Review

Stages in the development of adolescent smoking

Kathryn P. Mayhew *, Brian R. Flay, Joshua A. Mott

Health Research and Policy Centers, School of Public Health, University of Illinois at Chicago, Chicago, IL, USA

Contents
1. Introduction ................................................ S 62
2. Overview of stage definitions of smoking ...................... S 62
2.1. Measurement ............................................ S 63
3. Review of empirical studies: predictors of stages ............... S 64
3.1. Classification scheme of studies of predictors of stages of smoking uptake .... S 64
3.2. Category 1 studies: cross-sectional ............................. S 65
3.2.1. Individual variables ..................................... S 65
3.2.2. Family variables ....................................... S 65
3.2.3. Non-family characteristics ................................. S 72
3.2.4. Summary of category 1 studies .............................. S 72
3.3. Category 2 studies: prospective with aggregation of stages ........ S 73
3.3.1. Individual characteristics .................................. S 73
3.3.2. Family characteristics .................................... S 73
3.3.3. Non-family characteristics ................................. S 73
3.3.4. Interactions of characteristics ............................... S 73
3.3.5. Summary of category 2 studies.............................. S 73
3.4. Category 3 studies: prospective with delineation of stages .......... S 74
3.4.1. Individual characteristics .................................. S 74
3.4.2. Family characteristics .................................... S 74
3.4.3. Non-family characteristics ................................. S 74
3.4.4. Interactions of characteristics ............................... S 74
3.4.5. Summary of category 3 studies.............................. S 74
3.5. Category 4 studies: developmental issues ................. S 75
3.5.1. Individual characteristics .................................. S 75
3.5.2. Family characteristics .................................... S 75
3.5.3. Non-family characteristics ................................. S 75
3.5.4. Interactions of characteristics ............................... S 75
3.5.5. Summary of category 4 studies.............................. S 75
4. Discussion ................................................. S 75
4.1. Findings ............................................... S 75
4.2. Gaps in our knowledge ...................................... S 76
4.2.1. Theoretical stages and issues of measurement .......... S 76
4.2.2. Inter-individual differences in intra-individual change .... S 77
4.2.3. Does smoking progression consist of stages or is it continuous in nature? . S 78
5. Conclusions ................................................ S 78

* Corresponding author. Present address: Department of Applied Psychology, St Cloud State University, 720 S. 4th Street, St Cloud, MN 56301, USA. Tel.: +1-302-2553131.
E-mail address: kmayhew@stcloudstate.edu (K.P. Mayhew)

0376-8716/00/$ - see front matter © 2000 Elsevier Science Ireland Ltd. All rights reserved.
PII: S 0 3 7 6 - 8 7 1 6 ( 9 9 ) 0 0 1 6 5 - 9
Abstract

Many researchers have conceptualized smoking uptake behavior in adolescence as progressing through a sequence of developmental stages. Multiple social, psychological, and biological factors influence this process, and may play different functions at different points in the progression, and play different roles for different people. The major objective of this paper is to review empirical studies of predictors of transitions in stages of smoking progression, and identify similarities and differences related to predictors of stages and transitions across studies. While a number of factors related to stage of progression replicated across studies, few variables uniquely predicted a particular stage or transition in smoking behavior. Subsequently, theoretical considerations related to stage conceptualization and measurement, inter-individual differences in intra-individual change, and the staged or continuous nature of smoking progression are discussed. © 2000 Elsevier Science Ireland Ltd. All rights reserved.

Keywords: Stages; Transitions; Adolescence; Smoking

1. Introduction

Many authors have conceptualized smoking uptake behavior in adolescence as progressing through a sequence of developmental stages. A diversity of stage definitions reflects the involvement of multiple academic disciplines in smoking research (e.g. psychology, epidemiology, human development, behavioral medicine). Furthermore, multiple social, psychological, and biological factors influence this progression. In addition, different factors may play different functions at different points in the progression, and play different roles for different individuals (Flay et al., 1992). However, to date, no review of the literature has assessed whether specific factors (social, psychological, or biological) are associated with different stages of smoking progression. The major objective of this paper is to review empirical studies of predictors of transitions in stages of smoking progression, and identify similarities and differences related to predictors of stages across studies.

In the first section of this paper we provide an overview of the various stage definitions related to smoking behavior. In order to facilitate our analysis, we impose a re-labelling of stages based on our discussion of the theoretical stage definition of smoking. Second, we introduce a categorical classification scheme to facilitate an analysis of the predictors of stages found in empirical studies. For each category we discuss our findings of whether similar variables are related to specific stages across studies, and whether these variables differ according to stage of smoking or transition. Third, we discuss our empirical findings in light of theoretical assumptions. Fourth, we discuss and clarify issues related to ‘gaps’ in our knowledge about smoking uptake behavior and suggest directions for future research. These gaps include theoretical considerations related to stage conceptualizations, construct validity related to stage definitions, issues of developmental measurement, inter-individual differences in intra-individual change in the development of smoking behavior, and a discussion of the staged or continuous nature of smoking uptake behavior.

2. Overview of stage definitions of smoking

Leventhal and Cleary (1980) suggested that smoking has a complex ontogeny, and that the developmental history of a smoker moves through several stages. Flay et al. (1983) and Stern et al. (1987) essentially agreed with the basic premise of stages, and provided minor elaborations of the stages suggested by Leventhal and Cleary. The basic stages were described and summarized in Flay (1993) and the 1994 Surgeon General’s Report (USDHHS, 1994). Despite minor differences in terminology and stage definitions, these three groups of authors all assumed that developmental stages of smoking onset exist and attempted to spell them out. The description that follows is a composite of those models.

Adolescents who have never smoked have probably never thought about smoking and have no desire to start smoking in the near future are in the precontemplation phase. These adolescents have never smoked and are either unaware of positive reasons to start smoking or are ignoring or resisting pressures to smoke.

The contemplation or preparatory stage occurs when adolescents begin to think about smoking and have no desire to start smoking in the near future are in the precontemplation phase. These adolescents have never smoked and are either unaware of positive reasons to start smoking or are ignoring or resisting pressures to smoke.

The contemplation or preparatory stage occurs when adolescents begin to think about smoking. They are forming and modifying their pre-smoking beliefs and attitudes about cigarettes. In the preparatory stage children develop attitudes and have images of what smoking is like well before they try smoking. Often, these beliefs are not favorable, but negative pre-smoking beliefs of future smokers are often blunted by, for example, long-term exposure to media messages or role models, such as parents who smoke. This stage includes
the development of perceptions of what smoking involves, its potential functions, and an increasing awareness of social pressures to smoke. Leventhal and Cleary posited three psychological reasons (in the preparatory phase) for becoming a smoker: (a) to be cool, tough, and independent; (b) to reduce social anxiety by feeling more socially accepted; and (c) to regulate emotions.

