used in youth is even more harmful because it can affect brain development and result in permanent damage. In the area of male fertility, cannabis has been linked to reproductive hormone changes, altered semen parameters, and reduction in libido and sexual performance. Studies have shown that marijuana has been associated with decreased sperm count, morphology, and motility. These effects can impact fertility and the health of the offspring. Marijuana is the most widely used and debated drug in America. Throughout time, the stigma around marijuana and its potential harmful health effects have slowly been diminished. The legalization of marijuana has created a narrative that since it is legal, it is therefore, not harmful to the body. With the legalization of marijuana, also comes with the decriminalization of possession of marijuana which eliminates jail or prison time (Dills).

Marijuana and its legality is a very controversial issue because of marijuana's negative and positive effects on the human body. The active psychoactive ingredient in marijuana is called tetrahydrocannabinol (THC), that affects the endocannabinoid receptors, which results in a wide range of biological effects such as impaired mood, balance, memory and possible hallucinations. The endocannabinoid system is a complex network of receptors throughout our body that help regulate and communicate with the brain, endocrine tissues, and immune system. It plays a large role in controlling hormones and human reproduction in both sexes. Therefore, there are those that draw the conclusion that THC can interrupt the body's reproductive function and have a negative impact on fertility (Ries 2019). Men of reproductive age are the most prevalent users of marijuana, therefore studies of the effects of marijuana on male fertility are increasingly pertinent.

Marijuana has the highest consumption rate among all of the illicit drugs used in the USA and is used increasingly among men of reproductive age. The endocannabinoid system is deeply involved in the complex regulation of male reproduction through the endogenous release of endocannabinoids and binding to cannabinoid receptors. Endocannabinoids are lipids that act on the receptors CB1 and CB2 and therefore mimic some of the biological actions of THC. CB1 receptors are found in the central nervous system and ovaries, uterine endometrium, testis, vas deferens etc. Endocannabinoids that are found in THC can act on both CB1 and CB2 receptors. CB1 receptor activation has been found to not only decrease motility and viability of

spermatozoa but also inhibit the capacitation induced acrosome reaction. CB2 activation caused an increase in the slow and sluggish progressive sperm population. This is significant because cannabis might cause an inappropriate decrease in motility of spermatozoa, resulting in an incompleteness of capacitation in an area of the female reproductive tract prior to meeting the oocyte. This can be a cause of infertility in cannabis users (Plessis, et al.).

A study was done in 2015 among 1,215 healthy young, Danish men between the ages of 18-28. All of the participants delivered a semen sample and of those samples, 45% of them had smoked marijuana within the last 3 months. Those who smoked more than once a week had a 28% lower sperm concentration and a 29% lower total sperm count. Furthermore, the combined use of marijuana more than once a week and other recreational drugs reduced the sperm concentration by 52% and total sperm count by 55%. The study also showed that marijuana smokers had higher levels of testosterone compared to non smokers, also within the same range as cigarette smokers. This data is indicative of the fact that marijuana, although very popular within recreational use, has evidence of decreasing sperm count (Gundersen et al.).

The *Journal of Urology* published a systematic review of the literature found on the effects of marijuana on male fertility and reviewed many different experiments.. One experiment on mature male rats determined the effect of marijuana on sperm count and concentration. The rats were exposed to 16 puffs per day of marijuana for 75 days and a decrease in epididymal

sperm concentration was observed. Moreover, in another experiment, daily administration of cannabis at a rate of 12.5 mg/kg for 30 days in dogs was associated with complete spermatogenesis arrest. There are human studies that show 20 chronic marijuana users who smoked marijuana at least 4 days per week for 6 months had a significantly lower average sperm count than men who smoked 5-9 marijuana cigarettes per week. These studies show the clear harmful effects marijuana has on sperm count and how the amount of marijuana cigarettes used can have different levels of harm.

Regarding morphology, a 1978 study done by Zimmerman et al., treated male mice for 5 consecutive days with injections of THC. Mice treated with THC after 35 days exhibited a higher incidence of abnormal morphology than the control group. In another study, titled, *Effects of Marijuana Inhalation on Spermatogenesis of the Rat*, rats given inhaled marijuana had increased detachment of sperm heads from tails, a clear morphological disorder in the sperm. Despite the morphological changes, research suggests that cannabis does not induce chromosome breakage in sperm. This claim is supported in a study that was done that administered 50 mg/kg THC 5 times a week for 6 weeks in 498 male mice. However, after mating them with females there was no increase in lethal mutations of heritable translocations observed compared to the control group (Payne et al).

