



## A systematic review of the Diagnostic and Statistical Manual diagnostic criteria for nicotine dependence

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### ABSTRACT

The Diagnostic and Statistical Manual diagnostic criteria for nicotine dependence (DSM-ND) are based on the proposition that dependence is a syndrome that can be diagnosed only when a minimum of 3 of the 7 proscribed features are present. The DSM-ND criteria are an accepted research measure, but the validity of these criteria has not been subjected to a systematic evaluation.

To systematically review evidence of validity and reliability for the DSM-ND criteria, a literature search was conducted of 16 national and international databases. Each article with original data was independently reviewed by two or more reviewers.

In total, 380 potentially relevant articles were examined and 169 were reviewed in depth. The DSM-ND criteria have seen wide use in research settings, but sensitivity and specificity are well below the accepted standards for clinical applications. Predictive validity is generally poor. The 7 DSM-ND criteria are regarded as having face validity, but no data support a 3-symptom ND diagnostic threshold, or a 4-symptom withdrawal syndrome threshold. The DSM incorrectly states that daily smoking is a prerequisite for withdrawal symptoms. The DSM shows poor to modest concurrence with all other measures of nicotine dependence, smoking behaviors and biological measures of tobacco use.

The data support the DSM-ND criteria as a valid measure of nicotine dependence severity for research applications. However, the data do not support the central premise of a 3-symptom diagnostic threshold, and no data establish that the DSM-ND criteria provide an accurate diagnosis of nicotine dependence.

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## 1. Introduction

In 1980 the American Psychiatric Association (APA) proposed a diagnostic criteria for nicotine dependence (DSM-ND) in the 3rd edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM). (American Psychiatric Association, 1980b) These were developed based on the DSM criteria for alcoholism with only minor modifications, (Cottler, Helzer, Mager, Spitznagel, & Compton, 1991) reflecting a theory that all substance use disorders can be diagnosed using a single set of “generic” criteria (Benowitz, 1999; Cottler, 1993; Hughes, Oliveto et al., 2004; Woody, Cottler, & Cacciola, 1993). The DSM-ND criteria were changed in 1987, again in 1994, and are currently under review for another revision in DSM-V (American Psychiatric Association, 1987, 1994). The DSM is a nosology, i.e., a theoretical systematic classification of diseases, one of the many proposed for mental disorders over the years (World Health Organization, 1992). According to those involved, “DSM-III and III-R were developed by committee, without a systematic effort to collect reliability, validity and other comparative data.” (Cottler et al., 1991).

The DSM uses a “syndromal” approach to the diagnosis of nicotine dependence in which “the essential feature of this disorder is a cluster of cognitive, behavioral, and physiologic symptoms that indicate that the person has impaired control of psychoactive substance use and continues use of the substance despite adverse consequences.” (American Psychiatric Association, 1987). When the DSM-ND criteria were last revised in 1994, research had not yet identified the pathophysiology of nicotine dependence, and the generic alcoholism criteria were retained for nicotine dependence. The first published case series recently revealed that nicotine dependence is characterized by a compulsion to use tobacco that recurs with a predictable periodicity after each cigarette (DiFranza, Ursprung, & Carlson, 2010). The symptoms of this compulsion are wanting, craving or needing to smoke. Instruments that measure this compulsion predict the clinical course of nicotine dependence with 98% sensitivity and 98% specificity (DiFranza et al., 2007; DiFranza et al., 2002). It has been proposed that the recurrent compulsion to use tobacco is pathognomonic for nicotine dependence, and on this basis it has been proposed that the identification of this symptom is all that is required to make a diagnosis (DiFranza et al., 2010). Reliance on a single diagnostic criterion conflicts with the DSM approach which requires a minimum of 3 diagnostic criteria.

Given this controversy, we undertook the first systematic review of the DSM-ND criteria to examine the evidence that they accurately diagnose nicotine dependence. Accordingly, we have applied to the DSM-ND criteria the same critical evaluation that is applicable to all measures of nicotine dependence (Colby, S., Tiffany, Shiffman, & Niarua, 2000). We examined properties relevant to clinical diagnosis, such as sensitivity, specificity, accuracy and predictive validity. As there is concern that DSM-ND criteria may under-diagnose dependence in blacks, (Strong, Kahler, Ramsey, & Brown, 2003) we also examined the evidence relevant to this concern. In relation to research applications we considered theoretical foundation, face validity, factor structure, internal reliability, test–retest reliability, concurrent validity, and concordance among the three editions of DSM (III, III-R, and IV) and between these and other measures of dependence such as the Fagerström Tolerance Questionnaire (FTQ) and the International Classification of Diseases (ICD).

## 2. Materials and methods

A systematic search of the literature was conducted for articles published between 1980 and October 2008 that mentioned the DSM-III, DSM-III-R, or DSM-IV ND criteria. Databases searched included: Index Medicus, Medline, the Educational Resources Information Center (ERIC), the Cochrane Library, the American Psychological Association's PsychInfo/PsychLIT Database, Indmed, Koreamed, the World Health Organization Library Information System (WHOLIS), the World Health Organization's Network of Health Science Libraries across Asia (HELLIS), Latin American and Caribbean Health Sciences (LILACS), the Pan American Health Organization's Head Quarters' Library Catalog (PAHO), Caribbean Health Sciences Literature Database (MEDCARIB), Disaster Documentation Center Collection (DESASTRES), Latin American and Caribbean History of Public Health (HISA), Database of the Regional Program on Bioethics PAHO/WHO (BIOETHICS), and the Association for Health Information and Libraries in Africa (AHILA). Search terms included every combination of the following: addiction, Diagnostic and Statistical Manual, DSM, cigarettes, dependence, nicotine, smoking and tobacco. Retrieved articles were reviewed for relevant citations. An appeal for citations was posted on the Society for Research on Nicotine and Tobacco Listserv.

We considered all English language articles that could be retrieved online, through interlibrary loan, or by contacting the authors. As we

wished to consider all potentially contributory information, we did not set *a priori* exclusionary criteria. Potentially relevant articles were retrieved and reviewed by the first author. Articles that mentioned DSM but provided no original data were read by a single reviewer. All others were reviewed by at least two of the 13 reviewers.

As the DSM is intended for use in both clinical and research settings, the panel of reviewers comprised individuals with doctorate degrees and expertise in epidemiology, nursing, primary care, psychiatry, psychology, public health, pulmonary medicine, rehabilitation counseling, statistics, and substance abuse treatment. Article assignments exploited the reviewer's expertise.

The DSM criteria are premised on a number of assumptions about the nature of nicotine dependence (e.g., that it has a dichotomous structure with a 3-symptom threshold such that people with only two symptoms are not dependent). A major objective of our review was to determine if the evidence supports those assumptions. Using a structured data extraction tool, the reviewers examined each article for evidence addressing each of the following topic questions. (1) Are the DSM-ND criteria based on a stated theory? (2) Does each DSM criterion have face validity as an indicator of dependence? (3) Were the validity and reliability of the DSM-III, DSM-III-R or DSM-IV criteria established prior to their publication? (4) Does evidence confirm that smokers are not dependent until they have 3 symptoms as detailed in DSM? (5) Has it been established that symptoms must be clustered within 12 months? (6) Has it been established that a person must have 4 symptoms to have nicotine withdrawal? (7) Has it been established that a person must smoke daily to experience withdrawal? (8) Has it been established that withdrawal symptoms always appear in the first 24h of abstinence? (9) Are different DSM instruments equivalent? (10) Do the DSM-ND criteria diagnose the same tobacco users as other measures of dependence? (11) Do instruments that are faithful to the DSM-ND criteria demonstrate good internal reliability, good test–retest reliability, and good concurrence with one another? (12) Do the DSM-ND criteria have acceptable sensitivity for use in clinical settings? (13) Are the DSM-ND criteria a good predictor of clinical outcomes? (14) Have the DSM-ND criteria found a useful role in the clinical setting? (15) Do the DSM-ND criteria have concurrent validity as demonstrated by good correlations with other indices such as nicotine intake, smoking frequency, duration of use, and time to first morning cigarette? (16) Do the DSM-ND criteria result in differential rates of diagnosis across races?

Each article was presented using a structured format and discussed in a conference call between the two primary reviewers with one or more additional reviewers in attendance to resolve disagreements between primary reviewers. Discussion continued until a consensus was reached. A table was constructed to organize the data from all relevant publications for each topic question. The data in each topic table was inspected to determine if meta-analysis or statistical summarization were possible. There were no two articles with sufficiently similar methods to allow for any such analyses. Therefore, a narrative summary was prepared and circulated among the reviewers using the Delphi process to reach a consensus.