The third stage, initiation/try, is simply when adolescents try their first few cigarettes. Some writers consider this to be the culminating point of the contemplation stage (Stern et al., 1987; Pallonen et al., 1998) while others consider it the potential beginning of an experimental stage (Leventhal and Cleary, 1980). Most studies of predictors of transitions have included it as a separate category, as suggested by Flay et al. (1983). The initiation stage is also characterized by stronger peer influences than family influences. Improving one’s self-image is associated with initiation, and may be motivated by poor school performance, as well as by low approval from the desired peer groups.

The fourth stage of experimenting or becoming is characterized by a gradual increase in the frequency of smoking and an increase in the variety of situations in which cigarettes are used. Adolescents in this stage emphasize the positive aspects of smoking and few negative aspects. However, they may receive minimal pleasure from smoking (Eisenberg and Balster, 2000, this volume). They are not totally committed to smoking in the future and are still deciding whether or not it is for them. For those who will become regular smokers, harsh cues that accompany initial smoking may begin to fade (e.g. burning, roughness, bite of the heat) as perceived positive benefits of smoking are realized. It is in this stage that the individual may develop a self-image as a smoker. Family smoking may increase the opportunity for obtaining cigarettes in this stage of experimentation. Furthermore, this stage is characterized by learning how to handle the cigarette, and how to inhale correctly. It is during the stage of experimentation and early stages of regular smoking that physiological reactions may have their greatest effects. Initially, there may be immediate effects related to stimulation of the nervous system and increased heart rate.

In the fifth stage, regular smoking, adolescents progress beyond sporadic smoking to smoking on a regular, though still infrequent basis. Some will smoke every weekend at parties or other gatherings. Some will smoke most week days on the way to or from school. These youth are neither smoking every single day, nor smoking at very high rates. The Monitoring the Future Study data (Institute for Social Research, 1998) show that 58% of 10th grade adolescents have smoked in the past 30 days. However, among 12th grade adolescents only 22.4% report smoking at daily or established levels. These cross-sectional data suggest fewer older adolescents smoke at daily levels, and that many experimental or even regular smokers may not become established/daily smokers. Nevertheless, a sizable percentage may move on to become established/daily smokers.

The final stage is established/daily smoking, where adolescents are smoking daily, or almost every day. Adolescents in this stage may experience dependence/addiction and find it difficult to quit smoking (USDHHS, 1994). These adolescents have progressed beyond sporadic smoking and may develop cravings, heavy daily use of cigarettes and withdrawal symptoms. Smoking has become an integral part of self-regulation in a variety of situations. In this stage both psychological and biological factors influence the maintenance of smoking behaviors. Psychological factors may include smoking for stimulation, pleasure, relaxation, to reduce anxiety, to reduce cravings (psychological addiction), to handle the cigarette, and smoking from habit. Leventhal and Cleary (1980) integrate biological and psychosocial factors of smoking into a ‘multiple regulation’ model. These researchers suggest that initially, smoking regulates emotional responses elicited by environmentally induced stress, then smoking regulates cravings conditioned to external cues, and, finally, smoking regulates cravings due to internal cues caused by changes in blood levels of nicotine. However, it should be noted that, in this review paper, stages of smoking are based on previous research and theory construction, and are categorical in quality. Other researchers suggest a dimensional perspective of smoking intensity. More specifically, these researchers argue that dependency or addiction may occur at levels of smoking less than daily in the form of low rate and occasional smoking. These types of smokers, while considered dependent, have been referred to as ‘tobacco chippers’ (Shiffman, 1989).

Other authors have also suggested variations on the basic stage model: some suggested the term ‘susceptibility’ (and measures of it) in place of preparation or contemplation (Pierce et al., 1996; Wills et al., 1996). Following the tradition of the transtheoretical model, Pallonen et al. (1998) spelled out decision-making stages of acquisition contemplation (never smoked, but thinking about trying in the next 6 months) and acquisition preparation (never smoked, but thinking about starting in the next 30 days). These authors also suggested ‘recent acquisition’ (regular but low rate smoking begun within the last 6 months), a stage characterized by regular smoking but at a rate less than established smoking. Others have suggested stage definitions that have been driven by measurement traditions or strategies rather than theory.

2.1. Measurement

Flay et al. (1983) emphasized that measures of smoking stages should be developmental and not merely a
measure of smoking rate. However, measurement strategies have often driven definitions of stages. For example, regular smoking has been defined on the lower end as smoking more than 100 cigarettes in a lifetime (Distefan et al., 1998), and on the upper end as having smoked 100 cigarettes in a lifetime and smoked in the past 30 days (Flint et al., 1986; Wang et al., 1997). Note that measures like ‘any time in the last 30 days’ or ‘in the last 7 days’ are not strictly measures of monthly or weekly smoking, though they have often been used as such. In addition, the definition of and measurement of dependence has received much attention, and is the subject of two papers in this volume (Colby and Tiffany, 2000a,b).

In a number of empirical studies, researchers have used stage labels with less numerical specificity than those defined above. For example occasional smoking has been defined as smoking less than one cigarette per week. Triers have been defined by smoking more than one cigarette in a lifetime, but not having smoked in the last week. In some studies, ‘regular smokers’ must have smoked more than one cigarette per week (Hu et al., unpublished data; Flay et al., 1983, 1998; Santi et al., 1994; Chassin et al., 1986; Fergusson and Horwood, 1996). Still other studies have labelled stages according to criteria related to monthly use (Chassin et al., 1986) or packs of cigarettes smoked (Jackson and Henriksen, 1997).

In a qualitative research study on adolescent smoking, Hirschman et al. (1984) outlined developmental stages based on reports of 386 students from inner-city public schools in Milwaukee. From this qualitative study a frequency criterion emerged to describe stages of smoking progression in adolescents. These stages included, tried a cigarette, progressed to a second cigarette, progressed to a third cigarette, and progressed to current smoking (regular smokers).

Definitions of smoking stages may also be predicated on the distributional characteristics of the data or the general aim of the research endeavor (replication studies). Continuous data may be collapsed into theoretically meaningful discrete groups. However, a sufficient number of observations must be obtained in each classification to meet statistical and analytical demands, and to proceed with a meaningful analysis of the data (Fergusson, and Horwood, 1995). In a conceptual replication study, the desire for a comprehensive definition of higher level stages may be balanced with stage definitions that facilitate comparable categories across research studies (Hu et al., 2000).

For the purposes of this paper, we use the stage labels, their definitions, and measurement parameters outlined from our discussion of stages (Table 1). To avoid confusion, for each study reviewed, we re-label the author-defined stages into one of our five stages, or as closely as possible.