Furthermore, an integral part of successful fertilization, includes the capacitation of sperm. Capacitation is the final step of sperm maturation and is necessary to fertilize an oocyte. Research shows that the use of cannabis may be involved in inhibiting sperm capacitation and

activation. (Payne et al.). The usage of marijuana has a wide variety of effects on sperm motility, morphology, and capacitation, which inherently effects the changes of successful fertilization.

On the other hand, it is harder to measure women's fertility because there isn't a direct measure to look at, as opposed to semen count in men. Dr. Felice Gersh, an OBGYN and founder of the Integrative Medical Group in Irvine, California stated, "high amounts of THC can decrease the production of estrogen and without the high estrogen spike, ovulation will not occur." If ovulation does not occur, no egg will be released, and therefore, fertilization cannot take place (Ries 2019). Dr. Elizabeth Hartney claims that the use of marijuana can decrease libido and increase the risk of miscarriage. This is because marijuana is known to cross the placenta and may pose a risk to the fetus. She explains that the effects of marijuana can accumulate and although a young woman who smokes marijuana could not have any impact on her fertility, over time there can be problems and delays for conception (Hartney 2020).

This study conducted by Klonoff-Cohen et al., wanted to examine whether marijuana use effects in vitro fertilization and gamete intrafallopian transfer in addition to infant birth rate. Women smoking more than 90 times in their lifetime had 27% fewer oocytes retrieved and 1 fewer embryo transferred. Women who smoked marijuana more than 10 times in their lifetime had infants 17% smaller at birth. Men who smoked marijuana 11 to 90 times in their lifetime showed a 15% decrease in infant birth weight. Those who smoked marijuana more than 90 times in their lifetime had a 23% decrease in infant birth rate. Women smoking marijuana 1 year

before IVF treatment had 25% fewer oocytes retrieved and couples had 28% fewer oocytes fertilized. The results of this study concluded that the amount of marijuana use decreased the amount of oocyte retrieval, fertilization, and birth weight of the infant (Klonoff-Cohen et al.).

A cross sectional patient survey study was performed between July 2017 and September 2017. This study was done by Jordan et al. as a written survey in hopes of determining the prevalence of cannabis use in a metropolitan Canadian population of patients with infertility. 270 patients from a fertility clinic completed a written survey. The results showed that 13% of respondents disclosed use of cannabis in the past year and 38% had no use in the past year, but have used it in the past. 49% of the participants have never used cannabis. The author of this study commented that he would have thought given the known negative impacts of cannabis on pregnancy, infertility patients would cease cannabis use as a part of their efforts to conceive. He states, “This suggests that people who continue to use cannabis recreationally do not perceive any negative impact on fertility.” By this he means his results showed that people do not find marijuana as possibly affecting fertility and do not stop smoking when trying to conceive. The people that he surveyed do not have a negative perception of marijuana and either choose to completely ignore, or are ignorant of the negative health effects of using marijuana while trying to conceive. This perception results in many couples experiencing infertility without recognizing it might be due to the usage of marijuana (Jordan et al.).

Vaping has become all the rage for teenagers recently. A vape or juul has nicotine in it, which is a stimulant that makes the nervous system prepare the body for physical and mental activity. It causes breathing to become more rapid and shallow, and increases heart rate and blood pressure. Although there are no long term studies developed on the effects of vaping, because it is a relatively new phenomenon, studies have shown that teens and young adults who vape are four times more likely to end up smoking traditional cigarettes. This refers to people who never smoked cigarettes and had no intention of doing so. There are people who rely on vaping as a means to quit smoking cigarettes, however, there is research that shows that vaping is not a safe or reliable way to quit smoking and can actually make it harder to quit smoking. Young people who vape have five times the likelihood of using other tobacco products. The people who vape to help them quit smoking end up becoming “dual users.” Meaning, they are smoking in places and situations where they can do so and vaping in places and situations where smoking is impossible, therefore taking in double the amount of nicotine and other toxic chemicals (“How Vaping Affects Your Teen's Health”).

Despite the decades of encouraging teens to quit smoking, the creation of vaping products such as the JUUL resulted in a rapid increase in nicotine addiction in children. These e-cigarettes are so dangerous because their long term effects are still unknown. The government’s attempt to control the use of e-cigarettes, was to make it illegal to sell e-cigarettes and other electronic nicotine devices to people under the age of 18. Since 2016, the FDA has issued, “more than

8,000 warning letters to retailers...for sales of electronic nicotine devices and their components to minors” (*How FDA Is Regulating E-Cigarettes*). Due to the sharp increase seen in e-cigarette use in teens, the FDA created the Youth Tobacco Prevention plan that has three crucial parts, “preventing youth access to tobacco products, curbing the marketing of tobacco products aimed at youth, and educating teens and their families about the dangers of tobacco use” (*How FDA Is Regulating E-Cigarettes*). The governmental efforts to regulate e-cigarette use in teenagers is just beginning and more stringent laws should be put in place to protect teenagers from harming themselves.