### 3. Results

#### 3.1. Overview

A total of 2102 hits were returned on the literature search, resulting in the identification of 398 articles of initial interest. Closer examination of the content narrowed the field to 380 articles of likely interest. Twenty-one articles had no English translation. The remaining articles were reviewed by the first author, with the result that 169 articles were found to have potential relevance to our review and were assigned for data extraction by two reviewers. Additionally, the first author reviewed a number of articles that discussed the DSM substance abuse criteria but made no mention of nicotine dependence and were therefore not extracted. Single datasets often gave rise to multiple publications and

some publications concerned more than one version of DSM. About 20 articles concerned DSM-III, 50 the DSM-III-R, and 100 the DSM-IV. The measures used in 41 of the 169 articles modified the DSM criteria to such a degree (by adding or deleting criteria) that we could not justify using their data in this assessment (Etter & Hughes, 2006; Kandel, Huang, & Davies, 2001; Kawakami, Takatsuka, Inaba, & Shimizu, 1999; Piper et al., 2008). To avoid selective presentation of the data we have cited all relevant studies under each of the following sections.

#### 3.2. Indicators of interest for research applications

##### 3.2.1. Was the validity of each edition of the DSM-ND criteria established prior to its publication?

The historical record shows that the purpose of DSM was to increase diagnostic reliability by increasing inter-rater agreement (Cottler & Helzer, 1989; Spiegel, 2005). Although DSM measures were evaluated for retest reliability and agreement with previous editions of DSM, we could find no indication that the validity of any of the three editions of the DSM-ND criteria had been evaluated prior to their publication.

#### 3.3. Theoretical foundation

##### 3.3.1. Are the DSM-ND criteria based on a stated theory?

Some authors have suggested that clarity in the theoretical framework of DSM would be helpful as the validity of its criteria cannot be tested against a defined set of principles (Glautier, 2004; Mikulich, Hall, Whitmore, & Crowley, 2001; Piper, McCarthy, & Baker, 2006). Other authors assert that the DSM is intentionally “atheoretical” to encourage its use by those with diverse theoretical orientations (Hughes, 1998; Saunders, 2006). We found no published evidence that ties the DSM to a particular addiction theory.

#### 3.4. Face/content validity

##### 3.4.1. Does each DSM criterion have face validity as an indicator of dependence?

We found only one article that asserted, without citing specific data, that the DSM-ND criteria have face validity (Piper et al., 2006). All other authors that discussed face validity argued that only a few of the generic criteria provide a good fit for tobacco dependence (Benowitz, 1999; Breslau & Johnson, 2000; Broms et al., 2007; Hughes, 2006; West, 2005). All commentators agreed that ‘use to avoid withdrawal’ and ‘unsuccessful attempts to quit’ are signs of addiction. However, while all of the DSM criteria describe smokers' behavior, some authors cited data that questioned the face validity of certain criteria. For example, 6 of the criteria failed to predict abstinence at either 1 or 6 months in a cessation study (West, 2005).

*Tolerance* to intended effects or side effects is widespread with non-addictive drugs. Perkins found no difference between DSM-IV dependent and nondependent smokers on 12 measures of tolerance and concluded “These results suggest there is no close link between nicotine tolerance and dependence and question the utility of tolerance as one of the criteria for defining dependence.” (Perkins et al., 2001).

Spending a great deal of time smoking may not be a sensitive criterion since it has been established that nondaily smokers can be nicotine dependent (Dierker, L. et al., 2007; DiFranza et al., 2007; Kandel, Hu, Griesler & Schaffran, 2007; O'Loughlin, Gervais, Dugas, & Meshefedjian, 2009).

The discomfort caused by nicotine withdrawal may compel heavy smokers to give up activities that preclude smoking. However, this criterion may lack sensitivity as nondaily smokers who have withdrawal symptoms can tolerate much longer periods without smoking and are not confronted with the same choice (DiFranza et al., 2010). Based on a genetic analysis, Lessov concluded “these results suggest that the DSM-IV substance dependence criterion of ‘important social, occupational, or

recreational activities are given up because of substance use', as measured in our assessment, may not be a salient indicator of nicotine dependence in adults." (Lessov et al., 2004).

Most of the withdrawal symptoms listed in DSM are recognized as symptoms of nicotine withdrawal, but it has been argued that slowed heart rate, increased appetite, and weight gain are offset effects and are not true withdrawal symptoms (Hughes, 2007). These three symptoms and the withdrawal symptom of sleep disturbance do not predict cessation outcomes (Etter, 2005b; John, Meyer, Hapke, Rumpf, & Schumann, 2004; John, Meyer, Rumpf, & Hapke, 2004; Pomerleau, Marks, & Pomerleau, 2000; Swan, Ward, & Jack, 1996).

#### 3.4.2. Does the evidence confirm a 3-criteria threshold for dependence as detailed in DSM?

DSM-III-R and DSM-IV require individuals to meet a minimum of 3 criteria to receive a diagnosis of ND. The historical record suggests that the decision to use a 3-symptom threshold was not evidence-based: "the [DSM-IV] work group increased the requirement for dependence to a minimum of four from three criteria and decreased it to two; these changes greatly increased and reduced the proportion of users with reported problems who met criteria for dependence... After consideration, three continued to be judged as the most appropriate for meeting dependence." (Cottler et al., 1995). DSM-III-R and DSM-IV stipulate that individuals who have only 1 or 2 symptoms are not dependent. Only three studies were potentially relevant to this issue (John, Meyer, Rumpf, & Hapke, 2004; John, Rumpf, Schumann, Hapke, 2005; Pergadia, Heath, Martin, & Madden, 2006). At 3-year follow-up, smokers who had a DSM diagnosis were less likely (odds ratio (OR) = 0.4) to be abstinent than subjects that met no criteria, but so too were subjects who had one or two criteria and therefore, no dependence according to DSM (OR = 0.5) (John, Meyer, Rumpf, & Hapke, 2004). Smokers who fell both above and below the 3-criteria threshold were at elevated risk for having sustained high scores on the Fagerström Test for Nicotine Dependence (FTND) (John et al., 2005). No support for a threshold was found in a twin study in which the heritability of the diagnosis was very similar to that for individual symptoms (Pergadia et al., 2006). Thus, no data supported the validity of the central premise of DSM, the 3-symptom threshold, and commentary in the literature was uniformly critical of this approach (Colby, S. M., Tiffany, Shiffman, & Niaura, 2000; Ginetet, Mitchell, & Wellman, 2008; Johnson, Breslau, & Anthony, 1996).

#### 3.4.3. Does evidence support the requirement that symptoms be clustered within a 12 month period?

No data could be found that supported the requirement that symptoms be clustered in a 12 month period.

#### 3.4.4. Does evidence support the requirement of a 4-symptom threshold for a withdrawal syndrome diagnosis?

DSM dichotomizes withdrawal using a 4-symptom minimum. In a smoking cessation study, smokers who met the 4-symptom withdrawal threshold were more likely to continue smoking than those with no withdrawal symptoms, but this was true also of smokers who had fewer than 4 withdrawal symptoms (John, Meyer, Rumpf, & Hapke, 2004). In a study of 4112 Vietnam veterans, there was no evidence of a dichotomous latent class solution for withdrawal (Xian et al., 2005). We found no support or justification in the literature for this dichotomous approach to withdrawal or the use of a 4-symptom threshold.

#### 3.4.5. Is daily smoking required for withdrawal?

Although DSM-III stipulates prolonged heavy daily use is a prerequisite to withdrawal, and subsequent versions require prolonged daily use, we could find no data to support the hypothesis that

daily use is a prerequisite to withdrawal. All available evidence was to the contrary as withdrawal is well documented in nondaily smokers of all ages (DiFranza et al., 2007; Kandel, Hu, Griesler & Schaffran, 2007; O'Loughlin et al., 2003; Scragg, Wellman, Laugesen, & DiFranza, 2008; Wellman, DiFranza, & Wood, 2006).

#### 3.4.6. Must withdrawal symptoms appear within 24 h of abstinence?

Although DSM states that withdrawal must begin within 24 h of abstinence, we could find no study to support that claim; to the contrary, many light smokers report that their withdrawal symptoms appear after 24 h (DiFranza & Ursprung, 2008; Fernando, Wellman, & DiFranza, 2006).

### 3.5. Convergent validity

#### 3.5.1. Are different DSM instruments equivalent?

Table 1 outlines the 3 editions of the DSM-ND criteria (American Psychiatric Association, 1980a, b, 1987). Seven studies compared different versions of DSM in the same subjects. The 3 editions of the DSM diagnosed a similar proportion of smokers to be dependent, indicating good reliability. Compared to DSM-III, DSM-III-R diagnosed more subjects to be ND in 3 studies, fewer in one, and about the same in another (Cottler, 1993; Cottler et al., 1991; Cottler, Robins, & Helzer, 1989; Cottler et al., 1995; Jackson, Sher, Wood, & Bucholz, 2003). In two studies comparing DSM-III-R to DSM-IV, the proportion of persons diagnosed as dependent were similar, but in a third, DSM-IV diagnosed fewer (58.9%) than DSM-III-R (72.2%, kappa = 0.66), and in a fourth study these versions correlated at  $r = 0.75$  (Hughes, Oliveto et al., 2004; Jackson et al., 2003; Kawakami, Takatsuka, Shimizu, & Takai, 1998; Mikulich et al., 2001).