3. Review of empirical studies: predictors of stages

3.1. Classification scheme of studies of predictors of stages of smoking uptake

In this review paper an attempt was made to provide an exhaustive list of research studies that addressed stages of smoking during the adolescent years. No geographical limitations were imposed on the literature search. Articles in this review represent research from Canada, the United States, England, New Zealand, and Australia. Subsequently, generalizing these findings to other geographic locations should be made with these limitations in mind.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Definition</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a. Non-smoking — preparation</td>
<td>Non-smoker and does not intend to smoke.</td>
<td>‘Susceptible’ (Pierce et al., 1996) to smoking.</td>
</tr>
<tr>
<td>1b. Non-smoking — contemplation, preparation</td>
<td>Non-smoker and intends to smoke. Belief and attitude formation; susceptible to peer pressure.</td>
<td>‘Susceptible’ (Pierce et al., 1996) to smoking.</td>
</tr>
<tr>
<td>2. Tried</td>
<td>Answers yes to ‘ever smoke’, has not smoked more than one or two cigarettes. Has not smoked in last year. May state they have tried but quit.</td>
<td>Tried only a puff or one-two cigarettes</td>
</tr>
<tr>
<td>4. Experimenter</td>
<td>Smokes occasionally on an experimental basis. Does not intend to be a permanent smoker.</td>
<td>Smoked more than once, less than monthly (not in last 30 days) or weekly. Smoked more than one puff/one cigarette, but probably less than 100 cigarettes in life time.</td>
</tr>
<tr>
<td>5. Regular</td>
<td>Smokes at least monthly, not as frequently as daily</td>
<td>Smoked more than once, smoked in past month (30 days) or week. Smoked greater than 100 cigarettes in lifetime.</td>
</tr>
<tr>
<td>6. Established/daily smoker (dependent)</td>
<td>Smokes daily or almost daily. May smoke heavily on occasion. Smoking intensity is indicative of dependence (USDHHS, 1994).</td>
<td>Smokes daily or almost every day.</td>
</tr>
</tbody>
</table>
A large number of psychosocial risk factors have been associated with adolescent tobacco use (Conrad et al., 1992), but far less is known about predictors of higher-level smoking. The identification of psychosocial predictors of smoking behavior has informed stage definitions in psychosocial theories of smoking uptake behavior (Leventhal and Cleary, 1980; Flay et al., 1983). Clarification of current research findings is needed in order to substantiate or negate the hypothesis that similar variables (social, psychological, or biological) may be associated with specific stages of smoking across studies, and that these variables may differ according to stage or transition in smoking progression.

In order to facilitate our analysis, we classified studies dealing with stage progression in smoking according to two criteria (Table 2). First, we classified studies based on whether they utilized cross-sectional or prospective designs. Studies that were prospective provide stronger evidence for the developmental nature of smoking progression. Second, we classified studies based on whether or not they clearly specified smoking stages. Studies that delineate stages of higher-level smoking (e.g. experimental, regular, established) provide more evidence for the developmental nature of smoking progression than those studies that aggregate categories of higher level use. In sum, research studies that incorporate a prospective design and delineate stages of smoking will bolster our confidence in the potential developmental findings of this review. Historically, researchers have progressed from cross-sectional to prospective studies, and from consideration of fewer (aggregated) stages to analysis of a greater number of more refined stages. Hence, our categorical classification of studies.

Within each group of studies, we classify predictor variables of smoking stages into individual (intra-personal), familial, and social (non-familial) characteristics. This type of classification, characteristic of research on resilience (Rutter, 1987; Garmezy, 1993), further facilitated identification and clarification of predictor variables related to higher levels of smoking behavior (cf. Flay and Petrakis, 1994). Table 3 shows the studies reviewed and their design characteristics.

3.2. Category 1 studies: cross-sectional

Overall, category 1 studies are cross-sectional and clearly delineate levels of smoking heavier than tried or initiated. Predictors of smoking stages were classified according to individual, family, and non-family variables, and an interaction between these variables. We found 11 studies descriptive of this category.

3.2.1. Individual variables

Being male (Siddiqui et al., unpublished data; Palmer, 1970; Flay et al., 1983; Mott et al., 2000), and white (Siddiqui et al., unpublished data; Flay et al., 1983; Mott et al., 2000) was related to trying, experimental, and regular smoking. Positive attitudes and beliefs about smoking were related to trying, experimenting, regular and established smoking (Virgili et al., 1991; Wang et al., 1996; Robinson et al., 1997; Hill et al., 1998; Pallonen et al., 1998). In addition, concerns with body weight were identified as variables related to experimental and regular cigarette use (Wang et al., 1996; Robinson et al., 1997). Affect regulation, and perceptions that smoking helps with relaxation and stress reduction were related to experimental, regular, and established smoking (Wang et al., 1996; Pallonen et al., 1998), and perceptions of cigarette accessibility was related to trying, experimenting, and regular smoking (Jackson and Henriksen, 1997; Robinson et al., 1997).

3.2.2. Family variables

The number of family members who smoked was related to smoking at the trier, experimenter, and regular smoking stages (Palmer, 1970; Hunter et al., 1982; Flay et al., 1983; Jackson and Henriksen, 1997; Robinson et al., 1997; Hill et al., 1998; Mott et al.,...
### Table 3
Research studies included in this review