The long term health effects of vaping are still unknown but people report coughing, shortness of breath, headaches, dizziness, and seizures after smoking e-cigarettes. Scientists claim that potential long term side effects of vaping are lung injuries, respiratory problems, reproductive issues, and heart attack or stroke (*E-Cigarettes & JUUL: Serious Vaping Side Effects*).

Since vaping is a new phenomenon, the research on its effects on the human reproductive system is just getting started. Vaping invites harmful and unknown chemicals into the body and bloodstream. Vapes contain nicotine as well as liquid that is heated to create an aerosol and then inhaled. There has been a rise in use of vapes and e-cigarettes in reproductive aged women and men that represents a rising health concern in fertility. A study conducted by scientists at the university of North Carolina at Chapel Hill suggests that using e-cigarettes before conceiving delays implantation of a fertilized embryo in the uterus, thereby delaying and reducing fertility.

Although 25% of women quit smoking when pregnant, many switched to using e-cigarettes instead of tobacco products because they thought it would be less harmful. However, many e-cigarettes refill flavors are cytotoxic to human embryonic stem cells because they are filled with trace levels of formaldehyde, nickel, and lead (“Vaping: What's the Harm?”). By switching to e-cigarettes, a person is reducing tobacco in their system, however the amount of nicotine and toxic chemicals are still being ingested and thereby affecting the body, and fertility.

Researchers at the University College of London studied the issue of vaping and fertility and found that the flavoring found in vapes are the most harmful components and what most directly affect sperm. The study showed that vape juices greatly diminished fertility, specifically, the bubblegum flavor killed off cells in the testicles and the cinnamon flavor juice negatively impacted sperm motility (Mukherjee). Joyce Harper, a professor of reproductive science at the Institute for Women’s Health, University College of London, was studying the impacts of flavoring in vaping as well. Her research team used 30 samples of human sperm and tested two flavors of vape juice: cinnamon and bubblegum. The results showed that the sperm that were incubated with the highest concentration of flavoring moved significantly more slowly than sperm that had not, which indicated that these flavors have a negative effect on sperm motility. In addition, her research team exposed adult male mice to three versions of flavored vape smoke over a 4 week period and found that this causes the animals’ testicles to shrink (Canavan). Most teenagers are drawn to vaping because of the different flavors. Interestingly enough this

attractive feature in vapes can actually be what causes fertility issues in the future. The youth is not being educated properly on side effects of juul use and are being marketed with these flavors so that they purchase them.

Women who are trying to conceive have been using e-cigarettes as a seemingly safer and healthier alternative to cigarettes. Although cigarette smoking while pregnant is linked to fetal development abnormalities, little is known of the effects of using e-cigarettes while pregnant. A study conducted by Wentendorf et al. intended to test whether e-cigarette exposure impacts embryo implantation and offspring health in mice. The results showed that the mice exposed to e-cigarettes exhibited a significant delay in onset of the first litter and impaired embryo implantation. The mice that were exposed to e-cigarettes exhibited disorganized impanation sites with hemorrhagic blood cells. Moreover, this study projected to determine whether there was evidence of reduced fertility in the fetus. The results showed that in utero e-cigarette exposure does not affect female reproductive fitness, however, males exhibited a slight reduction in fertility and in offspring weight and number. The results suggest that, similar to smoking cigarettes while pregnant, e-cigarettes may have similar long term health effects on the offspring. (Wetendorf).

Smoking cigarettes is far more regulated than smoking marijuana and vaping. Knowing this I conducted a survey on 10 men and 10 women between the age range of 22-23 years old, all

single and not actively trying to conceive. We set out to ascertain whether students post adolescence, pre having children age, would quit smoking if trying to conceive and their views towards vaping. The survey was taken in order to gauge whether or not smoking vapes is more popular than marijuana and cigarettes, I asked them a series of 8 questions. To the question, do you smoke cigarettes, 90% of men and 100% of the women answered they do not. However, 60% of men and 30% of women do smoke marijuana at least once a week. Furthermore, 70% of men and 50% of women answered yes, when asked if they vaped at least once a week. When asked which smoking method, cigarettes, vaping or marijuana, was the most harmful 100% of all men and women replied smoking cigarettes. 100% of the men and 30% of the women were unaware that smoking vapes or marijuana can negatively affect fertility. After being informed of some of the ways that marijuana can affect fertility 100% of the men and 80% of the women stated that they would not stop smoking marijuana with that knowledge. Moreover, 100% of men and 80% of women also stated that they would not stop smoking marijuana or vaping when trying to conceive. The results showed that vaping/e-cigarettes was the most popular form of smoking and that despite being informed of its possible effects on fertility, they stated they would continue to use e-cigarettes.

