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Clearing the Smoke on Cannabis

Respiratory Effects of Cannabis Smoking

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This is the fourth in a series of reports that reviews the effects of cannabis use on various aspects of human functioning and development. In this report, the respiratory effects of cannabis smoking are presented. Other reports in this series address the effects of chronic cannabis use on cognitive functioning and mental health, maternal cannabis use during pregnancy and cannabis use and driving.

Background

Cannabis is the most widely used illicit drug in Canada. According to the 2004 Canadian Addiction Survey, nearly 45% of Canadians aged 15 years and older reported using cannabis at least once and 14% reported use in the past year (Adlaf, Begin & Sawka, 2005). The use of cannabis is generally more prevalent among youth, with 39.3% of 15- to 17-year-olds and 69.9% of 18- to 19-year-olds reporting lifetime use. Rates of past-year use increase from 15–17 years of age (29.2%) to 18–19 years of age (47.2%). Approximately 46% of past-year cannabis users in Canada aged 15 and older reported using cannabis two or fewer times during the three months prior to the survey. A sizable percentage of past-year users indicated that they use cannabis more regularly on either a weekly (20.1%) or daily (18.1%) basis.

A growing body of evidence suggests that cannabis use may negatively impact several aspects of people's lives, including mental and physical health, cognitive functioning, ability to drive a motor vehicle, and pre- and postnatal development among offspring. In this report—the fourth in a series reviewing the effects of cannabis use on various aspects of human functioning and development (see Beirness & Porath-Waller, 2009; Porath-Waller, 2009a,b)—the respiratory effects of cannabis smoking are described. Following a review of the evidence, this report concludes by discussing implications for policy and practice.

A Comparison and Contrast between Cannabis and Tobacco Smoke

There is a well established link between tobacco smoke and respiratory ailments, such as chronic obstructive pulmonary disease (COPD—a group of lung diseases that includes emphysema and chronic bronchitis), lung cancer, and lower respiratory tract infections (Tashkin, 2005). As cannabis is most commonly consumed by smoking, researchers have compared the respiratory effects of cannabis smoking to those of tobacco smoking and have documented several similarities. For instance, cannabis smoke contains a mixture of poisons that are qualitatively similar to that found in tobacco smoke (Lange, 2007; Tashkin, 2005). In addition, both cannabis and tobacco smoking have the potential to pass unhealthy levels of aluminum into the body through the lungs, which might contribute to respiratory as well as other health problems (Exley, Begum, Woolley & Bloor, 2006). Research also suggests that the respiratory outcomes of smoking cannabis are as damaging as or worse than those associated with smoking tobacco. In their review of the literature, Taylor and Hall (2003) argued that cannabis should be considered as damaging to the airways as tobacco, as the 'tar content' is comparable for both types of smoke. Others have suggested that cannabis smoking may be even more harmful than tobacco smoking, since the technique for smoking cannabis generally involves unfiltered smoking, larger puffs, deeper inhalation, longer breath holding, and possible accompaniment by the use of the Valsalva manoeuvre[1] to increase absorption of delta-9-tetrahydrocannabinol (THC—the principal psychoactive ingredient in cannabis) (Aldington et al., 2007; Lange, 2007). The inhalation technique used by cannabis smokers causes greater inhalation and retention of combusted particulate matter, resulting in approximately three to five times the level of tar deposition that occurs in the lungs of tobacco cigarette smokers (Taylor & Hall, 2003). Moreover, Aldington and colleagues (2007) reported that one cannabis cigarette had the potential obstructing effects on the lungs equal to that of two to five tobacco cigarettes. That comparison also found that cannabis smoking was linked to lower lung density and greater total lung capacity, associations that were not found with tobacco smoking (Aldington et al., 2007).

> Cannabis is a tobacco-like greenish or brownish material consisting of the dried flowering, fruiting tops and leaves of the cannabis plant, *Cannabis sativa*. Hashish or cannabis resin is the dried brown or black resinous secretion of the flowering tops of the cannabis plant. Cannabis produces euphoria and relaxation, changes in perception, time distortion, deficits in attention span and memory, body tremors, and impaired motor functioning. It is a controlled substance under the *Controlled Drugs and Substances Act*—meaning that the acts of growing, possessing, distributing and/or selling cannabis are illegal.