<table>
<thead>
<tr>
<th>Study and year of publication</th>
<th>Age/grade at start of study, place, and n</th>
<th>Research design and analytic strategy</th>
<th>Study stages</th>
<th>Re-labelled stages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category 1 studies</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hunter et al., 1982</td>
<td>8–17 years Louisiana (n = 3014)</td>
<td>Cross-sectional Regression analyses-Guttman Scales</td>
<td>Never-smokers Non-current smokers (smoked, but not in last week) Current smokers (smoked at least once a week)</td>
<td>Non-smoking Experimenter</td>
</tr>
<tr>
<td>Palmer, 1970</td>
<td>7th and 8th grades South Dakota, Iowa (n = 2729)</td>
<td>Cross-sectional Stratified descriptive tables</td>
<td>Never smoked (I have never tried even one cigarette) Experimenter (I have tried to smoke but quit) Regular smoker (I smoke most or all of time)</td>
<td>Non-smoking Tried Regular</td>
</tr>
<tr>
<td>Flay et al., 1983</td>
<td>9–13 years Canada (n = 668)</td>
<td>Cross-sectional Chi-square</td>
<td>Never-smokers Quitters (subjects who had smoked, but quit) Experimenters (subjects who smoked less than once a week) Regular smokers (smoked at least once per week)</td>
<td>Non-smoking Tried Experimenter Regular</td>
</tr>
<tr>
<td>Hill et al., 1997</td>
<td>7th grade Canada (n = 360)</td>
<td>Cross-sectional MANOVA Discriminant function analysis</td>
<td>Non-smoker (weak intention to smoke) Non-smoker (strong intention to smoke) Occasional smoker (weak intention to smoke) Occasional smoker (strong intention to smoke) Regular smoker (strong intention to smoke) Likely quitter (weak intention to smoke)</td>
<td>Non-smoking (contemplation/preparatory) Experimenter Regular</td>
</tr>
<tr>
<td>Jackson, 1997</td>
<td>4th and 6th grades North Carolina (n = 1442)</td>
<td>Cross-sectional Discriminant function analysis</td>
<td>Never smoked Initiators (have tried smoking, and have smoked between one or two puffs and most or all of one cigarette) Experimenters (have tried smoking and report having smoked from two to four cigarettes to more than five packs of cigarettes)</td>
<td>Non-smoking Tried Experimenter</td>
</tr>
<tr>
<td>Pallonen et al., 1998</td>
<td>10th and 11th grades Rhode Island</td>
<td>Cross-sectional ANOVA and (\chi^2) statistics</td>
<td>Acquisition pre-contemplation (never smoked and not intention to in next 6 months) Acquisition contemplation (never smoked but think about trying in next 6 months) Acquisition preparation (never smoked but thinking about starting in next 30 days) Recent acquisition (smoking less than 6 months) First cessation stage: pre-contemplation (smoking greater than 6 months, no intention to quit in next 6 months)</td>
<td>Non-smoking Regular Established</td>
</tr>
<tr>
<td>Study and year of publication</td>
<td>Age/grade at start of study, place, and n</td>
<td>Research design and analytic strategy</td>
<td>Study stages</td>
<td>Re-labelled stages</td>
</tr>
<tr>
<td>------------------------------</td>
<td>------------------------------------------</td>
<td>--------------------------------------</td>
<td>--------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Virgili et al., 1991</td>
<td>10th and 11th grades Australia n = 199</td>
<td>Cross-sectional Bivariate and discriminant function analyses</td>
<td>Never smokers (never smoked, Non-smoking and no plans to start)</td>
<td>Tried</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Experimenters (smoked one or two cigarettes just to see what it was like)</td>
<td>Established</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Current smokers (regularly smokes at least one cigarette a day)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ex-smokers (tried smoking but no longer smokes)</td>
<td></td>
</tr>
<tr>
<td>Robinson et al., 1997</td>
<td>7th grade Middle southern US n = 6967</td>
<td>Cross-sectional Logistic regression analysis</td>
<td>Non-smokers</td>
<td>Non-smoking</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Experimenters (smoked, but less than once a week)</td>
<td>Regular</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Regular smokers (once a week or more)</td>
<td>Regular</td>
</tr>
<tr>
<td>Mott et al., 2000</td>
<td>9th grade California n = 2352</td>
<td>Cross-sectional Logistic regression analysis for ordinal outcomes</td>
<td>Never-smokers</td>
<td>Non-smoking</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Experimenters (smoked once per month or less)</td>
<td>Tried</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Regular smokers (smoked at least several times per month)</td>
<td>Regular</td>
</tr>
<tr>
<td>Siddiqui et al., unpublished data</td>
<td>9th grade California n = 913</td>
<td>Cross-sectional Poisson random-effects regression analysis</td>
<td>Number of cigarettes smoked in the last week, among a sample of smokers (smoked in the past 12 months)</td>
<td>Frequency</td>
</tr>
<tr>
<td>Wang et al., 1996</td>
<td>12–18 years US national sample n = 9774</td>
<td>Cross-sectional Logistic regression and odds ratios</td>
<td>Non-smokers (never smoked a cigarette)</td>
<td>Non-smoking</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Experimenters (had smoked or tried smoking, but had not smoked 100 cigarettes in life time, and had not smoked in the past 30 days)</td>
<td>Regular</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Regular smokers (current smokers, smoked at least 10 of the last 30 days, and smoked at least 100 cigarettes in life time)</td>
<td></td>
</tr>
</tbody>
</table>

**Category 2 studies**

<table>
<thead>
<tr>
<th>Study</th>
<th>Age/grade at start of study, place, and n</th>
<th>Research design and analytic strategy</th>
<th>Study stages</th>
<th>Re-labelled stages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reynolds and Nichols, 1976</td>
<td>12th grade (T1) 1 year between T1 and T2 n = 730 National sample</td>
<td>Longitudinal One-way ANOVA</td>
<td>Never smoked (did not smoke in 1962 or 1963)</td>
<td>Not re-labelled</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Starter (did not smoke in 1962, but smoked in 1963)</td>
<td>Higher stages aggregated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Quitter (smoked in 1962 but did not smoke in 1963)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Regular smoker (smoked in 1962 and 1963)</td>
<td></td>
</tr>
<tr>
<td>Gerber and Newman, 1989</td>
<td>7th and 8th grades 1 year between T1 and T2 Midwestern US n = 2550</td>
<td>Longitudinal Discriminant function analysis</td>
<td>Experimental smokers (smoked a few times in last 6 months, usually smoked a half pack or less per day) and assessed for an increase or decrease in smoking</td>
<td>Higher stages aggregated</td>
</tr>
<tr>
<td>Study and year of publication</td>
<td>Age/grade at start of study, place, and ( n )</td>
<td>Research design and analytic strategy</td>
<td>Study stages</td>
<td>Re-labelled stages</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>---------------------------------</td>
<td>-----------------------------------</td>
<td>--------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Murray et al., 1983</td>
<td>11 and 12 years&lt;br&gt;1 year between T1 and T2&lt;br&gt;England&lt;br&gt;( n = 3971 )</td>
<td>Longitudinal&lt;br&gt;Proportional analysis</td>
<td>Non-smokers (never smoked a cigarette)&lt;br&gt;Triers (have only tried smoking once)&lt;br&gt;Occasional smokers (smoke sometimes but not as much as once a week)&lt;br&gt;Light smokers (smokes one to six cigarettes a week)&lt;br&gt;Regular smokers (smokes six or more cigarettes a week)</td>
<td>Not re-labelled&lt;br&gt;Higher stages aggregated</td>
</tr>
<tr>
<td>Ary and Biglan, 1983</td>
<td>Middle and high school&lt;br&gt;6 months between T1 and T2&lt;br&gt;Oregon&lt;br&gt;( n = 884 )</td>
<td>Longitudinal&lt;br&gt;Hierarchical multiple regression analyses</td>
<td>Predicted smoking among a sample of baseline non-smokers&lt;br&gt;Predicted continuous smoking among a sample of baseline smokers</td>
<td>Not re-labelled&lt;br&gt;Higher stages aggregated</td>
</tr>
<tr>
<td>Chassin et al., 1984</td>
<td>6–11th grades&lt;br&gt;1 year between T1 and T2&lt;br&gt;Midwestern US&lt;br&gt;( n = 2818 )</td>
<td>Longitudinal&lt;br&gt;Discriminant function analyses</td>
<td>Never smoked&lt;br&gt;Triers (had smoked just to try)&lt;br&gt;Regular (not more than one cigarette per month, not more than one cigarette per week, more than one cigarette per week)</td>
<td>Not re-labelled&lt;br&gt;Higher stages aggregated</td>
</tr>
<tr>
<td>Pederson and Lefcoe, 1986</td>
<td>10 years&lt;br&gt;8 years between T1 and T2&lt;br&gt;Ontario&lt;br&gt;( n = 1955 )</td>
<td>Longitudinal&lt;br&gt;Discriminant function analyses</td>
<td>Never smoked&lt;br&gt;Experimentation (tried a few cigarettes or used to smoke)&lt;br&gt;Current smoking (smoke once in a while or more)</td>
<td>Not re-labelled&lt;br&gt;Higher stages aggregated</td>
</tr>
<tr>
<td>Chassin et al., 1986</td>
<td>6–11th grades&lt;br&gt;1 year between T1 and T2&lt;br&gt;Midwestern US&lt;br&gt;( n = 2660 )</td>
<td>Longitudinal&lt;br&gt;Logistic regression analysis</td>
<td>Never smoked&lt;br&gt;Triers (smoked just to try)&lt;br&gt;Regular (not more than one cigarette per month, not more than one cigarette per week, more than one cigarette per week)</td>
<td>Not re-labelled&lt;br&gt;Higher stages aggregated</td>
</tr>
<tr>
<td>Ary and Biglan, 1988</td>
<td>7–10th grades&lt;br&gt;1 year between T1 and T2&lt;br&gt;Oregon&lt;br&gt;( n = 801 )</td>
<td>Longitudinal&lt;br&gt;Multiple regression analyses and discriminant function analyses</td>
<td>Non-smoker&lt;br&gt;Continuous smoke (number of cigarettes smoked in last week + (7 \times \text{number of cigarettes smoked yesterday})/2)</td>
<td>Not re-labelled&lt;br&gt;Higher stages aggregated</td>
</tr>
<tr>
<td>Chassin et al., 1992</td>
<td>6–11th grades&lt;br&gt;1 year between T1 and T2&lt;br&gt;Midwestern US&lt;br&gt;( n = 2078 )</td>
<td>Longitudinal&lt;br&gt;Logistic regression analysis</td>
<td>Never smoked&lt;br&gt;Triers (smoked just to try)&lt;br&gt;Regular (not more than one cigarette per month, not more than one cigarette per week, more than one cigarette per week)</td>
<td>Not re-labelled&lt;br&gt;Higher stages aggregated</td>
</tr>
</tbody>
</table>
Table 3 (Continued)