The APA does not provide an official research instrument for the nicotine dependence criteria. It is important to determine if the instruments that researchers have developed concur with one another; however no study has evaluated reliability across DSM survey instruments. Researchers have operationalized the DSM criteria quite differently from one another. For example, in some instruments, tolerance has been operationalized as smoking 10 or 20 cigarettes per day, while in others it is operationalized as no longer experiencing nausea (Clemente Jimenez et al., 2003; Kandel, Hu, Griesler & Schaffran, 2007; Lessov et al., 2004). In one study, tolerance was diagnosed in only 19% of adults who smoked 20 or more cigarettes per day and had smoked for at least 16 years. In contrast, in another study tolerance was diagnosed in 27% of youth who had been smoking for only 1–2 days (John, Meyer, Rumpf, & Hapke, 2008; Kandel, Hu, Griesler & Schaffran, 2007).

#### 3.5.2. Do the DSM-ND criteria diagnose the same subjects as other measures of dependence?

As a diagnostic measure, the DSM-ND criteria may not be intended or expected to measure the same thing as other dependence measures. In 9 studies, all versions of the DSM showed poor correlation and concordance with the FTQ, the modified FTQ, or the FTND (Broms et al., 2007; Cohen, Myers, & Kelly, 2002; Hughes, Gust, & Pechacek, 1987; Hughes, Oliveto et al., 2004; Kandel et al., 2005; Kawakami et al., 1998; Mikami et al., 1999; Moolchan et al., 2002; Strong, Brown, Ramsey, & Myers, 2003). Hughes demonstrated a moderately high correlation between DSM-IV and DSM-III-R (0.75), but only low to moderate correlations between DSM-IV and FTQ (0.35), FTND (0.32), time to first morning cigarette (−0.06), the heaviness of smoking index (0.20), cigarettes smoked per day (0.33), self-reported quitting difficulty (0.37), and self-reported addiction (0.48) (Hughes, Oliveto et al., 2004). A DSM-IV diagnosis showed weak concordance ( $k = 0.66$ ) with expert-clinician assessments (Hughes, Oliveto et al., 2004). DSM-III-R also showed generally low correlations with FTQ (0.29), FTND (0.24), time to first cigarette (−0.01), heaviness of smoking index (0.15), cigarettes per day (0.22), self-reported quitting difficulty (0.24), and self-reported addiction (0.30) (Hughes, Oliveto et al., 2004). The development of the DSM and ICD definition of tobacco dependence was coordinated, and this is



**Table 1**

Three sequential versions of the DSM criteria for nicotine dependence.

DSM-III (American Psychiatric Association, 1980a)	DSM-III-R (American Psychiatric Association, 1987)	DSM-IV (American Psychiatric Association, 1994)
Continuous use of tobacco for at least one month. AND At least one of the following:	Some symptoms of the disturbance have persisted for at least one month, or have occurred repeatedly over a longer period of time. AND At least three of the following:	A maladaptive pattern of substance use, leading to clinically significant impairment or distress, as manifested by three (or more) of the following, occurring at any time in the same 12-month period.
Serious attempts to stop or reduce the amount of tobacco use on a permanent basis have been unsuccessful	Persistent desire or one or more unsuccessful efforts to cut down or control substance use	There is a persistent desire or unsuccessful efforts to cut down or control substance use
The individual continues to use tobacco despite a serious physical disorder that he or she knows is exacerbated by tobacco use.	Continued substance use despite knowledge of having a persistent or recurrent social, psychological, or physical problem that is caused or exacerbated by the use of the substance	The substance use is continued despite knowledge of having a persistent or recurrent physical or psychological problem that is likely to have been caused or exacerbated by the substance
Attempts to stop smoking have led to the development of tobacco withdrawal. (see below)	Characteristic withdrawal symptoms (see below) Substance often taken to relieve or avoid withdrawal symptoms	Withdrawal, as manifested by either of the following: (a) the characteristic withdrawal syndrome for the substance (see below) (b) the same (or closely related) substance is taken to relieve or avoid withdrawal symptoms
	Marked tolerance: need for markedly increasing amounts of the substance (i.e., at least a 50% increase) in order to achieve intoxication or desired effect, or markedly diminished effect with continued use of the same amount	Tolerance, as defined by either of the following: (a) a need for markedly increased amounts of the substance to achieve intoxication or desired effect (b) markedly diminished effect with continued use of the same amount of the substance
	The substance is often taken in larger amounts or over a longer period than was intended A great deal of time is spent in activities necessary to get the substance (e.g., theft), taking the substance (e.g., chain-smoking), or recovering from its effects	The substance is often taken in larger amounts or over a longer period than was intended A great deal of time is spent in activities necessary to obtain the substance (e.g., visiting multiple doctors or driving long distances), use the substance (e.g., chain-smoking), or recover from its effects
	Important social, occupational, or recreational activities are given up or reduced because of substance use Frequent intoxication or withdrawal symptoms when expected to fulfill major role obligations at work, school, or home (e.g., does not go to work because hung over, goes to school or work "high," intoxicated while taking care of his or her children), or when substance use is physically hazardous (e.g., drives when intoxicated)	Important social, occupational, or recreational activities are given up or reduced because of substance use
<i>Diagnostic criteria for tobacco withdrawal</i>	<i>Nicotine withdrawal</i>	<i>Diagnostic criteria for nicotine withdrawal</i>
A. Use of tobacco for at least several weeks at a level equivalent to more than 10 cigarettes per day, with each cigarette containing at least 0.5 mg of nicotine AND	A. Daily use of nicotine for at least several weeks AND	A. Daily use of nicotine for at least several weeks AND
B. Abrupt cessation or reduction in tobacco use, followed within 24 hours by at least four of the following: Craving for tobacco Irritability Anxiety Difficulty concentrating Restlessness Headache Drowsiness Gastrointestinal disturbances	B. Abrupt cessation of nicotine use, or reduction in the amount of nicotine used, followed within 24 hours by at least four of the following signs: Craving for nicotine Irritability, frustration, or anger Anxiety Difficulty concentrating Restlessness	B. Abrupt cessation of nicotine use, or reduction in the amount of nicotine used, followed within 24 hours by four (or more) of the following signs:  Irritability, frustration, or anger Anxiety Difficulty concentrating Restlessness
	Decreased heart rate Increased appetite or weight gain	Decreased heart rate Increased appetite or weight gain Dysphoric or depressed mood Insomnia
		C. The symptoms in Criterion B cause clinically significant distress or impairment in social, occupational, or other important areas of functioning D. The symptoms are not due to a general medical condition and are not better accounted for by another mental disorder.

reflected in moderately strong correlations between the DSM-III, III-R and IV and the ICD-10 (0.71, 0.71, and 0.87 respectively). Subjects with DSM-III-R-ND had scores of 1–10 on the FTND, while those without dependence had scores of 0–9 (Mikami et al., 1999).

### 3.5.3. Do the DSM-ND criteria concur with other indices?

A large number of studies provided data that address the concurrent validity of the DSM-ND-criteria against a variety of tobacco use and self-report indicators.

Smoking duration was associated with higher life-time risk of DSM-III-R and DSM-IV diagnoses (Kawakami et al., 1998). Although 83% of current smokers considered themselves to be dependent, only 31% were dependent according to DSM-III-R, 79% of those who did not meet the DSM-III-R criteria identified themselves as dependent, while 9% of the dependent smokers considered themselves not to be dependent (Poirier et al., 2002). The DSM did not diagnose dependence in the majority of smokers who identified themselves as being addicted.

The correlation between DSM and daily consumption may reflect the use of frequency of use to assess the tolerance and much time spent using criteria. Higher levels of daily cigarette consumption are consistently associated with higher numbers of DSM criteria being met and likelihood of diagnosis, (Clemente Jimenez et al., 2003; John, Meyer, Hapke, & Rumpf, 2004; Kandel et al., 2005; Kawakami et al., 1998; Nelson & Wittchen, 1998; Stanton, 1995) but correlations with daily consumption are much lower ( $r=0.22$ – $0.55$ ) than has been observed with other dependence measures such as the Hooked on Nicotine Checklist (HONC,  $r=0.69$ ) which does not assess tolerance or much time spent smoking (Broms et al., 2007; Hughes, Oliveto et al., 2004).

Additional studies confirm a poor correlation between tobacco dependence, as conceptualized by DSM, and smokers' own assessments. DSM-III did not correlate with self-rated quitting difficulty, while DSM-IV showed a weak correlation ( $r=0.37$ ) (Hughes, Oliveto et al., 2004). Self-assessed addiction correlates highly with self-rated difficulty quitting ( $r=0.89$ ), but DSM-III ( $r=0.30$ ) and DSM-IV ( $r=0.48$ ) correlated weakly to moderately with self-assessed addiction. Self-assessed addiction outperformed both versions of DSM in correlations with cigarettes/day, time to first morning cigarette, and all Fagerström measures (Hughes, Oliveto et al., 2004). While self-reported quitting difficulty ( $r=-0.50$ ) and self-reported addiction ( $r=-0.50$ ) correlated moderately with time to first cigarette, DSM-IV did not ( $r=-0.06$ ) (Hughes, Oliveto et al., 2004). The number of DSM symptoms did not correlate with smoking quantity/frequency, years since first cigarette, or desire to quit (Cohen et al., 2002).

