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What are candidate biobehavioral mechanisms underlying the association between secondhand smoke exposure and mental health?

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Abstract

There is a consistent positive and significant association between secondhand smoke exposure and mental health outcomes in the literature. There are potential genetic and behavioral confounders (e.g., psychological stress, maternal depression, and family functioning) were discussed, as well as potential causal neurobiological pathways (e.g., dopamine system). Further neurobiological research to establish causal pathways is needed as well as the integration of positive observational findings into clinical and public health prevention practices.

Introduction

Secondhand smoke exposure has been associated with a multitude of physical health outcomes ranging from cardiovascular and respiratory events (1-8). It is well established from epidemiological studies that firsthand smokers are at greater risk for poor mental health (9-11), although the exact nature of this association is still not clear. It is possible for depressed persons to smoke and “self-medicate” (9), or it is possible that smoking precedes the onset of poor mental health (11). Alternatively, a shared family history may explain the association (10). Since 1975, there has been some speculation that secondhand smoke exposure may be somehow linked to poor mental health (12), but it was not until recently that a potential association between secondhand smoke exposure and poor mental health has been reported (13-22). The purpose of this paper is to provide candidate *hypotheses* of the biobehavioral mechanisms underlying the association and discuss potential confounds.

Important confounds taken into consideration by the previous epidemiological studies include gender, age, race/ethnicity, socioeconomic status, alcohol consumption, physical activity, prenatal exposure to smoking, and other physical conditions (13-22). Observational studies (13-22) on the association between secondhand smoke exposure and mental health could be confounded by other shared genetic and socioenvironmental factors. For example, mothers exposed to secondhand smoke may pass down genetic risk for poor mental health to their children (passive gene-environment correlation) (23, 24). Passive gene-environment correlation occurs when genetic factors common to both the parent and the children are correlated with measures of the family environment (e.g., psychological stress) (23, 24). Being exposed to secondhand smoke may be a proxy to stressful living and working

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conditions. In fact, in one recent study, it was found that homes that did not allow smoking had persons who had a healthy lifestyle of diet and exercise which in turn was associated with less risk of depression (20). Maternal depression and family environment may also be a potential pathway explaining the association. It is well established in the literature that children of depressed mothers are likely to be depressed themselves (25-27); and a potential mechanism for transmission is family environment (25-27).

We also *hypothesize* that if the association is truly causal, then the neurobiological mechanisms involve neural pathways through the dopamine system. Indeed, there is some evidence suggesting that SHS has an effect on the dopamine system in animals. Bahk, Li, Park, and Kim exposed rats to secondhand smoke; and they found that dopamine D1 and D2 receptors greatly increased in the caudate-putamen, nucleus accumbens, and olfactory tubercle (28). In a study by Li et al., secondhand smoke exposure highly unregulated dopamine transporter mRNA in the ventral tegmental area and substantia nigra in rats (29). In another study by Li et., secondhand smoke exposure changed levels of γ -aminobutyric acid β_2 receptors (GABAB2), and dopamine D1 receptors in the nucleus accumbens and caudate-putamen (30). A study by Naha et al. found that secondhand smoke exposure modulated the localization dopamine D1 and D2 receptors in the caudate-putamen in rats (31). Carr et al. also found that SHS inhibits the reuptake of dopamine (32) and that SHS caused an inhibition of monoamine oxidase A and B in vitro in mice (33). Last, Fa et al. found that 1.0 mg of SHS caused activation of mesolimbic dopamine neurons in rats (34). Although SHS may have an acute effect on the dopamine system, there has been no research on the effects of long-term exposure on the dopamine system. We *hypothesize* that perhaps, as with firsthand smoking (35), long-term exposure exposure may lead to a decrease in dopamine receptor availability. We also *hypothesize* that other pathways through serotonin, noradrenaline, and glutamate may be involved, although there is no current extant evidence of this *hypothesis*.

Future Directions

Controlled animal studies with secondhand smoke exposure and behavioral outcomes, such as the forced swimming test, are warranted. Similar neurodevelopmental studies on the effect of secondhand smoke exposure on the development of animal brains can be conducted. For example, animals could be exposed to secondhand smoke in a cage and subsequent longitudinal measures of neurotransmitter or neural system functioning can be done with functional magnetic resonance imaging (fMRI) and positron emission topography scans (PET).

Studies in humans can also use fMRI and PET scanning techniques; however, exposure to secondhand smoke in a controlled setting is difficult because of ethical reasons. Thus, it is preferable to sample non-smoking participants who work occupations where there are high levels of secondhand smoke exposure, such as waiters or bartenders (36). Sampling these persons can also be complemented by careful measures of salivary or serum cotinine. Longitudinal observational studies are also warranted to disentangle the direct and indirect effects of secondhand smoke exposure on mental health and also identify potential confounders.

In the United States, smoking bans are implemented depending on the area of residence at the state and metropolitan area level. For example, states such as California have banned smoking in all enclosed public areas such as schools, restaurants and bars; and newer bans are implementing bans in open areas in public places such as parks. To date there have been no studies examining the effects of smoking bans on mental health. In order to do these types of analysis, assessment of poor mental health needs to be done before and after

smoking bans have been implemented. These studies can assess how long a potential reduction in poor mental health systems is maintained. Further, comparison of community areas with stricter smoking bans to areas with less strict smoking bans can be done. These comparisons can be complemented with spatial or geographical analyses.

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