<table>
<thead>
<tr>
<th>Study and year of publication</th>
<th>Age/grade at start of study, place, and n</th>
<th>Research design and analytic strategy</th>
<th>Study stages</th>
<th>Re-labelled stages</th>
</tr>
</thead>
<tbody>
<tr>
<td>McGee and Stanton, 1993</td>
<td>13 years 2 years between T1 and T2 New Zealand n = 719</td>
<td>Longitudinal Logistic regression analysis</td>
<td>Never smoker (not in last 30 days or past 2 years) Some level of smoking (smoked in last 30 days)</td>
<td>Higher stages aggregated</td>
</tr>
<tr>
<td>Eckhardt et al., 1994</td>
<td>12–15 years 3 years between T1 and T2 California n = 2480</td>
<td>Longitudinal Multiple regression Residual gain scores</td>
<td>Frequency of smoking in the past 30 days (1 = none to 5 = ten or more times)</td>
<td>Higher stages aggregated</td>
</tr>
<tr>
<td>Day et al., unpublished data</td>
<td>7th grade 1 year between T1, T2 and T3 California n = 3781</td>
<td>Longitudinal Logistic regression analysis</td>
<td>Never smokers Frequency of lifetime smoking (1 = none to 7 = five or more packs)</td>
<td>Higher stages aggregated</td>
</tr>
<tr>
<td>Chassin et al., 1990</td>
<td>T1 grades 6–12 (1980–1983), T2 adults (1987–1988) n = 4156</td>
<td>Longitudinal Multinomial logistic regression</td>
<td>Never smokers Tiers (Chassin et al., 1986) Ex-smokers (used to be a regular smoker) Regular smokers (once a month or more) Regular smoking at T2 (having smoked in the last week)</td>
<td>Not re-labelled</td>
</tr>
<tr>
<td>Krohn et al., 1985</td>
<td>Junior high and high school 1 year each between T1, T2, and T3</td>
<td>Longitudinal Path analysis</td>
<td>Never used Tried (used once or twice) Frequency of smoking (1 = never to 6 = daily)</td>
<td>Higher stages aggregated</td>
</tr>
<tr>
<td>Krohn et al., 1983</td>
<td>Junior high and high school 1 year each between T1, T2, and T3</td>
<td>Longitudinal Multiple regression</td>
<td>Frequency of smoking (1 = never; 6 = daily)</td>
<td>Higher stages aggregated</td>
</tr>
<tr>
<td>Alexander et al., 1983</td>
<td>10–12 years 1 year between T1 and T2 Australia n = 5616</td>
<td>Longitudinal Logistic regression analysis</td>
<td>Non-smoking Adopter (smoke at any level) Quitter (smoke at T1 and not T2)</td>
<td>Not re-labelled</td>
</tr>
<tr>
<td>Bauman et al., 1984</td>
<td>8th grade 1 year between T1 and T2 North Carolina n = 1334</td>
<td>Longitudinal Correlations and regression</td>
<td>Never smokers Puffers (just a few puffs lifetime) Current smokers (more than one pack in life)</td>
<td>Higher stages aggregated</td>
</tr>
<tr>
<td>Flay et al., 1994</td>
<td>7th grade 15 months between T1 and T2 California n = 4896</td>
<td>Longitudinal Structural equation 7th grade (T1); 9th grade (T2) modelling</td>
<td>Never smoker Experimenters (one or less cigarettes) Higher level (more than one cigarette)</td>
<td>Not re-labelled</td>
</tr>
<tr>
<td>Croft et al., 1985</td>
<td>8–17 years 1 year between T1 and T2 Louisiana n = 2880</td>
<td>Longitudinal Percentages</td>
<td>Non-smoking Experimental non-adopters (smoke less than one cigarette a week, but quit later) Adopters (those who smoke at least once per week)</td>
<td>Higher stages aggregated</td>
</tr>
<tr>
<td>Study and year of publication</td>
<td>Age/grade at start of study, place, and n</td>
<td>Research design and analytic strategy</td>
<td>Study stages</td>
<td>Re-labelled stages</td>
</tr>
<tr>
<td>------------------------------</td>
<td>------------------------------------------</td>
<td>--------------------------------------</td>
<td>--------------</td>
<td>-------------------</td>
</tr>
<tr>
<td><strong>Category 3 studies</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flint, et al., 1998</td>
<td>11–18 years</td>
<td>Longitudinal</td>
<td>Experimental smokers (tried or experimented with cigarette smoking (even a few puffs, smoked a cigarette, smoked less than 100 cigarettes in lifetime and had smoked 10 days or less in the past 30 days))</td>
<td>Regular</td>
</tr>
<tr>
<td></td>
<td>4 years between T1 and T2 National US sample n = 2467</td>
<td>Multiple logistic regression analysis</td>
<td>Regular smokers (smoked at least 100 cigarette in lifetime and had smoked in the past 30 days).</td>
<td>Regular</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lawrence and Rubinson, 1986</td>
<td>6th and 7th grade 5 months between T1 and T2, and 3 months between T2 and T3 n = 554</td>
<td>Longitudinal Discriminant function analysis</td>
<td>Never-smokers</td>
<td>Non-smoking</td>
</tr>
<tr>
<td></td>
<td>Never smoked Experimenters (smoked less than once a week)</td>
<td></td>
<td>Experimented</td>
<td></td>
</tr>
<tr>
<td>Stanton et al., 1991</td>
<td>9 years 2 years each between T1, T2, T3, and T4 New Zealand n = 967</td>
<td>Longitudinal Spearman correlations percent</td>
<td>Regular smokers (smoked at least once per week)</td>
<td>Regular</td>
</tr>
<tr>
<td></td>
<td>Never smoked Not in last year In last year but not in last month In last month but not each day</td>
<td></td>
<td>Non-smoking</td>
<td></td>
</tr>
<tr>
<td>Santi et al., 1994</td>
<td>6th grade 1 year between T1 and T2 Ontario n = 3884</td>
<td>Longitudinal Logistic regression analyses</td>
<td>Never smoked</td>
<td>Non-smoking</td>
</tr>
<tr>
<td></td>
<td>Tried once Experimental (smokes but not weekly)</td>
<td></td>
<td>Experimented</td>
<td></td>
</tr>
<tr>
<td>Pierce et al., 1996</td>
<td>12–18 years 4 years between T1 and T2 National US sample n = 4500</td>
<td>Longitudinal SUDAAN multi-level modelling and nested logistic regressions</td>
<td>Never smoked</td>
<td>Non-smoking</td>
</tr>
<tr>
<td></td>
<td>Regular smokers (smokes weekly)</td>
<td></td>
<td>Regular</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Never smoked (susceptible, non-susceptible)</td>
<td></td>
<td>Non-smoking</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Experimenters (tried, smoked a puff, smoked a cigarette in the last 30 days) Current smokers (ever smoked Regular 100 cigarettes, smoked in last 30 days)</td>
<td></td>
<td>Experimented</td>
<td></td>
</tr>
<tr>
<td>Choi et al., 1997</td>
<td>12–18 years 4 years between T1 and T2 National US sample 0n = 2684</td>
<td>Longitudinal SUDAAN and multiple logistic regression</td>
<td>Puffers (smoked a few puffs in life but not whole cigarette) Non-current experi</td>
<td>Regular</td>
</tr>
<tr>
<td></td>
<td>Never smoked Experimenters (one to 100 cigarettes, not in past 30 days)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wang et al., 1997</td>
<td>11–18 years 4 years between T1 and T2 National US sample n = 7950</td>
<td>Longitudinal 2 × 2 Tables with odds ratios</td>
<td>Never smoke</td>
<td>Non-smoking</td>
</tr>
<tr>
<td></td>
<td>Experimented (one to 100 cigarettes, not in past 30 days)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Regular smokers (smoked in past 30 days and more than 100 cigarettes in life)</td>
<td></td>
<td>Regular</td>
<td></td>
</tr>
<tr>
<td>Study and year of publication</td>
<td>Age/grade at start of study, place, and n</td>
<td>Research design and analytic strategy</td>
<td>Study stages</td>
<td>Re-labelled stages</td>
</tr>
<tr>
<td>------------------------------</td>
<td>----------------------------------------</td>
<td>--------------------------------------</td>
<td>--------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Flay et al., 1998</td>
<td>7th grade 5 years between T1 and T2 California n = 2912</td>
<td>Longitudinal Multinomial logistic regression analysis</td>
<td>Never smokers Tiers (smoked all or part of one cigarette) Experimenters (smoked more than one cigarette, but not in last week) Regular smokers (smoked in past week)</td>
<td>Non-smoking Tried Experimenters Regular</td>
</tr>
<tr>
<td>Distefan et al., 1998</td>
<td>12–18 years 4 years between T1 and T2 National US sample n = 2684</td>
<td>Longitudinal SUDAAN multi-level logistic regression analysis</td>
<td>Never smokers Experimenters (smoked but less than 100 cigarettes) Regular smokers (smoked more than 100 cigarettes in lifetime)</td>
<td>Non-smoker Experimenters Regular</td>
</tr>
<tr>
<td>Category 4 studies</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Andrews and Duncan, 1998</td>
<td>11–15 years 1 year between each of four waves Oregon n = 763</td>
<td>Longitudinal Latent growth modelling</td>
<td>Never smokers Current smoker (smoked greater than 30 cigarettes/month) Assessed frequency of lifetime use</td>
<td>Non-smoker Regular</td>
</tr>
<tr>
<td>Fergusson and Horwood, 1995</td>
<td>10 years 2 years between each of four waves New Zealand n = 957</td>
<td>Longitudinal Markov latent transition analysis</td>
<td>Non-smoker Occasional smoker (less than one per week) Regular smoker (more than one per week)</td>
<td>Non-smoker Experimenters Regular</td>
</tr>
<tr>
<td>Patton et al., 1998a</td>
<td>14 years 6 months between each of six waves Australia n = 1947</td>
<td>Longitudinal Odds ratios and Cox proportional hazard models with GLM</td>
<td>Non-smokers (no smoking in month before survey, includes ex-smokers) Current smoking (any smoking in past month) Daily smoking (smoked on 6 or 7 days in past week)</td>
<td>Non-smoking Established</td>
</tr>
<tr>
<td>Patton et al., 1998b</td>
<td>14–15 years 6 months between each of six waves Australia n = 2032</td>
<td>Longitudinal Odds ratios and hazard ratios from time survival analysis</td>
<td>Non-smokers (no smoking in month before survey, includes ex-smokers) Current smoking (any smoking in past month) Daily smoking (smoked on 6 or 7 days in past week)</td>
<td>Non-smoking Established Regular</td>
</tr>
<tr>
<td>Rowe et al., 1996</td>
<td>6–12th grades 3 years between T1 and T2 Midwest US n = 4624</td>
<td>Longitudinal Transition analysis</td>
<td>Never smokers Tiers (smoked once or twice just to try, or smoked regularly but no more than one cigarette per month) Regular smokers (smoked weekly or more)</td>
<td>Non-smoking Experimented Regular</td>
</tr>
</tbody>
</table>
Table 3 (Continued)