Respiratory Ailments and Serious Conditions Related to Cannabis Smoking

Regular cannabis smoking can lead to respiratory problems for users that can range from minor irritations and discomfort to serious health threats. Although not all cannabis users will suffer from the most serious conditions, there are common respiratory ailments that affect a relatively large number of users, with some symptoms affecting 40% of the user population (Moore, Augustson, Moser & Budney, 2005). Common self-reported respiratory problems include coughing on most days, wheezing, shortness of breath after exercise, nocturnal chest tightness, chest sounds without a cold, early morning phlegm and mucus, and acute and chronic bronchitis (Moore et al., 2005; Taylor, Poulton, Moffit, Ramankutty & Sears, 2000). These symptoms were associated to cannabis smoking even when gender, age, tobacco smoking, and asthma were controlled (Moore et al., 2005). Taylor and colleagues (2000) reported that respiratory symptoms were significantly more likely for those who were cannabis-dependent and/or tobacco smokers than for non-smokers. Similarly, Moore and colleagues (2005) reported that cannabis smokers were comparable to tobacco smokers for most of the symptoms (Moore et al., 2005). Although the rates of common respiratory ailments of cannabis users were comparable to those of tobacco smokers, cannabis users tended to have shorter smoking histories than tobacco users (Moore et al., 2005). On average, cannabis users were 10 years younger

[1] The Valsalva manoeuvre occurs when a person's breath is held while he or she tightly contracts the muscles of the chest and abdomen, causing pressure in the thoracic cavity to increase.

than tobacco-only smokers (Moore et al., 2005). Similar findings were noted by Taylor et al. (2000) in their sample of 21-year-olds; this group of cannabis smokers showed significant respiratory symptoms despite relatively short smoking histories. It is also worth noting, though, that a majority of cannabis smokers from both Taylor et al. (2000) and Moore et al.'s (2005) studies were also tobacco smokers. If cannabis smoking with a shorter duration of use leads to negative respiratory symptoms at rates that are comparable to tobacco smoking, the large numbers of reported cannabis smokers in North America and around the world could burden health systems based on the costs associated to respiratory problems alone (Moore et al., 2005).

Regular cannabis smoking has also been linked to serious and life-threatening respiratory illnesses. One potential harm is COPD, a progressive lung disease involving damage to the air sacs in the lungs and the narrowing and blocking of the airways. This disease, which is prevalent among nearly 15% of tobacco smokers (Tashkin & Roth, 2006) makes breathing difficult and currently has no cure. While some researchers have found no association between cannabis smoking and an increased risk of COPD (Tashkin & Roth, 2006), others have suggested that COPD may be a serious risk for cannabis smokers (Aldington et al., 2007; Taylor et al., 2000). The synergistic effect of tobacco and marijuana smoking was well described in a population-based study that reported that people who smoked both marijuana and tobacco were almost 2.5 times more likely than non-smokers to have respiratory symptoms and nearly 3 times more likely than non-smokers to have COPD as defined by lung function testing. These effects persisted even after adjustment for potential confounders such as age, sex, asthma and other comorbidities, and comparable tobacco exposure (in pack-years). A self-reported lifetime exposure to marijuana of at least 50 marijuana cigarettes was strongly associated with an increased risk of COPD (Tan et al., 2009).

Another serious respiratory condition that has received attention in the literature is bullous lung disease, which is characterized by the formation of air-filled spaces in the lungs caused by damage to the alveoli (Hii, Tam, Thompson & Naughton, 2008). Research has also found that cannabis smoking increased the risk of lung collapse in otherwise healthy adults (Beshay, Kaiser, Neidhart, Reymond & Schmid, 2007; Gill, 2005). Perhaps most alarming was that this condition appeared in patients who were on average 20 years younger than the average tobacco smoker upon diagnosis of COPD (Hii et al., 2008). Some researchers have suggested that the extra breath holding and Valsalva manoeuvre commonly used by cannabis smokers could be contributing to this condition (Gill, 2005).

Other conditions associated with cannabis smoking include pulmonary fibrosis[2], byssinosis[3], and lung tumours (Phan, Lau & Li, 2005). The state of research on cannabis smoking and respiratory conditions is too limited to provide estimates of the prevalence of these and other serious health threats. However, given the harms known to be associated with tobacco smoking and the existing evidence suggesting that cannabis smokers may demonstrate comparable respiratory symptoms with shorter smoking histories, there is reason to believe that prolonged cannabis use may put users at risk of acquiring serious lung and airway diseases.