Although we question whether all of the following are indicators of concurrent validity we include them here to provide a broad view of DSM performance. DSM-III-R was related to being a “regular” smoker before the age of 15, wanting to quit for health reasons, having multiple unsuccessful attempts to quit or cut down (a DSM criterion), relying on will power to quit or cut down, and relying on multiple quit strategies (Stanton, 1995). DSM-III-R was not related to nicotine metabolite levels, ever having tried to quit, or willingness to participate in a cessation program (Stanton, 1995). More DSM-IV ND smokers (4.6%) than nondependent smokers (1.6%) used smoking cessation aids (Nelson & Wittchen, 1998).

### 3.6. Predictive validity

#### 3.6.1. Are the DSM-ND criteria a good predictor of clinical outcomes?

Predictive validity concerns how measures predict future relevant outcomes. In one study, DSM-ND was an excellent predictor of continued smoking during pregnancy (OR = 30 among all smokers, OR = 2.3 among regular smokers) (Agrawal et al., 2008). In a 5-year prospective study, a modified version of DSM-III-R predicted persistence of smoking in young adults; those who were diagnosed with ND were 8.6 times more likely to persist with smoking (Breslau & Peterson, 1996; Johnson, Chase, & Breslau, 2002). In a prospective study of young adults who smoked at least one cigarette per week, the DSM-IV was modified by ignoring the requirement that symptoms must cause significant distress or impairment. The modified DSM predicted the length of longest abstinence as well as smoking status at one year (OR = 4.5) and two years (OR = 7.3) (Sledjeski et al., 2007).

In adults, none of the individual DSM-IV criteria predicted 1 or 6 month cessation (West, 2005). In young adults, daily cigarette consumption and the FTND both predicted smoking status one year later, but DSM-III-R did not (Breslau & Johnson, 2000). In 3 cessation trials of adult moderate to heavy smokers, cessation was predicted by cigarette consumption and the FTND, but not DSM-IV (Hendricks, Prochaska, Humfleet, & Hall, 2008). The 3-criterion threshold was not supported in a longitudinal study with smoking status at follow-up as the outcome (John, Meyer, Rumpf, & Hapke, 2004). Nor did the distinction between fewer than 4, versus 4 or more withdrawal symptoms predict smoking status (John, Meyer, Rumpf, & Hapke, 2004).

### 3.7. Reliability

#### 3.7.1. Test–retest reliability

3.7.1.1. *Do instruments that are faithful to the DSM-ND have good test–retest reliability?* Test–retest reliability assesses an instrument's consistency when used under the same conditions with the same subjects. The test–retest reliability of a DSM-ND diagnosis was adequate to excellent in all 7 studies in which well-trained evaluators used the same instrument twice ( $\kappa=0.63$ – $0.89$ ) (Cottler et al., 1989; Grant et al., 2003; Hughes, Oliveto et al., 2004; Koenen et al., 2005; Lachner et al., 1998; Lee et al., 1990; Robins, Helzer, Ratcliff, & Seyfried, 1982).

#### 3.7.2. Internal reliability

3.7.2.1. *Do instruments that are faithful to the DSM-ND criteria demonstrate good internal reliability?* The internal reliability of researcher-generated DSM instruments has been poor ( $\alpha=0.51$ – $0.64$ ) (Clemente Jimenez et al., 2003; Cohen et al., 2002; Hendricks et al., 2008) and deemed “below standards for clinical use.” (Hendricks et al., 2008; Streiner & Norman, 2003).

#### 3.7.3. Factor structure

In two studies, the DSM criteria solved to two factors, but the item loadings on those factors were inconsistent between studies (Johnson et al., 1996; Muthen & Asparouhov, 2006).

#### 3.7.4. Indicators relevant to clinical applications

##### 3.7.4.1. Have the DSM-ND criteria found a useful role in the clinical setting?

The APA's 1996 Clinical Guidelines recommended that physicians use DSM to evaluate smokers, (American Psychiatric Association, 1996) but no study has demonstrated a role for DSM-ND assessment in treatment decisions. As all smokers benefit from smoking cessation, current treatment algorithms do not recommend that clinicians take the time to establish a diagnosis of dependence (West, 2005).

##### 3.7.4.2. Do the DSM-ND criteria have acceptable sensitivity for use in clinical settings?

Sensitivity is the probability that a measure will correctly diagnose a condition (in this case nicotine dependence), whereas specificity is the probability that it will correctly identify a non-affected individual (i.e., a person who is not dependent). About one third of smokers who seek professional help with quitting in smoking cessation trials do not meet the DSM-ND diagnostic criteria (Hall et al., 2008; Hendricks et al., 2008). About 90% of smokers relapse when they attempt to quit unassisted, (Garvey, Bliss, Hitchcock, Heindol, & Rosner, 1992) yet in our review of 34 prevalence reports, on average the DSM diagnosed only about half of smokers to be dependent (Donny & Dierker, 2007). In one study, only two-thirds of current smokers who had failed to quit in six or more attempts were DSM-IV nicotine dependent (John, Meyer, Hapke, Rumpf, & Schumann, 2004).

Hughes has demonstrated that self-assessed addiction correlates strongly with many measures of dependence and tobacco use, and correlates with all other indicators better than does the DSM-ND (Hughes, Oliveto et al., 2004). A potential use for a diagnostic test would be to identify ND in smokers who are in denial, in which case the test might diagnose addiction in more people than would be identified by self-assessment. The DSM diagnosed only 66% of adults who felt addicted to nicotine gum (Hughes, Pillitteri et al., 2004). No study was designed for the purpose of evaluating the sensitivity or specificity of the DSM-ND criteria, and no study reported sensitivity or specificity, but we were able to compute these from the published data from 5 studies. Table 2 shows the test performance of the DSM-ND criteria as a potential screener for smokers who might be targeted for assistance because they have failed a quit attempt, have

**Table 2**

Test properties of DSM if it were to be used to screen for adult smokers who feel addicted, have failed a previous quit attempt, or who desire to quit.

Test property	Population				
	Psychiatric patients DSM-III-R (Poirier et al., 2002)	Community sample DSM-IV (Schumann et al., 2004)	Primary care patients DSM-IV (Hoch, Muehlig, Hoffer, Lieb, & Wittchen, 2004)	Community sample DSM-IV (Schumann et al., 2004)	Primary care patients DSM-IV (Hoch et al., 2004)
	Self-reported addiction	Past failed quit attempt	Desire to quit or failed quit	Self-reported addiction	Self-reported addiction
Sensitivity	34%	41%	64%	52%	63%
Specificity	84%	89%	83%	83%	74%
False positive rate	9%	6%	14%	23%	24%
False negative rate	79%	74%	43%	37%	39%
Predictive value positive	91%	94%	86%	76%	76%
Predictive value negative	21%	26%	57%	63%	61%
Proportion correctly identified	43%	50%	71%	68%	68%

a desire to quit or feel they are addicted. Sensitivities ranged from 34% to 64%.

**3.7.4.3. Do the DSM-ND criteria result in differential rates of diagnosis across races?** Because blacks, on average, metabolize nicotine more slowly than whites, (Perez-Stable, Herrera, Jacob & Benowitz, 1998) they need not smoke as much to obtain the same effect and blacks tend to be lighter smokers (Vega, Chen, & Williams, 2007). In one survey, whites smoked twice as many cigarettes per day as blacks (21.3 vs. 10.3), and were 7.8 times as likely to smoke 20 cigarettes/day (Andreski & Breslau, 1993). When instruments equate tolerance and frequent use with smoking 20 or more cigarettes per day, the DSM may diagnose fewer blacks. In all 7 studies we found examining this question, black smokers were less likely to be diagnosed dependent than whites (Breslau, 1995; Breslau, Fenn, & Peterson, 1993; Breslau, Kilbey, & Andreski, 1994; Kandel et al., 2005; Moolchan et al., 2002; Storr, Zhou, Liang, & Anthony, 2004; Strong, Kahler, Ramsey, & Brown, 2003; Vega et al., 2007). Strong et al. concluded that dichotomizing the number of cigarettes per day to define tolerance “results in a biased dependence given that an equal number of cigarettes suggested qualitatively different estimations of levels of dependence for young smokers, women, African Americans, and lower income smokers.” (Strong, Kahler, Ramsey, & Brown, 2003).

#### 4. Discussion

In 1980, the APA published a diagnostic criteria for nicotine dependence reflecting an assumption that criteria developed to diagnose alcoholism would be valid and reliable indicators of nicotine dependence (American Psychiatric Association, 1980b). This is the first systematic review of the DSM-ND criteria in the 3 decades since their initial publication. The DSM enjoys wide use in research and has demonstrated modest concurrent and predictive validity when used in the research setting to measure the severity of dependence. This is an appropriate use for the DSM. Although some claim that the DSM criteria represent a “gold standard” (Schmitz, Kruse, & Kugler, 2003), we could find no justification for that determination as the DSM was outperformed in terms of concurrent and predictive validity by other measures of dependence in almost every comparison.