<table>
<thead>
<tr>
<th>Study and year of publication</th>
<th>Age/grade at start of study, place, and n</th>
<th>Research design and analytic strategy</th>
<th>Study stages</th>
<th>Re-labelled stages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hu et al., unpublished data</td>
<td>7–12th grades Indiana: five waves; 6 months between T1 and T2, T2 and T3; 1 year between T3 and T4, T4 and T5</td>
<td>Longitudinal Random effects ordinal regression</td>
<td>Never users Triers (one cigarette or less)</td>
<td>Non-smoking Tried</td>
</tr>
<tr>
<td>California: five waves; 6 months between T1 and T2, T2 and T3; 1 year between T3 and T4; 2 years between T4 and T5</td>
<td>Proportional odds and multinomial models</td>
<td>Experimenters (smoked, but not in last week)</td>
<td>Regular users (smoked in last week)</td>
<td>Regular</td>
</tr>
<tr>
<td>n = 801</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hu et al., 2000</td>
<td>7th grade 5 years between T1 and T2 California</td>
<td>Longitudinal Proportional odds and multinomial logistic regression models</td>
<td>Never smokers Triers (more than one cigarette in life, but not in past week)</td>
<td>Non-smoking Experimented</td>
</tr>
<tr>
<td>n = 2912</td>
<td></td>
<td></td>
<td>Regular smokers (smoked in past week)</td>
<td>Regular</td>
</tr>
</tbody>
</table>

Adolescent perceptions of parental permissive attitudes toward smoking (Wang et al., 1996; Jackson and Henriksen, 1997), and parental approval of smoking (Siddiqui et al., unpublished data; Palmer, 1970; Hunter et al., 1982) were also found to be related to an increase in smoking frequency, and to trying, experimenting, and regular smoking.

