**Nico-teen: Nicotine, Cigarettes, Electronic Nicotine Delivery System and the Body**

**Introduction**

 Tobacco and nicotine products are all around us, all the time. In the United States, 2 out of 25, or approximately 8%, of high school age teenagers reported smoking cigarettes in the last 30 days. Eight years ago, in 2011, that amount was 15.8%, meaning that cigarette smoking could be going out of fashion. **Cigarettes** are slim cylinders of cut, dried leave of the tobacco plant, *Nicotiana tabacum*, enclosed in a thin paper, either with or without a fiber filter. While the amount of teenage cigarette smokers is going down, the number of teens who use electronic nicotine delivery systems is going up. **Electronic nicotine delivery systems**, abbreviated as ENDS, also called vapes or e-cigs, are electronic devices that produce an aerosol containing nicotine that is then inhaled by the user. **Aerosols** are a mist that contains fine particles of solids or liquids suspended in a gas. As of 2018, 1 in 5, or 20%, of high school age teenagers reported using ENDS in the last 30 days. Since 2011, the percentage of teenagers using ENDS has risen by 19.3%. What is driving this change in teenage smoking culture?

**Nicotine: Your Best Frenemy**

 **Nicotine** is a chemical that is found the tobacco plant, most concentrated in the leaves. Traditionally, nicotine had been consumed by smoking the leaves of the tobacco plant, but with advancing technology, it can now be consumed in several ways, including ENDS. People who are attempting to overcome a nicotine addiction may chew nicotine gum or wear a transdermal patch that delivers the substance through the skin.

 Nicotine is a **cholinergic drug**, meaning that it mimics the actions of the neurotransmitter acetylcholine, which is the main method of communication used by the brain. Our brains are full of **neurons**, which are nerve cells that that transmit information from the brain to the rest of the body with electrical impulses and special chemicals, called neurotransmitters. Neurotransmitters are received by receptors, but only certain receptors can receive signals from certain groups of neurotransmitters. Nicotine disrupts this process, because it is so similar to acetylcholine.

 The metabolization of nicotine begins with consuming nicotine. After the nicotine is absorbed, it travels in the blood stream to the brain, where it overstimulates nicotinic receptors. Normally, acetylcholine binds to the nicotinic cholinergic receptors, opens a channel allowing in **cations**, which are positively charged molecules, and then closes the channel to by repelling the acetylcholine molecule, which becomes unbound. The receptor is left in a desensitized state but returns to a state of rest to begin the process again. In the case of nicotine metabolization, the receptor is deactivated for far longer than in normal would be. Then, the excess nicotine activates the dopamine reward system in the brain. **Dopamine** is a neurotransmitter that controls the pleasure response, which the brain uses to reward “good” behavior. This makes the user feel more alert, relaxed and euphoric.

 The effects don’t stop there, unfortunately. Nicotine, in the short term, can cause dizziness, coughing, increased blood pressure and heart rate, increased skin temperature, decreased appetite, nausea, vomiting and abdominal pain, as well as decreased blood flow to the extremities and bad breath. These symptoms are caused by the acute and intense activation of the parasympathetic nervous system (PSNS), which is responsible for conserving energy and regulating basic bodily functions. Despite these unwanted effects, the addiction and dependence to nicotine keeps many nicotine users coming back for more. In essence, the act of consuming nicotine for a dependent user is based in the desire to avoid the withdrawals from lack of use while the ‘high’ eludes them. When the body becomes dependent on a substance, it requires the chemical it is dependent on, to the point where the user will experience **withdrawals**, or unpleasant physical and/or mental symptoms, if they go without. In the same sense that Dopamine is released in response to nicotine when it floods the nicotinic receptors, if the receptors are active when nicotine is unavailable, withdrawals will begin. When nicotine is compared to other substances, such as alcohol, caffeine, heroin or cocaine, it is considered to have the highest addiction potential, meaning that it is the hardest to quit out of the substances listed.

**Cigarette Smoke Versus ENDS Fluid: Which is Worse?**

 Tobacco cigarettes are a very simple design. At their most basic, they are nothing more than a piece of cigarette paper and dried tobacco. Commercially, they are available by the pack or carton, and often feature attractive, eye-catching art to entice consumers. Modern, commercially-sold tobacco cigarettes are generally made of cigarette paper, a fiber filter, tobacco and a variety of additives. Up until the 1950s, tobacco cigarettes were commercially made, and consumed, without a filter. When the relationship between cigarettes and lung cancer was discovered, it only took a decade for filtered cigarettes to become the new norm. The concept behind the filter was to reduce the amount of tar and nicotine entering the body, but despite the introduction of the filter, smoking-related disease is still rampant. **Smoking-related diseases**, abbreviated SRDs, are diseases that are caused or linked to smoking tobacco cigarettes. Some of these diseases include a variety of cancers, various cardiovascular diseases and assorted respiratory diseases.