Inter-observer diagnostic agreement as reported in the literature is inflated because the diagnosticians were all specially trained to apply the criteria in a proscribed fashion, and this does not reflect real-world practices. The limited use of the Structured Clinical Instrument for DSM (SCID), and the lack of specificity of some of the DSM criteria, has resulted in a plethora of DSM-based instruments which differ markedly in how they operationalize the criteria. (Clemente Jimenez et al., 2003; Dierker, L.C. et al., 2007; Etter, 2005a; Kandel et al., 2005; Kawakami et al., 1999; Shiffman & Sayette, 2005). The literature

reveals a sometimes striking lack of concurrence between different DSM-based instruments. The prevalence of DSM dependence among alcoholic smokers was measured at 89% in one study, but only 2% in a Japanese study with tobacco industry connections (Hashimoto et al., 2001; Hertling et al., 2005). The DSM criteria may be too loosely defined to produce the standardization of measurement across observers that is a chief goal of a nosology.

In the 169 articles reviewed, no author justified their use of the DSM-ND criteria by citing evidence supporting their validity. This suggests that authors, peer reviewers and journal editors accepted the validity of the DSM-ND criteria as a given. To say that nicotine dependence is whatever the DSM defines it to be would be a tautological argument that carries no scientific weight. We could find no evidence that the DSM-ND criteria provide an accurate diagnosis of nicotine dependence. Published in 1994, the DSM-IV criteria have been dated by recent research advances. Assertions that withdrawal symptoms require prolonged and heavy cigarette use (first appearing “within a few years of daily smoking” (American Psychiatric Association, 1996), and must begin within 24h of abstinence, are all contradicted by all available evidence as cited above. Published data contradict the notion that tolerance, giving up activities, and the withdrawal symptoms of slowed heart rate, increased appetite, weight gain and insomnia are clinically important features of nicotine dependence (Etter, 2005b; John, Meyer, Hapke, Rumpf, & Schumann, 2004; John, Meyer, Rumpf, & Hapke, 2004; Lessov et al., 2004; Perkins et al., 2001; Pomerleau et al., 2000; Swan et al., 1996).

We found no evidence in support of (1) the validity of the syndromal approach with a 3-symptom threshold, (2) a 4-symptom threshold for withdrawal, (3) the requirement for repeated, rather than a single attempt to quit, (4) that symptoms must cause significant distress or impairment, (5) that symptoms must be clustered in a 12 month period, or (6) the relevance of use despite harmful consequences. The DSM provides no scientific justification for any of these stipulations and no data supports them. In other words, we found no data supporting the basic premise of DSM that “the essential feature of this disorder is a cluster of cognitive, behavioral, and physiologic symptoms that indicate that the person has impaired control of psychoactive substance use and continues use of the substance despite adverse consequences.”

The DSM did not diagnose dependence in the majority of smokers who identified themselves as being addicted. This suggests that the DSM conceptualization of addiction is distinctly different from what smokers themselves experience as addiction. Self-diagnosed addiction outperformed the DSM diagnosis by a wide margin in every comparison of concurrent validity. The superior performance of self-diagnosis over the DSM diagnosis is a major challenge to the validity of the DSM conceptualization of nicotine dependence. The fact that one third of individuals who had failed in 6 or more quit attempts were not dependent by DSM-ND criteria suggests the DSM

conceptualization of dependence is something foreign to the way dependence is commonly conceived by society as a whole.

It has been suggested that “determining the prevalence of DSM/ICD-defined nicotine dependence provides one estimate of how many current smokers meet an established threshold for clinically significant dependence” (page 92) (Hughes, Helzer, & Lindberg, 2006). However, we could find no data indicating that crossing the DSM diagnostic threshold is a clinically relevant milestone. The DSM-ND criteria demonstrated poor sensitivity across settings and populations (Table 2). The evidence suggests that the DSM may under-diagnose dependence in blacks (Strong, Kahler, Ramsey, & Brown, 2003). However, a parallel assessment of DSM and other measures of dependence across races is needed before it can be concluded that the DSM under-diagnoses blacks.

According to the DSM Source Book “the ultimate validator of criteria defining abuse or dependence will be how well abuse and dependence independently predict course of illness...” (page 41) (Nathan, 1994). On this score, the performance of the DSM is mixed. More often than not, the DSM criteria failed to predict important clinical outcomes such as relapse during smoking cessation. In contrast, the diagnosis of addiction based on the single criterion of a recurrent periodic compulsion to use tobacco meets this test of validity by predicting the trajectory of smoking with 98% sensitivity and 98% specificity (DiFranza et al., 2007; DiFranza et al., 2010). The DSM criteria do not include the recurrent periodic compulsion to use tobacco.

The poor correlations between DSM and non-DSM-based measures of dependence such as the FTQ, mFTQ, FTND, and the HONC is not necessarily a short-coming, as the DSM is not intended to measure the same aspects of dependence as these other measures. More concerning however, is the generally poor concurrent validity demonstrated by the DSM in relation to clinical indicators of dependence including: time to first morning cigarette; the heaviness of smoking index; cigarettes per day; self-reported quitting difficulty; and self-reported addiction.

We identified 32 articles associating DSM-ND with the following conditions, agoraphobia, alcoholism, anxiety, attention deficit disorder, bulimia, childhood conduct disorder, depression, drug addiction, explosive disorder, obsessive-compulsive disorder, panic disorder, social phobia, suicidality, and post-traumatic stress disorder (Breslau et al., 1994; Bronisch, Hofer, & Lieb, 2008; Goodwin, Zvolensky, & Keyes, 2008; John, Meyer, Rumpf, & Hapke, 2006; Kessler et al., 2007; Koenen et al., 2005; Nelson & Wittchen, 1998; Poirier et al., 2002; Schumann, Hapke, Meyer, Rumpf, & John, 2004). With its emphasis on heavy and harmful use, the DSM may preferentially diagnose individuals with other addictions or mental illness.

Having a diagnostic label and billing code is helpful for billing purposes and documentation on treatment plans; however the APA acknowledges that “the DSM system has not been formally tested as a measure to guide therapy.” (American Psychiatric Association, 1996). From our review and collective clinical experience, the DSM criteria do not appear to be used to guide clinical decisions such as the selection of pharmacotherapy or the intensity of behavioral therapy. Although the use of DSM-ND diagnostic criteria is likely to be more common in clinical settings than is evident from a review of the literature, the only reported clinical use of DSM that we found was in a case report of ND in an 18-month-old girl (Sir & Ozkan, 1998). The apparent lack of use of the DSM-ND criteria in clinical settings may reflect that they are unable to distinguish smokers who are or are not motivated to quit, or those who can and cannot quit without assistance. Based on our clinical experience, we are more concerned that many clinicians and clinical services do not address tobacco use by including it in problem lists and treatment plans.

We did not set minimum quality standards for the reviewed articles as we did not wish to exclude any evidence that might support the validity of the DSM. A limitation of this study is the exclusion of studies that were not available in English. Study strengths include the thoroughness of the literature search, the breadth of expertise among the reviewers, the participation of professionals from multiple institutions, and the involvement of professionals from outside of the US.

#### 4.1. What approach can be taken in DSM-V?

The DSM criteria are currently being reassessed for DSM-V. This provides an opportunity to consider new evidence. Recent research concerning the pathophysiology of nicotine dependence has shown that it can be recognized by the appearance of a recurrent and periodic compulsion to use tobacco (DiFranza et al., 2010). This compulsion is manifested as symptoms of wanting, craving or needing tobacco that emerge at predictable intervals following the onset of abstinence. As no other condition shares these symptoms, this presentation is pathognomonic for nicotine dependence (DiFranza et al., 2010). Although more research is needed to evaluate the significance of the recurrent compulsion to smoke in adults, we believe that it may serve as a single criterion for the diagnosis of nicotine dependence as it predicts the trajectory of tobacco use in novice smokers with 98% accuracy (DiFranza, Riggs, & Pentz, 2008; DiFranza et al., 2007; DiFranza et al., 2002). This reflects the relentless progression of this condition. The high degree of predictive accuracy provided by the recurrent compulsion suggests that this criterion captures the condition's core feature. While nicotine dependence produces many other symptoms in addition to the recurrent compulsion, research would be needed to determine if these represent clinically meaningful milestones, if they predict the clinical course of illness, or if they reflect the severity of dependence.