3.2.3. Non-family characteristics

A trend to smoke at higher levels was observed across the tried, experimented, and regular levels as the number of smoking friends in the adolescents’ social network increased (Palmer, 1970; Hunter et al., 1982; Flay et al., 1983; Jackson and Henriksen, 1997; Robinson et al., 1997).

3.2.4. Summary of category 1 studies

Across studies, being male and White, holding positive attitudes toward smoking, concerns with body weight, affect regulation, perceptions of accessibility, parental smoking, parental approval and permissive attitudes toward smoking, and number of smoking friends discriminated stages of trying, experimenting, and regular and established smoking from never smoking. Nevertheless, no variables were found to predict a particular level exclusively. Cross-sectional studies tell us little about the development of smoking behavior prospectively, and cannot separate out the antecedents of the behavior from the consequences. Only when transitions are examined directly across time can strong inferences about the factors that induce the transitions be made (Chassin et al., 1986). The remaining studies reviewed in this paper enable identification of whether certain variables uniquely predict onset as compared to higher stages of smoking over time.

3.3. Category 2 studies: prospective with aggregation of stages

Category 2 studies incorporate a prospective design. However they aggregate higher levels of smoking behavior rather than investigating them separately. A number of these studies assess increases and decreases in smoking behavior over time; but since the focus of this review is on smoking acquisition, only variables related to an increase in smoking behavior will be reported here. We found 19 studies that represented this category. Several studies evaluated factors associated with smoking onset, and the factors related to increased smoking over time, while other studies provided information on increased or higher levels of smoking in adolescents in multiple stages of smoking. Furthermore, some studies assessed an increase in smoking intensity by observing variables related to the transitions from non-smoking to trying, and from trying to a higher level of smoking. However, these studies aggregated all higher levels — experimenting, regular, established — into one group. As in category 1, predictors of onset and increased smoking were classified according to individual, family, and non-family variables, and an interaction between these variables.
3.3.1. Individual characteristics

Smoking onset variables included the number of cigarette offers (Ary and Biglan, 1983, 1988; Eckhardt et al., 1994), a belief about the positive function of smoking and minimization of risks (Bauman et al., 1984; Chassin et al., 1984; McGee and Stanton, 1993; Flay et al., 1994), intentions to smoke in the future (Ary and Biglan, 1983; Chassin et al., 1984; Eckhardt et al., 1994), a tolerance for deviance and antisocial behavior (Reynolds and Nichols, 1976; Krohn et al., 1983; Chassin et al., 1984), and other drug use (Alexander et al., 1983; Ary and Biglan, 1983, 1988; McGee and Stanton, 1993; Eckhardt et al., 1994). Individual variables related to a continuation, an increase in smoking, or higher levels of smoking across studies, included number of cigarette offers (Ary and Biglan, 1988; Eckhardt et al., 1994), intentions for smoking in the future (Chassin et al., 1984; Pederson and Lefcoe, 1986; Ary and Biglan, 1988; Eckhardt et al., 1994; Flay et al., 1994), previous smoking (Ary and Biglan, 1983, 1988; Krohn et al., 1985; Chassin et al., 1990), and beliefs about the positive function of smoking and minimization of health risks (Murray et al., 1983; Bauman et al., 1984; Chassin et al., 1984; Croft et al., 1985; Krohn et al., 1985; Pederson and Lefcoe, 1986; Gerber and Newman, 1988; Flay et al., 1994). Normative beliefs, prevalence estimates, early onset, and other drug use were also factors related to higher levels of smoking that were greater than merely trying (Chassin et al., 1984, 1990; Pederson and Lefcoe, 1986; Ary and Biglan, 1988; Gerber and Newman, 1988; McGee and Stanton, 1993; Eckhardt et al., 1994).

3.3.2. Family characteristics

Smoking onset was related to smoking parents and siblings (Day et al., unpublished data; Alexander et al., 1983; Chassin et al., 1984, 1986; Croft et al., 1985; Flay et al., 1985; Flay et al., 1994). An increase in smoking and higher level use was also related to having smoking parents or siblings (Alexander et al., 1983; Murray et al., 1983; Chassin et al., 1984, 1986; Pederson and Lefcoe, 1986; Eckhardt et al., 1994; Flay et al., 1994), and to parental involvement and support (Murray et al., 1983; Chassin et al., 1986).

3.3.3. Non-family characteristics

Smoking onset was related to number of smoking friends (Day et al., unpublished data; Alexander et al., 1983; Ary and Biglan, 1983, 1988; Chassin et al., 1984, 1986; Croft et al., 1985; Eckhardt et al., 1994; Flay et al., 1994), a positive attitude and approval of smoking by friends, and low academic expectations (Krohn et al., 1983; Chassin et al., 1984). Higher level smoking was also related to number of smoking friends (Day et al., unpublished data; Ary and Biglan, 1983, 1988; Chassin et al., 1984, 1986; Pederson and Lefcoe, 1986; Croft et al., 1994; Eckhardt et al., 1994; Flay et al., 1994), peer approval and supportiveness of smoking behavior (Krohn et al., 1985; Chassin et al., 1986; Flay et al., 1994), lower expectations for school achievement or less educational achievement (Krohn et al., 1983; Murray et al., 1983; Gerber and Newman, 1988), and commitment to employment and working a part time job (Krohn et al., 1983; Murray et al., 1983; Gerber and Newman, 1989).

3.3.4. Interactions of characteristics

Parent smoking and degree of parental support, plus being female, was related to smoking onset in two studies (Chassin et al., 1986; Flay et al., 1994).

3.3.5. Summary of category 2 studies

In the category 2 studies, the number of cigarette offers, a belief in the positive function of smoking and minimization of risks, intentions to smoke in the future, other drug use, smoking parents, smoking siblings, number of smoking friends, friend's approval of smoking, and low expectations for school achievement were variables related to both onset and higher level smoking. Tolerance for deviance or antisocial behavior, and being female with parental smoking and support were variables related to onset, and not to higher levels of smoking. Furthermore, previous smoking, early smoking onset, normative beliefs, prevalence estimates, parental involvement and support, low educational achievement, and commitment to employment were variables specifically related to higher level smoking (and not to initiation). Despite their longitudinal design, category 2 studies do not provide a clear picture of variables related to specific stages of smoking greater than tried.