 ENDS are some of the newest, latest piece of technology for consuming nicotine. With the click of a button, a cloud of flavored nicotine is at the user’s fingertips. There is a common misconception that the aerosol produced is made of water vapor. Since many adolescents and adults believe this to be true, ENDS are frequently perceived as a safer option. The Food and Drug Administration (FDA) has approved mixtures that contain propylene glycol, glycerin, nicotine, and flavoring, and has labeled these items as “Generally Recognized as Safe”. Propylene glycol is a type of antifreeze used in foods, while glycerin, also called glycerol, is a solvent and sweetening agent. A **solvent** is a substance that dissolves other substances, while **antifreeze** is a substance that is added to other substances to keep them from freezing. Often, manufactures of ENDS fluid will create or modify their own fluids, and as a result, ENDS fluid can contain things like heavy metals, ultrafine particles and flavoring agents that have been linked to cancer.

 Commercially-sold tobacco cigarettes and ENDs fluid contain additives, some of which are carcinogenic. **Additives** are substances that are added to in small amounts to either improve or preserve an item or to counteract any undesirable characteristics. Many of these additives, when burned, are carcinogenic. **Carcinogens** are substances that cause **cancer**. Cancer describes diseases in which abnormal cells replicate without control, with the possibility of the cancer cells invading other tissues and organs. Carcinogens are what is responsible for causing mutations in DNA and how it is expressed. **DNA**, or deoxyribonucleic acid, is a molecule that serves as the molecular basis for heredity. DNA is made of three components, which are deoxyribose sugar, phosphate and nitrogenous bases. The order of the nitrogenous bases determines the instructions the DNA codes for. Some carcinogens actively change the DNA, resulting in mutations that cause cancer. Other carcinogens work by manipulating the process of cell division, causing them to replicate quickly and uncontrollably. Human cell division has three ‘checkpoints’ to ensure that abnormal cells don’t proceed to replicate. Somatic cell division begins with the cell growing, replicating its contents and then repairing any mistakes made during the replication process. After correcting any mistakes, it moves into mitosis, where the replicated nucleus is divided. Following this is cytokinesis, which is where the new cell separates from the cell that produced it. The first checkpoint for cell replication occurs when the cell decides it is time to replicate, which is at the end of the G1 Phase. If the cell does not have the resources for cell replication, the cell will either delay passage into cell division or it will become dormant until conditions are more favorable. If the cell has adequate resources, it will begin the process of cell division. The second checkpoint occurs at the beginning of the G2 Phase, to make sure that all replication up until the second checkpoint is correct. If there are errors in replication, the cell will be delayed at this point until the errors are fixed. If the DNA cannot be repaired, the cell will undergo **apoptosis**, or programmed cell death. The last checkpoint occurs during mitosis, and it functions so that the spindle fibers used to separate the copies of genetic material are aligned correctly, producing two identical cells. If there is an issue with spindle fibers, the cell cannot replicate with the necessary fidelity and will undergo apoptosis.

 As previously mentioned, cigarette smoking can cause cardiovascular disease as well as respiratory disease. ENDS fluid is capable of the same, due to the heavy metals and ultra-fine particles that are present in solution. Cigarette smoke causes cardiovascular disease by causing atherosclerosis, which is the hardening of the walls of the blood vessels with a plaque made of cholesterol, fat and calcium. This plaque reduces blood flow, which cause ischemic heart diseases like carotid artery disease, peripheral artery disease and chronic kidney disease. Ultra-fine particles can enter the blood stream due to its small size and contribute to plaque formation. Cigarette smoke causes respiratory disease by damaging the alveoli, or air sacs, in the lungs. The cigarette smoke degrades the alveoli into inefficiency by scarring the tissue and reducing it’s elasticity, eventually causing chronic obstructive pulmonary disease. Heavy metals, when inhaled, can cause the lungs and trachea to become inflamed or fill with fluid.

**Conclusion**

 Nicotine is a highly addictive chemical that keeps users coming back for more, whether they smoke cigarettes or use an ENDS. Nicotine consumption and the mechanism of dependence can be described as a balancing act, where the user attempts to keep withdrawal symptoms at bay while chasing after a ‘high’ that is just beyond their reach. While an addiction develops, health deteriorates with more and more use, making the risk of developing cancer or a cardiovascular or respiratory disease become higher and higher as the user continues to consume nicotine products. Many additives found in cigarettes and ENDS fluid are also carcinogenic, which damages health down to its DNA. ENDS are perceived as less harmful and more socially acceptable, while their risks and benefits are simply different from traditional cigarettes. The best way to avoid developing a disease from nicotine consumption is to avoid using ENDS and cigarettes in general.

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