The recurrent compulsion to use tobacco was recognized as a core feature of addiction by the DSM-III committee. In the draft for DSM-III, “distress at the need to repeatedly take the substance” was sufficient to diagnose nicotine dependence (Neuman, Bitton, & Glantz, 2005). A disease is defined as a disruption in normal physiological functioning. The recurrent periodic compulsion to use tobacco is identifiable as a disruption of physiological functioning by its periodicity, (DiFranza & Ursprung, 2008) by its disruption of normal brain functions such as concentration, and because withdrawal is associated with physical signs such as slowed heart rate, electroencephalographic changes and alterations in neurotransmitters (DiFranza & Ursprung, 2008; Gilbert et al., 1999; Hughes, 2007; Kenny & Markou, 2001). The recurrent periodic compulsion to use tobacco is identifiable as a disease because it represents a disruption of neurophysiology, regardless of whether the smoker finds it distressful, or experiences substance-related problems.

#### 4.2. Conclusion

A growing body of empirical research contradicts the DSM-IV syndromal conceptualization of nicotine dependence and supports the DSM-III idea that a recurrent compulsion to use tobacco is the core feature of nicotine dependence. The available data support the proposition of defining nicotine dependence as a recurrent, periodic compulsion to use tobacco that can be diagnosed based on that single symptom.

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#### Contributors

Dr. Joseph DiFranza designed the study and developed the data extraction tool for included articles. Sanouri Ursprung and Christina Bancej conducted literature searches and collected articles for pre-review. Through the Delphi process all authors participated in the analysis of the articles and the extraction of relevant data for comparison. Dr. Joseph DiFranza and Sanouri Ursprung wrote the first draft of the manuscript and all authors have contributed to and approved the final manuscript.

#### Conflict of Interest

None of the authors have conflict of interest.



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## References

- Agrawal, A., Knopik, V. S., Pergadia, M. L., Waldron, M., Bucholz, K. K., Martin, N. G., et al. (2008). Correlates of cigarette smoking during pregnancy and its genetic and environmental overlap with nicotine dependence. *Nicotine & Tobacco Research*, 10(4), 567–578.
- American Psychiatric Association (1980). *Diagnostic and statistical manual of mental disorders*, 3rd edition. Washington, DC: American Psychiatric Association.
- American Psychiatric Association (1980). *Diagnostic and statistical manual of mental disorders*, 3rd edition (Third Edition). Washington, DC: American Psychiatric Association.
- American Psychiatric Association (1987). *Diagnostic and statistical manual of mental disorders*, 3rd edition. Washington, DC: American Psychiatric Association.
- American Psychiatric Association (1994). *Diagnostic and statistical manual of mental disorders*, 4th edition. Washington, DC: American Psychiatric Association.
- American Psychiatric Association (1996). Practice guideline for the treatment of patients with nicotine dependence. American psychiatric association. *American Journal of Psychiatry*, 153(10 Suppl.), 1–31.
- Andreski, P., & Breslau, N. (1993). Smoking and nicotine dependence in young adults: Differences between blacks and whites. *Drug and Alcohol Dependence*, 32(2), 119–125.
- Benowitz, N. L. (1999). Nicotine addiction. *Primary Care*, 26(3), 611–631.
- Breslau, N. (1995). Psychiatric comorbidity of smoking and nicotine dependence. *Behavior Genetics*, 25(2), 95–101.
- Breslau, N., Fenn, N., & Peterson, E. L. (1993). Early smoking initiation and nicotine dependence in a cohort of young adults. *Drug and Alcohol Dependence*, 33(2), 129–137.
- Breslau, N., Kilbey, M. M., & Andreski, P. (1994). DSM-III-R nicotine dependence in young adults: Prevalence, correlates and associated psychiatric disorders. *Addiction*, 89(6), 743–754.
- Breslau, N. P., & Johnson, E. O. P. (2000). Predicting smoking cessation and major depression in nicotine-dependent smokers. *American Journal of Public Health HIV/AIDS*, 90(7), 1122–1127.
- Breslau, N., & Peterson, E. L. (1996). Smoking cessation in young adults: Age at initiation of cigarette smoking and other suspected influences. *American Journal of Public Health*, 86(2), 214–220.
- Broms, U., Madden, P. A., Heath, A. C., Pergadia, M. L., Shiffman, S., & Kaprio, J. (2007). The nicotine dependence syndrome scale in Finnish smokers. *Drug and Alcohol Dependence*, 89(1), 42–51.
- Bronisch, T., Hoffer, M., & Lieb, R. (2008). Smoking predicts suicidality: Findings from a prospective community study. *Journal of Affective Disorders*, 108(1–2), 135.
- Clemente Jimenez, M. L., Trullen, A. P., Aranda, E. R., Tundidor, R. M., Ibanez, M. L. R., & Labarga, I. H. (2003). A version of DSM-IV criteria adapted for adolescents and applied to young smokers. *Archivos De Bronconeumologia*, 39(7), 303–309.
- Cohen, L. M., Myers, M. G., & Kelly, J. F. (2002). Assessment of nicotine dependence among substance abusing adolescent smokers: A comparison of the DSM-IV criteria and the modified Fagerström tolerance questionnaire. *Journal of Psychopathology and Behavioral Assessment*, 24(4), 225.
- Colby, S., Tiffany, S., Shiffman, S., & Niaura, R. (2000). Measuring nicotine dependence among youth: A review of available approaches and instruments. *Drug & Alcohol Dependence*, 59(Supplement 1), S23–S39.
- Colby, S. M., Tiffany, S. T., Shiffman, S., & Niaura, R. S. (2000). Measuring nicotine dependence among youth: A review of available approaches and instruments. *Drug and Alcohol Dependence*, 59(Suppl 1), S23–39.
- Cottler, L. B. (1993). Comparing DSM-III-R and ICD-10 substance use disorders. *Addiction*, 88(5), 689–696.
- Cottler, L. B., & Helzer, J. E. (1989). Diagnostic agreement between DSM-III and DSM-III-R dependence disorders. *NIDA Research Monograph*, 95, 380–381.
- Cottler, L. B., Helzer, J. E., Mager, D., Spitznagel, E. L., & Compton, W. M. (1991). Agreement between DSM-III and III-R substance use disorders. *Drug and Alcohol Dependence*, 29(1), 17–25.
- Cottler, L. B., Robins, L. N., & Helzer, J. E. (1989). The reliability of the CIDI-SAM: A comprehensive substance abuse interview. *British Journal of Addiction*, 84(7), 801–814.
- Cottler, L. B., Schuckit, M. A., Helzer, J. E., Crowley, T., Woody, G., Nathan, P., et al. (1995). The DSM-IV field trial for substance use disorders: Major results. *Drug and Alcohol Dependence*, 38(1), 59–69 discussion 71–83.
- Dierker, L., Donny, E., Tiffany, S., Colby, S., Perinne, N., Clayton, R., et al. (2007). The association between cigarette smoking and DSM-IV nicotine dependence among first year college students. *Drug & Alcohol Dependence*, 86, 106–114.
- Dierker, L. C., Donny, E., Tiffany, S., Colby, S. M., Perrine, N., & Clayton, R. R. (2007). The association between cigarette smoking and DSM-IV nicotine dependence among first year college students. *Drug and Alcohol Dependence*, 86(2–3), 106–114.