Cannabis and the Lung's Immune System Defence

Apart from the respiratory conditions caused by the inhalation of cannabis smoke and combusted materials, risks may be exacerbated by the THC in cannabis smoke. The presence of THC in human airways was found to cause cellular changes, especially to mitochondrial energetics, which are responsible, in part, for the health of cells and their energy production (Sarafian et al., 2006). In effect, the THC from cannabis smoke that enters the lungs and airways increases the risk of adverse pulmonary conditions (Sarafian et al., 2006).

Among those cells affected by THC are the alveolar macrophages, which are a main defence against infections in the lungs. If the immune system is compromised as a result of cannabis smoking, there may be significant

[2] Pulmonary fibrosis is a condition that involves scarring to the lungs, where fibrotic tissue forms in the place of the alveoli, irreversibly limiting the ability to transfer oxygen into the bloodstream.

[3] Byssinosis is caused by the endotoxins of a bacteria, and results in the narrowing of the trachea and destruction of lung tissue. The disease is most commonly associated with exposure to cotton dust in poorly ventilated working conditions.

implications for health care systems around the world (Copeland, Gerber & Swift, 2006). The belief that cannabis smoking may cause deficiencies in the immune system is based, in part, on findings that THC inhibits the ability of T-cells and alveolar macrophages to protect the body from foreign pathogens (Shay et al., 2003; Tashkin & Roth, 2006). A weakened immune response in the lungs predisposes cannabis smokers to affliction by viral, bacterial, or fungal pathogens that would normally pose little threat to a healthy immune system (Shay et al., 2003). Copeland and colleagues (2006) have suggested that high doses of THC may substantially impair immune system functioning.

Lung Cancer and Cannabis Smoking

Cannabis smoke contains many of the same carcinogens that exist in tobacco smoke, making the link between cannabis smoking and lung cancer worth exploring (Tashkin, 2005). Current estimates of annual deaths of Canadians as a result of lung cancer are greater than 20,000 (Canadian Cancer Society, 2008), which underscores the importance for examining the carcinogenic effects of smoking cannabis. The limited research literature is mixed as to whether cannabis smoking is in fact associated with lung cancer. On one hand, the results from several case-control studies provide evidence that cannabis smoking poses a significant risk for the development of lung cancer. Aldington and colleagues (2008) studied a sample of adults (55 years of age or younger) in New Zealand (n = 79 people with lung cancer; n = 324 controls) and reported that the risk of lung cancer increased by 8% for each joint-year of cannabis smoking after adjusting for various confounding variables, including tobacco smoking. These results, however, may be subject to recall bias as the data were not prospectively collected. Similar results were noted by Berthiller and colleagues (2008) in their study of men (n = 430 with lung cancer; n = 778 controls) from Tunisia, Morocco and Algeria. A 2.4-fold increase in the risk of lung cancer was estimated among those men who had ever smoked cannabis, compared to those men who had never smoked cannabis, after adjusting for age, tobacco smoking and other covariates. As this study was hospital-based, the possibility of a selection bias, particularly for the control subjects, cannot be excluded. In another hospital-based case-control study in Tunisia that included 110 lung cancer cases and 110 control subjects, Hsairi et al. (1993) reported an increased risk (8.2-fold) of lung cancer among those who reported ever using cannabis compared to those who never used the drug, after adjusting for age, sex, cigarettes per day, snuff tobacco and water pipe use. The amount of cannabis and tobacco used among these subjects, however, was not known. Moreover, as cannabis is mixed with tobacco in North Africa (Hsairi et al., 1993), the relationship between cannabis smoking and lung cancer could be due solely to tobacco effects.