This data is alarming and shows that people that never smoke cigarettes will vape even if they're trying to conceive. Since there is not enough research on how vaping directly affects fertility, people are less exposed to the harmful health effects and therefore don't find it pressing

enough to quit. The lack of public education on this topic makes vaping much more socially acceptable. While socially both vaping and marijuana are more acceptable than ever before, biologically they seem to have an effect that can affect the human race far longer than just getting cancer or other respiratory diseases. If the attitude toward vaping and marijuana does not change, quite like it did with cigarettes, it will become more common in American culture. The rise of smoking marijuana and vapes have an effect on sperm count, motility, and morphology, not to mention its possible effects on a potential fetus. The legalization of marijuana and unregulated and lack of education regarding the use of e-cigarettes can potentially result in a global decrease in fertility. There needs to be more educational programs and laws put in place to warn the youth of the long term effects of smoking in general to preserve and continue the survival of the human race.

Bibliography

Burns, David. "How Far We Have Come in the Last 50 Years in Smoking Attitudes and Actions." *Annals of the American Thoracic Society*, 24 Sept. 2013, www.atsjournals.org/doi/full/10.1513/AnnalsATS.201308-258PS.

Dills, Angela, et al. "The Effect of State Marijuana Legalizations: 2021 Update." *Cato Institute*, 2 Feb. 2021, www.cato.org/policy-analysis/effect-state-marijuana-legalizations-2021-update#history-stat-e-level-marijuana-legalizations.

"E-Cigarettes & JUUL: Serious Vaping Side Effects." *Drugwatch.com*, www.drugwatch.com/e-cigarettes/side-effects/.

Gundersen TD;Jørgensen N;Andersson AM;Bang AK;Nordkap L;Skakkebæk NE;Priskorn L;Juul A;Jensen TK; "Association Between Use of Marijuana and Male Reproductive Hormones and Semen Quality: A Study Among 1,215 Healthy Young Men." *American*

Journal of Epidemiology, U.S. National Library of Medicine, pubmed.ncbi.nlm.nih.gov/26283092/.

Gurevich, Rachel. “The Surprising Truth About Smoking and Male Fertility.” *Verywell Family*, 13 Feb. 2020, www.verywellfamily.com/male-fertility-and-smoking-1960256.

Harlev, Avi, et al. “Smoking and Male Infertility: An Evidence-Based Review.” *Wjmh*. <https://doi.org/10.5534/Wjmh.2015.33.3.143>, 23 Dec. 2015, wjmh.org/DOIx.php?id=10.5534%2Fwjmh.2015.33.3.143.

Hartney, Elizabeth. “Why You Should Quit Smoking Marijuana for Fertility.” *Verywell Mind*, 18 June 2020, www.verywellmind.com/can-marijuana-cause-infertility-22305.

“Health Effects of Cigarette Smoking.” *Centers for Disease Control and Prevention*, Centers for Disease Control and Prevention, 10 Dec. 2020, www.cdc.gov/tobacco/data_statistics/fact_sheets/health_effects/effects_cig_smoking/index.htm.

“How FDA Is Regulating E-Cigarettes.” *U.S. Food and Drug Administration*, FDA, www.fda.gov/news-events/fda-voices/how-fda-regulating-e-cigarettes.

“How Vaping Affects Your Teen's Health.” *Partnership to End Addiction*, 26 Jan. 2021, drugfree.org/article/how-vaping-affects-teens-health/.

Jenkins, T. G., et al. “Cigarette Smoking Significantly Alters Sperm DNA Methylation Patterns.” *Wiley Online Library*, John Wiley & Sons, Ltd, 26 Sept. 2017, onlinelibrary.wiley.com/doi/full/10.1111/andr.12416.

Jordan, T, et al. “The Use of Cannabis and Perceptions of Its Effect on Fertility among Infertility Patients.” *Human Reproduction Open*, Oxford University Press, 13 Feb. 2020, www.ncbi.nlm.nih.gov/pmc/articles/PMC7016357/.