- DiFranza, J., Riggs, N., & Pentz, M. (2008). Time to re-examine old definitions of nicotine dependence. *Nicotine and Tobacco Research*, 10, 1109–1111.
- DiFranza, J., Savageau, J. A., Fletcher, K., O'Loughlin, J. E., Pbert, L., Ockene, J. K., et al. (2007). Symptoms of tobacco dependence after brief intermittent use—the development and assessment of nicotine dependence in youth-2. *Archives of Pediatrics and Adolescent Medicine*, 167(7), 704–710.
- DiFranza, J. R., Savageau, J. A., Rigotti, N. A., Fletcher, K., Ockene, J. K., McNeill, A. D., et al. (2002). Development of symptoms of tobacco dependence in youths: 30 month follow up data from the dandy study. *Tobacco Control*, 11(3), 228–235.
- DiFranza, J., & Ursprung, W. (2008). The latency to the onset of nicotine withdrawal: A test of the sensitization-homeostasis theory. *Addictive Behaviors*, 33, 1148–1153.
- DiFranza, J., Ursprung, W., & Carlson, A. (2010). New insights into the compulsion to use tobacco from an adolescent case series. *Journal of Adolescence*, 33, 209–214.
- Donny, E. C., & Dierker, L. C. (2007). The absence of DSM-IV nicotine dependence in moderate-to-heavy daily smokers. *Drug and Alcohol Dependence*, 89(1), 93–96.
- Etter, J. F. (2005). A comparison of the content-, construct- and predictive validity of the cigarette dependence scale and the Fagerstrom test for nicotine dependence. *Drug and Alcohol Dependence*, 77(3), 259–268.
- Etter, J. F. (2005). A self-administered questionnaire to measure cigarette withdrawal symptoms: The cigarette withdrawal scale. *Nicotine & Tobacco Research*, 7(1), 47–57.
- Etter, J. F., & Hughes, J. R. (2006). A comparison of the psychometric properties of three cigarette withdrawal scales. *Addiction (Abingdon, England)*, 101(3), 362.
- Fernando, W., Wellman, R., & DiFranza, J. (2006). The relationship between level of cigarette consumption and latency to the onset of retrospectively reported withdrawal symptoms. *Psychopharmacology*, 188, 335–342.
- Garvey, A., Bliss, R., Hitchcock, J., Heindel, J., & Rosner, B. (1992). Predictors of smoking relapse among self-quitters: A report from the normative aging study. *Addictive Behaviors*, 17, 367–377.
- Gilbert, D., McClernon, F., Rabinovich, N., Dibb, W., Plath, L., Hiyane, S., et al. (1999). EEG, physiology, and task-related mood fail to resolve across 31 days of smoking abstinence: Relations to depressive traits, nicotine exposure, and dependence. *Experimental and Clinical Psychopharmacology*, 7(4), 427–443.
- Ginestet, C. E., Mitchell, K., & Wellman, N. (2008). Taxometric investigation of the latent structure of nicotine dependence: An epidemiological sample. *Nicotine & Tobacco Research*, 10(5), 833–841.
- Glautier, S. (2004). Measures and models of nicotine dependence: Positive reinforcement. *Addiction*, 99(Suppl. 1), 30–50.
- Goodwin, R. D., Zvolensky, M. J., & Keyes, K. M. (2008). Nicotine dependence and mental disorders among adults in the USA: Evaluating the role of the mode of administration. *Psychological Medicine*, 1–10.
- Grant, B. F., Dawson, D. A., Stinson, F. S., Chou, P. S., Kay, W., & Pickering, R. (2003). The Alcohol Use Disorder and Associated Disabilities Interview Schedule-IV (AUDADIS-IV): Reliability of alcohol consumption, tobacco use, family history of depression and psychiatric diagnostic modules in a general population sample. *Drug and Alcohol Dependence*, 71(1), 7–16.
- Hall, S. M., Humfleet, G. L., Gorecki, J. A., Munoz, R. F., Reus, V. I., & Prochaska, J. J. (2008). Older versus younger treatment-seeking smokers: Differences in smoking behavior, drug and alcohol use, and psychosocial and physical functioning. *Nicotine & Tobacco Research*, 10(3), 463–470.
- Hashimoto, E., Sakaguchi, S., Shiga, M., Ikeda, N., Toki, S., & Saito, T. (2001). Epidemiological studies of tobacco smoking and dependence in Japan. *Alcohol*, 24(2), 107–110.
- Hendricks, P. S., Prochaska, J. J., Humfleet, G. L., & Hall, S. M. (2008). Evaluating the validities of different DSM-IV-based conceptual constructs of tobacco dependence. *Addiction*, 103(7), 1215–1223.
- Hertling, I., Ramskogler, K., Dvorak, A., Klingler, A., Saletu-Zyhlarz, G., Schoberberger, R., et al. (2005). Craving and other characteristics of the comorbidity of alcohol and nicotine dependence. *European Psychiatry*, 20(5–6), 442–450.
- Hoch, E., Muehlig, S., Hoffer, M., Lieb, R., & Wittchen, H. U. (2004). How prevalent is smoking and nicotine dependence in primary care in Germany? *Addiction*, 99(12), 1586–1598.
- Hughes, J. (1998). Nicotine withdrawal, dependence, and abuse. *DSM-IV sourcebook* (pp. 109–116).
- Hughes, J. R. (2006). Should criteria for drug dependence differ across drugs? *Addiction*, 101(Suppl 1), 134–141.
- Hughes, J. R. (2007). Effects of abstinence from tobacco: Valid symptoms and time course. *Nicotine & Tobacco Research*, 9(3), 315–327.
- Hughes, J. R., Gust, S. W., & Pechacek, T. F. (1987). Prevalence of tobacco dependence and withdrawal. *American Journal of Psychiatry*, 144(2), 205–208.
- Hughes, J. R., Helzer, J. E., & Lindberg, S. A. (2006). Prevalence of DSM/ICD-defined nicotine dependence. *Drug and Alcohol Dependence*, 85(2), 91–102.
- Hughes, J. R., Oliveto, A. H., Riggs, R., Kenny, M., Liguori, A., Pillitteri, J. L., et al. (2004). Concordance of different measures of nicotine dependence: Two pilot studies. *Addictive Behaviors*, 29(8), 1527–1539.
- Hughes, J. R., Pillitteri, J. L., Callas, P. W., Callahan, R., & Kenny, M. (2004). Misuse of and dependence on over-the-counter nicotine gum in a volunteer sample. *Nicotine & Tobacco Research*, 6(1), 79–84.
- Jackson, K. M., Sher, K. J., Wood, P. K., & Bucholz, K. K. (2003). Alcohol and tobacco use disorders in a general population: Short-term and long-term associations from the St. Louis epidemiological catchment area study. *Drug and Alcohol Dependence*, 71(3), 239–253.
- John, U., Meyer, C., Hapke, U., & Rumpf, H. J. (2004). Nicotine dependence and lifetime amount of smoking in a population sample. *European Journal of Public Health*, 14(2), 182–185.
- John, U., Meyer, C., Hapke, U., Rumpf, H. J., & Schumann, A. (2004). Nicotine dependence, quit attempts, and quitting among smokers in a regional population sample from a country with a high prevalence of tobacco smoking. *Preventive medicine*, 38(3), 350.
- John, U., Meyer, C., Rumpf, H. J., & Hapke, U. (2004). Depressive disorders are related to nicotine dependence in the population but do not necessarily hamper smoking cessation. *The Journal of clinical psychiatry*, 65(2), 169.
- John, U., Meyer, C., Rumpf, H. J., & Hapke, U. (2006). Psychiatric comorbidity including nicotine dependence among individuals with eating disorder criteria in an adult general population sample. *Psychiatry Research*, 141(1), 71–79.
- John, U., Meyer, C., Rumpf, H. J., & Hapke, U. (2009). Nicotine dependence criteria and nicotine withdrawal symptoms in relation to pain among an adult general population sample. *European Journal of Pain*, 13(1), 82–88.

