Addictive Behaviors 39 (2014) 1418–1429

Contents lists available at ScienceDirect

Addictive Behaviors

How robust is the association between smoking and depression in adults? A meta-analysis using linear mixed-effects models☆,☆☆

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HIGHLIGHTS

- Eighty-five studies investigating adult smoking and depression were reviewed.
- Few studies reported background information like smoking levels or abstinence length.
- Current smokers were more likely to be depressed than former or never smokers.
- Current smokers had greater odds of incident depression at follow-up.
- Smoking was associated with depression across a variety of moderators.

ARTICLE INFO

Available online 28 May 2014

Keywords:
Smoking
Depression
Meta-analysis
Measurement

ABSTRACT

Introduction: Our objective was to use meta-analytic techniques to assess the strength of the overall relationship and role of potential moderators in the association between smoking and depression in adults.
Methods: Two popular health and social science databases (PubMed and PsycINFO) were systematically searched to identify studies which examined the association between adult smoking behavior and major depressive disorder (MDD) or depressive symptoms. A total of 85 relevant studies were selected for inclusion. Studies were analyzed using a linear mixed effects modeling package ("lme4" for R) and the Comprehensive Meta-Analysis program version 2.
Results: Multiple nested linear mixed-effects models were compared. The best fitting models were those that included only random study effects and smoking status. In cross-sectional studies, current smokers were more likely to be depressed than never smokers ($OR = 1.50$, $CI = 1.39–1.60$), and current smokers were more likely to be depressed than former smokers ($OR = 1.76$, $CI = 1.48–2.09$). The few available prospective studies, that used the requisite statistical adjustments, also showed smokers at baseline had greater odds of incident depression at follow-up than never smokers ($OR = 1.62$, $CI = 1.10–2.40$).
Conclusions: In cross-sectional studies, smoking was associated with a nearly two-fold increased risk of depression relative to both never smokers and former smokers. In the smaller set of prospective studies, the odds of subsequent depression were also higher for current than never smokers. Attesting to its robustness, the relationship between smoking and depression was exhibited across several moderators. Findings could help health care providers to more effectively anticipate co-occurring health issues of their patients. Several methodological recommendations for future research are offered.

Published by Elsevier Ltd.

☆ The opinions and assertions herein are those of the authors and do not necessarily represent those of the National Cancer Institute, the Department of Veterans Affairs or the United States Government.

☆☆ Financial Statement: The work reported in this manuscript was not supported by any internal or external funding.

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http://dx.doi.org/10.1016/j.addbeh.2014.05.011
0306-4603/Published by Elsevier Ltd.

Contents

1. Introduction

An association between depression and smoking, two important public health problems, has been documented in many cross-sectional studies of adults. Recent estimates suggest that 30% of patients with major depressive disorder are current smokers, and smokers with a history of depression are twice as likely to be nicotine dependent as those without a depression history (Ziedonis et al., 2008). Nevertheless, the magnitude and consistency of the smoking-depression relationship is not well-characterized in adults. Some reviews claim that current or past depression increases the probability of smoking two-fold (e.g., Mendelsohn, 2012); others refer to "robust" or "well-established" associations, but without any quantitative indices of magnitude or variability (e.g., Halperin, Smith, Heiligenstein, Brown, & Fleming, 2010; Morrell & Cohen, 2006; Wadsworth, Moss, Simpson, & Smith, 2004). The relationship is better characterized in adolescents (e.g., Audrain-McGovern, Rodriguez, & Kassel, 2009; Wang, Fitzhugh, Turner, Fu, & Westerfield, 1996). In a meta-analysis of longitudinal studies of adolescent smoking, Chaiton, Cohen, O'Loughlin, and Rehm (2009) found a risk of 1.71 for smoking and subsequent depression and a risk of 1.41 between depression and future smoking. The empirical interest in adolescence is understandable as smoking tends to begin during that time (USDHHS, 2012), yet a focus on adolescence presents an incomplete picture. Adolescent quitting is relatively infrequent so depression levels of former smokers cannot be established – making case-control investigations unfeasible. Optimally, a systematic review would provide quantitative indices of risk of depression in former smokers, current smokers and non-smokers, something that is afforded by an analysis in adults.

Beyond estimating the magnitude of the overall association between depression and smoking, it is important to assess whether the risk varies with demographic and measurement moderators. For example, the association, on occasion, has been reported to be stronger in women than in men (e.g., Frederick, Frerichs, & Clark, 1988; Son, Markovitz, Winders, & Smith, 1997). Self-reports of depressive symptoms constitute the measure of depression in some studies, while others used validated clinical interviews. The degree to which the magnitude of the association varies according to measurement is unknown, and in neither case has a systematic review been conducted to assess whether these or other moderators significantly affect the size of the association. The present quantitative review used a state-of-the-art meta-analytic approach (based on linear mixed-effects models) to establish the overall magnitude and variability of the cross-sectional association between depression and smoking in adults and to assess whether moderator variables (e.g., sample characteristics like gender or measurement variables such as method of assessing depression) significantly affect the size of the association.

A linear mixed-effects model meta-analytic approach was adopted to address a complication often ignored in conventional meta-analyses. Studies in this area vary widely in types of measures and the variables that serve as covariates (such as age or ethnicity). Biases in estimation can occur when studies using different covariates are aggregated meta-analytically. Fortunately, linear mixed-effects models allow each potential moderator to be tested simultaneously for its independent contribution to the overall effect.

An additional goal was to assess the directionality and magnitude of the longitudinal relationship between smoking and depression in adults. However, because there is a relatively small set of prospective studies and/or their designs or measurement often are not optimal to draw causal inferences, a more conventional meta-analytic approach was used to address the third aim. In fact, a close examination of the available adult literature indicated that only an assessment of the longitudinal association between baseline smoking and the risks of subsequent depression could be conducted, as too few studies on the association between baseline depression and subsequent smoking status using adult samples were available.

In sum, the aims of our review were:

Research Aim 1: To examine the overall magnitude of the association between smoking and depression using linear mixed-effects models meta-analytic techniques.

Research Aim 2: To investigate how moderators influence the magnitude of the association between smoking and depression.

Research Aim 3: To examine the magnitude of the prospective association between smoking and depression.

2. Methods

2.1. Selection process and inclusion criteria

We systematically searched the health and social science databases PubMed and PsycINFO for studies published from the earliest catalogued date in the database through December 2012 that examined the association between smoking behavior and major depressive disorder (MDD) or depressive symptoms. The terms for smoking used in the search were as follows: *smoking*, *cigarettes*, and *tobacco* while the terms for depression were: *depression*, *major depressive disorder*, *depressive symptoms*, and *mood*. Each smoking term was paired with each depression term for at least one search, ensuring that the maximum number of studies was