Klonoff-Cohen HS;Natarajan L;Chen. “A Prospective Study of the Effects of Female and Male Marijuana Use on in Vitro Fertilization (IVF) and Gamete Intrafallopian Transfer (GIFT) Outcomes.” *American Journal of Obstetrics and Gynecology*, U.S. National Library of Medicine, 2006, pubmed.ncbi.nlm.nih.gov/16458631/-.

Kunzle R, Mueller MD, Hanggi W, Birkhauser MH, Drescher H, Bersinger NA. Semen quality of male smokers and nonsmokers in infertile couples. *Fertil Steril*. 2003;79(2):287–287. [[PubMed](#)] [[Google Scholar](#)]

Mai, Zixin, et al. “The Effects of Cigarette Smoke Extract on Ovulation, Oocyte Morphology and Ovarian Gene Expression in Mice.” *PloS One*, Public Library of Science, 28 Apr. 2014, www.ncbi.nlm.nih.gov/pmc/articles/PMC4002431/.

Mukherjee, Tanmoy. “The Effects of Smoking and Vaping on Fertility.” *Reproductive Medicine Associates of New York*, 23 Mar. 2020, www.rmany.com/blog/the-effects-of-smoking-and-vaping-on-fertility.

Oyeyipo, Ibukun Peter, et al. “Effects of Nicotine on Sperm Characteristics and Fertility Profile in Adult Male Rats: a Possible Role of Cessation.” *Journal of Reproduction & Infertility*, Avicenna Research Institute, July 2011, www.ncbi.nlm.nih.gov/pmc/articles/PMC3719292/.

Payne, Kelly S, et al. “Cannabis and Male Fertility: A Systematic Review.” *The Journal of Urology*, U.S. National Library of Medicine, Oct. 2019, www.ncbi.nlm.nih.gov/pmc/articles/PMC7385722/.

Plessis, Sefan S. du, et al. *Marijuana, Phytocannabinoids, the Endocannabinoid System, and Male Fertility*, Springer Science + Business Media New York, 16 Aug. 2015, yulib002.mc.yu.edu:2264/openurl?custid=s6086892.

“Policy and Legislation.” *Centers for Disease Control and Prevention*, Centers for Disease Control and Prevention, 18 Feb. 2020, www.cdc.gov/tobacco/data_statistics/by_topic/policy/index.htm.

Ramlau-Hansen CH, Thulstrup AM, Aggerholm AS, Jensen MS, Toft G, Bonde JP. Is smoking a risk factor for decreased semen quality? A cross-sectional analysis. *Hum Reprod*. 2007;22(1):188–188. [[PubMed](#)] [[Google Scholar](#)]

Ries, Julia. “What to Know About Marijuana Use and Fertility.” *Healthline*, Healthline Media, 10 June 2019, www.healthline.com/health-news/5-things-to-know-about-fertility-and-marijuana#4.-Marijuana-use-can-exasperate-preexisting-fertility-issues.

Sarokhani, Mandana, et al. “Association between Cigarette Smoking Behavior and Infertility in Women: a Case-Control Study.” *Biomedical Research and Therapy*, www.bmrat.org/index.php/BMRAT/article/view/376.

“Smoking.” *Your Fertility*, 29 Aug. 2018, www.yourfertility.org.au/everyone/lifestyle/smoking.

Van Voorhis, B J, et al. “The Effects of Smoking on Ovarian Function and Fertility during Assisted Reproduction Cycles.” *Obstetrics and Gynecology*, U.S. National Library of Medicine, Nov. 1996, pubmed.ncbi.nlm.nih.gov/8885914/.

“Vaping: What's the Harm?” *Fertility Answers*, 28 Jan. 2021, www.fertilityanswers.com/vaping-whats-the-harm/.

Wetendorf, Margeaux, et al. “E-Cigarette Exposure Delays Implantation and Causes Reduced Weight Gain in Female Offspring Exposed *In Utero*.” *Journal of the Endocrine*

Society, Endocrine Society, 5 Sept. 2019,
www.ncbi.nlm.nih.gov/pmc/articles/PMC6777403/.

Wong WY, Thomas CM, Merkus HM, Zielhuis GA, Doesburg WH, Steegers-Theunissen RP. Cigarette smoking and the risk of male factor subfertility: minor association between cotinine in seminal plasma and semen morphology. *Fertil Steril.* 2000;74(5):930–930.

“Why Experts Are Worried About the Impact of Vaping on Your Fertility.” *Women's Health,* 18 June 2020,
www.womenshealthmag.com/uk/health/female-health/a30546587/vaping/.