- John, U. M. C., Rumpf, H. J., Schumann, A., & Hapke, U. (2005). Consistency or change in nicotine dependence according to the Fagerstrom test for nicotine dependence over three years in a population sample. *Journal of Addictive Disease*, 24(1), 85–100.
- Johnson, E. O., Breslau, N., & Anthony, J. C. (1996). The latent dimensionality of DIS/DSM-III-R nicotine dependence: Exploratory analyses. *Addiction*, 91(4), 583–588.
- Johnson, E. O., Chase, G. A., & Breslau, N. (2002). Persistence of cigarette smoking: Familial liability and the role of nicotine dependence. *Addiction*, 97(8), 1063–1070.
- Kandel, D. B., Hu, M. C., Griesler, P., & Schaffran, C. (2007). On the development of nicotine dependence in adolescence. *Drug & Alcohol Dependence*, 91, 26–39.
- Kandel, D. B., Hu, M. C., Griesler, P. C., & Schaffran, C. (2007). On the development of nicotine dependence in adolescence. *Drug and Alcohol Dependence*, 91(1), 26–39.
- Kandel, D. B., Huang, F., & Davies, M. (2001). Comorbidity between patterns of substance use dependence and psychiatric syndromes. *Drug and alcohol dependence*, 64(2), 233.
- Kandel, D., Schaffran, C., Griesler, P., Samuolis, J., Davies, M., & Galanti, R. (2005). On the measurement of nicotine dependence in adolescence: Comparisons of the MFTQ and a DSM-IV-based scale. *Journal of Pediatric Psychology*, 30(4), 319–332.
- Kawakami, N., Takatsuka, N., Inaba, S., & Shimizu, H. (1999). Development of a screening questionnaire for tobacco/nicotine dependence according to ICD-10, DSM-III-R, and DSM-IV. *Addictive Behaviors*, 24(2), 155–166.
- Kawakami, N., Takatsuka, N., Shimizu, H., & Takai, A. (1998). Life-time prevalence and risk factors of tobacco/nicotine dependence in male ever-smokers in Japan. *Addiction*, 93(7), 1023–1032.
- Kenny, P., & Markou, A. (2001). Neurobiology of the nicotine withdrawal syndrome. *Pharmacology Biochemistry and Behavior*, 70, 531–549.
- Kessler, R. C., Berglund, P. A., Borges, G., CastillaPuentes, R. C., Glantz, M. D., Jaeger, S. A., et al. (2007). Smoking and suicidal behaviors in the national comorbidity survey: Replication. *Journal of Nervous and Mental Disease*, 195(5), 369.
- Koenen, K. C., Hitsman, B., Lyons, M. J., Niaura, R., McCaffery, J., Goldberg, J., et al. (2005). A twin registry study of the relationship between posttraumatic stress disorder and nicotine dependence in men. *Archives of General Psychiatry*, 62(11), 1258–1265.
- Lachner, G., Wittchen, H. U., Perkonig, A., Holly, A., Schuster, P., Wunderlich, U., et al. (1998). Structure, content and reliability of the Munich-Composite International Diagnostic Interview (M-CIDI) substance use sections. *European Addictive Research*, 4(1–2), 28–41.
- Lee, C. K., Kwak, Y. S., Yamamoto, J., Rhee, H., Kim, Y. S., Han, J. H., et al. (1990). Psychiatric epidemiology in Korea. Part I: Gender and age differences in Seoul. *Journal of Nervous and Mental Diseases*, 178(4), 242–246.
- Lessov, C. N., Martin, N. G., Statham, D. J., Todorov, A. A., Slutske, W. S., Bucholz, K. K., et al. (2004). Defining nicotine dependence for genetic research: Evidence from Australian twins. *Psychological Medicine*, 34(5), 865–879.
- Mikami, I., Akechi, T., Kugaya, A., Okuyama, T., Nakano, T., Okamura, H., et al. (1999). Screening for nicotine dependence among smoking-related cancer patients. *Japanese Journal of Cancer Research*, 90(10), 1071–1075.
- Mikulich, S. K., Hall, S. K., Whitmore, E. A., & Crowley, T. J. (2001). Concordance between DSM-III-R and DSM-IV diagnoses of substance use disorders in adolescents. *Drug and Alcohol Dependence*, 61(3), 237–248.
- Moolchan, E. T., Radzius, A., Epstein, D. H., Uhl, G., Gorelick, D. A., Cadet, J. L., et al. (2002). The Fagerstrom test for nicotine dependence and the diagnostic interview schedule: Do they diagnose the same smokers? *Addictive Behaviors*, 27(1), 101–113.
- Muthen, B., & Asparouhov, T. (2006). Item response mixture modeling: Application to tobacco dependence criteria. *Addictive Behaviors*, 31(6), 1050–1066.
- Nathan, P. (1994). Psychoactive substance dependence. In T. Widiger, A. Frances, H. Pincus, M. First, R. Ross, & W. Davis (Eds.), *Dsm-iv sourcebook* (pp. 33–43). Washington, DC: American Psychiatric Association.
- Nelson, C. B., & Wittchen, H. U. (1998). Smoking and nicotine dependence. Results from a sample of 14- to 24-year-olds in Germany. *European Addiction Research*, 4(1–2), 42–49.
- Neuman, M. D., Bitton, A., & Glantz, S. A. (2005). Tobacco industry influence on the definition of tobacco related disorders by the American psychiatric association. *Tobacco Control*, 14(5), 328–337.
- O'Loughlin, J., DiFranza, J., Tyndale, R. F., Meshefedjian, G., McMillan-Davey, E., Clarke, P. B., et al. (2003). Nicotine-dependence symptoms are associated with smoking frequency in adolescents. *American Journal of Preventive Medicine*, 25(3), 219–225.
- O'Loughlin, J., Gervais, A., Dugas, E., & Meshefedjian, G. (2009). Milestones in the process of cessation among novice adolescent smokers. *American Journal of Public Health*, 99(3), 499–504.
- Perez-Stable, E., Herrera, B., Jacob, P., & Benowitz, N. (1998). Nicotine metabolism and intake in black and white smokers. *JAMA*, 280, 152–156.
- Pergadia, M. L., Heath, A. C., Martin, N. G., & Madden, P. A. (2006). Genetic analyses of DSM-IV nicotine withdrawal in adult twins. *Psychological Medicine*, 36(7), 963–972.
- Perkins, K. A., Gerlach, D., Broge, M., Grobe, J., Sanders, M., Fonte, C., et al. (2001). Dissociation of nicotine tolerance from tobacco dependence in humans. *Journal of Pharmacology & Experimental Therapeutics*, 296, 849–856.
- Piper, M. E., McCarthy, D. E., & Baker, T. B. (2006). Assessing tobacco dependence: A guide to measure evaluation and selection. *Nicotine & Tobacco Research*, 8(3), 339–351.
- Piper, M. E., McCarthy, D. E., Bolt, D. M., Smith, S. S., Lerman, C., Benowitz, N., et al. (2008). Assessing dimensions of nicotine dependence: An evaluation of the Nicotine Dependence Syndrome Scale (NDSS) and the Wisconsin Inventory of Smoking Dependence Motives (WISDM). *Nicotine & Tobacco Research*, 10(6), 1009–1020.
- Poirier, M., Canceil, O., Bayle, F., Millet, B., Bourdel, M., Moatti, C., et al. (2002). Prevalence of smoking in psychiatric patients. *Progress in neuro-psychopharmacology & biological psychiatry*, 26(3), 529.
- Pomerleau, C. S., Marks, J. L., & Pomerleau, O. F. (2000). Who gets what symptom? Effects of psychiatric cofactors and nicotine dependence on patterns of smoking withdrawal symptomatology. *Nicotine & Tobacco Research*, 2(3), 275–280.
- Robins, L. N., Helzer, J. E., Ratcliff, K. S., & Seyfried, W. (1982). Validity of the diagnostic interview schedule, version II: DSM-III diagnoses. *Psychological Medicine*, 12(4), 855–870.
- Saunders, J. (2006). Substance dependence and non-dependence in the Diagnostic and Statistical Manual of mental disorders (DSM) and the International Classification of Diseases (ICD): Can an identical conceptualization be achieved? *Addiction*, 101(Suppl. 1), 48–58.
- Schmitz, N., Kruse, J., & Kugler, J. (2003). Disabilities, quality of life, and mental disorders associated with smoking and nicotine dependence. *American Journal of Psychiatry*, 160(9), 1670–1676.
- Schumann, A., Hapke, U., Meyer, C., Rumpf, H. J., & John, U. (2004). Prevalence, characteristics, associated mental disorders and predictors of DSM-IV nicotine dependence. *European Addiction Research*, 10(1), 29–34.
- Scragg, R., Wellman, R. J., Laugesen, M., & DiFranza, J. R. (2008). Diminished autonomy over tobacco can appear after the first cigarette. *Addictive Behaviors*, 33, 689–698.
- Shiffman, S., & Sayette, M. (2005). Validation of the Nicotine Dependence Syndrome Scale (NDSS): A criterion-group design contrasting chippers and regular smokers. *Drug & Alcohol Dependence*, 79(1), 45–52.
- Sir, A., & Ozkan, M. (1998). Nicotine dependency of a girl at the age of 18 months. *Addiction Biology*, 3, 483–484.
- Sledjeski, E. M., Dierker, L. C., Costello, D., Shiffman, S., Donny, E., & Flay, B. R. (2007). Predictive validity of four nicotine dependence measures in a college sample. *Drug and Alcohol Dependence*, 87(1), 10–19.
- Spiegel, A. (2005). *The dictionary of disorder*: The New Yorker January 3.
- Stanton, W. R. (1995). DSM-III-R tobacco dependence and quitting during late adolescence. *Addictive Behaviors*, 20(5), 595–603.
- Storr, C. L., Zhou, H., Liang, K. Y., & Anthony, J. C. (2004). Empirically derived latent classes of tobacco dependence syndromes observed in recent-onset tobacco smokers: Epidemiological evidence from a national probability sample survey. *Nicotine & Tobacco Research*, 6(3), 533–545.
- Streiner, D., & Norman, G. (2003). *Health measurement scales a practical guide to their development and use*. New York: Oxford University Press, Inc.
- Strong, D. R., Brown, R. A., Ramsey, S. E., & Myers, M. G. (2003). Nicotine dependence measures among adolescents with psychiatric disorders: Evaluating symptom expression as a function of dependence severity. *Nicotine & Tobacco Research*, 5(5), 735–746.
- Strong, D. R., Kahler, C. W., Ramsey, S. E., & Brown, R. A. (2003). Finding order in the DSM-IV nicotine dependence syndrome: A Rasch analysis. *Drug and Alcohol Dependence*, 72(2), 151–162.
- Swan, G. E., Ward, M. M., & Jack, L. M. (1996). Abstinence effects as predictors of 28-day relapse in smokers. *Addictive Behaviors*, 21(4), 481.
- Vega, W. A., Chen, K. W., & Williams, J. (2007). Smoking, drugs, and other behavioral health problems among multiethnic adolescents in the NHSDA. *Addictive Behaviors*, 32(9), 1949.
- Wellman, R., DiFranza, J., & Wood, C. (2006). Tobacco chippers report diminished autonomy over tobacco use. *Addictive Behaviors*, 31, 717–721.
- West, R. (2005, 2006). *Understanding nicotine and tobacco addiction*. Paper presented at the Symposium on Understanding Nicotine and Tobacco, Addiction, Chichester, UK; Hoboken, NJ.
- Woody, G. E., Cottler, L. B., & Cacciola, J. (1993). Severity of dependence: Data from the DSM-IV field trials. *Addiction*, 88(11), 1573–1579.
- World Health Organization. (1992). *International classification of diseases and related health problems, 10th rev*. Geneva: World Health Organization.
- Xian, H., Scherrer, J. F., Madden, P. A. F., Lyons, M. J., Tsuang, M., True, W. R., et al. (2005). Latent class typology of nicotine withdrawal: Genetic contributions and association with failed smoking cessation and psychiatric disorders. *Psychological medicine*, 35(3), 409.