In contrast, there is some research that has not yielded evidence of an association between cannabis smoking and lung cancer. A large, retrospective cohort study (n = 64,855) conducted in Northern California indicated that current and ever-cannabis use (defined as use of cannabis six or more times over a lifetime) was not associated with an increased risk of cancer overall, tobacco-related cancers (cancers of the upper aerodigestive tract, lung, pancreas, kidney, and bladder), or other cancer sites that were studied, after adjustment for age, race, education, alcohol use, and cigarette smoking (Sidney, Quesenberry, Friedman & Tekawa, 1997). In accounting for these results, several methodological limitations need to be considered. First, the results may be subject to recall bias because the data were not prospectively collected. This cohort may have had a small number of heavy or long-term cannabis users, making it difficult to observe an effect. It is also possible that the cut-off for ever-cannabis use of six or more times per lifetime was too low for cancer risk to be increased. Finally, the relatively young age of the subjects (mean age of 43 years) at follow-up may not have provided an adequate period of time for the development of malignancy. Research by Hashibe and colleagues (2006) in Los Angeles also suggests that cannabis smoking does not increase the risk of lung and upper aerodigestive tract cancers. This study included 1,212 incident cancer cases and 1,040 cancer-free controls who were matched to cases on age, gender and neighbourhood. Although the smoking of cannabis for 30 or more joint-years was positively associated with lung cancer, this relationship was not statistically significant after adjustment for several confounding variables, including cigarette smoking. The authors of this work caution that their subjects' recall of how much cannabis they smoked over their lifetime may be subject to recall bias as this study was not prospective in nature.

Some evidence from cell culture systems and animal models shows that THC and other cannabinoids may inhibit the growth of some tumours by modulating key signalling pathways leading to growth arrest and cell death, as well as by inhibiting tumour angiogenesis (growth) (for reviews, see Bifulco, Laezza, Pisanti & Gazzerro, 2006; Hall, MacDonald & Currow, 2005). It is important to keep in mind, however, that these inhibitory effects have been demonstrated using THC (not cannabis smoke) in preclinical models, and do not necessarily imply that exposure to cannabis smoke can prevent cancer occurrence in humans (Hashibe et al., 2006).

Conclusions and Implications

Recent research suggests that cannabis smoking has the potential to cause considerable harm to the lungs and airways. These harms are evident in the commonly reported symptoms of cannabis smokers, and in the less common, but very serious, respiratory conditions that have been diagnosed by researchers and physicians. The respiratory effects of cannabis smoking can impair breathing, which may negatively affect athletic performance (Saugy et al., 2006) and possibly limit activities of daily living (Moore et al., 2005). Although the evidence is mixed as to whether cannabis smoking is linked with lung cancer, the fact that cannabis smoke contains many of the carcinogens found in tobacco smoke necessitates further research on this topic. THC exposure to the lungs appears to be unhealthy, as it may compromise the immune system defences of the lungs—specifically the ability to defend against foreign pathogens.

Since the majority of respiratory ailments are linked to smoking the drug, some researchers have explored a harm-reduction approach, examining whether vaporizers provide a less harmful way to consume cannabis (Earleywine & Barnwell, 2007). Briefly, a vaporizer is a device that is intended to reduce the inhalation of toxins from the smoking of cannabis by heating cannabis to a temperature high enough to form active cannabinoid vapours, but lower than that needed for combustion. The user inhales the active cannabinoids but not the hazardous materials contained in smoke after combustion. Self-reported measures of respiratory symptoms after using vaporizers to inhale cannabinoids have led researchers to conclude that these devices provide some measure of safety, especially as the amount of cannabis inhaled is increased (Earleywine & Barnwell, 2007). Vaporizers, however, may not protect against any potential negative effects that might be caused by the consumption of active cannabinoids into the lungs or the rest of the body, regardless of the fact that smoke may not be inhaled using such devices.

The dissemination of information on respiratory harms—and indeed all potential harms—linked with cannabis use is intended to convey a clear message that it is not a benign drug but rather one that is associated with a risk of personal harm. The potential for serious harm to lungs, airways, and immune systems of cannabis smokers should be of concern to users and policy makers alike. Just as efforts exist to encourage prevention, reduction, and cessation of tobacco smoking, similar efforts are required to target cannabis smoking, since the respiratory effects are similar to tobacco smoking even with shorter smoking histories (Moore et al., 2005). Continued regular cannabis smoking among youth and young adults has the potential to increase the burden on health care systems, as cannabis smokers in their 20s may become afflicted by respiratory problems that are generally exhibited by tobacco smokers in their 40s and 50s. Moreover, the negative effects of cannabis smoking are compounded when a user also regularly smokes tobacco (Taylor & Hall, 2003). It is important for health care professionals to inform users, whether potential, confirmed, or suspected, of the potential harms associated with smoking cannabis and to develop strategies to promote further awareness and general respiratory health.

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