3.4. Category 3 studies: prospective with delineation of stages

Category 3 studies involve longitudinal designs and differentiate between stages of higher-level smoking or smoking stages greater than tried (e.g. experimental, regular, established). We found nine studies that fit into this group.

3.4.1. Individual characteristics

The transition from non-smoking to experimental smoking was predicted by a lack of commitment not to smoke, positive intentions to smoke or susceptibility (Pierce et al., 1996; Distefan et al., 1998). Susceptibility was also related to the experimented to regular smoking transition in two studies (Choi et al., 1997; Distefan et al., 1998). Being Caucasian (Pierce et al., 1996; Choi et al., 1997; Distefan et al., 1998; Flint et al., 1998) and male (Distefan et al., 1998; Flint et al., 1998), experiencing early smoking onset, and prior smoking (Stan-
tion et al., 1991; Choi et al., 1997; Flint et al., 1998) were also related to the experimental to regular cigarette use transition.

3.4.2. Family characteristics

The presence of smoking parents and family members was predictive of both the progression from non-smoking to experimental use (Pierce et al., 1996; Distefan et al., 1998), and the transition from experimental to regular use (Pierce et al., 1996; Choi et al., 1997; Flay et al., 1998; Flint et al., 1998).

3.4.3. Non-family characteristics

Average or below average school performance, best friend smoking, at least one male friend that smoked, and friend smoking (Lawrence and Rubinson, 1986; Pierce et al., 1996; Wang et al., 1997; Distefan et al., 1998) were predictive of the non-smoking to experimental transition. Predictors of the experimental to regular use transition included friend/best friend smoking (Pierce et al., 1996; Choi et al., 1997; Wang et al., 1997; Distefan et al., 1998; Flint et al., 1998), and average or below average school performance (Pierce et al., 1996; Choi et al., 1997; Distefan et al., 1998).

3.4.4. Interactions of characteristics

Across three studies being female and experiencing smoking in the family and the social network was related to the experimental to regular smoking transition (Lawrence and Rubinson, 1986; Wang et al., 1997; Flay et al., 1998).

3.4.5. Summary of category 3 studies

Across the category 3 studies, parent, family, friend/best friend smoking, and school performance were important for the non-smoking to experimenting and the experimenting to regular smoking transitions. A lack of commitment not to smoke (susceptibility) or positive intentions to smoke were related to the non-smoking to experimental and the experimenting to regular use transition. Being Caucasian and male, early smoking onset, prior smoking, and being female with a smoking family and social network were related to the experimenting to regular cigarette use transition.

3.5. Category 4 studies: developmental issues

These studies are discussed in more detail than other categories because of their greater sophistication in addressing developmental issues. Furthermore, these types of studies will be referred to in the subsequent discussion section in relation to their importance for future smoking research.

Longitudinal studies that assess differences in the power of variables to predict distinct stages are included in this category. Utilizing multinominal and proportional odds modelling, two studies provide evidence for the differential strength of certain predictor variables as they relate to specific stages (Hu et al., unpublished data; Hu et al., 2000).

Category 4 studies are also characterized by their depiction of growth patterns in smoking behavior that are discontinuous, continuous, non-linear and linear. Research that demonstrates change in smoking behavior as a function of time, and transitions between stages or the shape of the growth trajectory are of interest. In addition, studies that depict group and individual growth characteristics, and differing rates and characteristics of growth, as a function of various psychological, social, and biological predictors are included in this category (Fergusson and Horwood, 1995; Rowe et al., 1996; Andrews and Duncan, 1998).

3.5.1. Individual characteristics

The rate of transition to higher levels of cigarette smoking and growth in cigarette use seem to accelerate with age (Fergusson and Horwood, 1995). Rowe et al. (1996) found that the transition from experimenter to regular smoker was best modelled by a constant rate transition, or that in a given year a constant proportion of individuals at a given stage (trier, regular smoker) will advance to the next stage regardless of social contact. Others have found that over time the proportion of never smokers and triers decreases, and the proportion of experimenters and regular smokers increases (Hu et al., 2000). Positive attitudes toward smoking have been found to explain higher initial levels of smoking and a faster rate of increased smoking over time (Andrews and Duncan, 1998). In addition, prevalence estimates, and alcohol use have been shown to be important predictors of the transition from tried to experimental smoking, and marijuana use was found to predict the non-smoking to tried, the tried to experimental, and the experimental to regular use transitions in two diverse samples (Hu et al., unpublished data). Finally, previous levels of smoking predicted the regular to established use transition in two studies (Patton et al., 1998a,b).

3.5.2. Family characteristics

Rowe et al. (1996) demonstrated that the ease of transition from non-smoking to experimental smoking was greater for adolescents with smoking parents. Hu et al. (unpublished data) found that parental smoking was more important for the transition from experimental to regular smoking than for any earlier transitions. In addition, parental divorce was found to be an important predictor of the transition from established smoking to regular smoking (Patton et al., 1998a,b).
3.5.3. Non-family characteristics

Social network smoking or the number of peers who smoke has been identified as predictive of the rate of transition from non-smoking to experimenting (Rowe et al., 1996), and an important predictor for the transition from never smoking to trying and from trying to experimenting (Hu et al., unpublished data).

3.5.4. Interactions of characteristics

Hu et al. (2000) demonstrated that friend smoking and family conflicts were equally important predictors for the transition from non-smoker to experimenting and from non-smoking to regular smoking for adolescent males. However, for females, only friend smoking was an important predictor for these transitions. When comparing experimenters to regular smokers, friend smoking and family smoking remained equally important predictors for males, and family conflict was important for females. Finally, depressed and anxious adolescents who had smoking peers were more likely to transition from non-smoking to experimenting and from experimenting to established smoking (Patton et al., 1998b).

3.5.5. Summary of category 4 studies

Across these category 4 studies, the rate of transition and the progression from experimental to regular use, has been related to increased age (Fergusson and Horwood, 1995), and to a constant rate transition and not to social context (Rowe et al., 1996). Furthermore, the proportion of adolescents who became experimental or regular smokers increased over time (Hu et al., unpublished data). Marijuana use predicted the non-smoking to tried, tried to experimental, and experimental to regular smoking in two samples (Hu et al., unpublished data). The presence of smoking peers was the most important predictor of the rate of transition and progression from non-smoker to tried, and tried to experimented across several research samples (Hu et al., unpublished data; Rowe et al., 1996). Across two samples, prevalence estimates and alcohol use were important in predicting the tried to experimental transition (Hu et al., unpublished data). Parental smoking was an important predictor of the transition from experimental to regular/established use in three studies (Hu et al., unpublished data; Patton et al., 1998a,b). Finally, prior smoking intensity predicted the regular to established transition in two studies (Patton et al., 1998a,b).

4. Discussion

4.1. Findings

Stages of smoking progression have been conceptualized based on previous research and observations leading to theoretical conceptualizations (Leventhal and Cleary, 1980; Flay et al., 1983; Prochaska and DiClemente, 1983). Partial support for the theoretical assumptions has been established in this review of the literature.

Category 1 studies were cross-sectional and revealed little regarding the developmental course and predictors or variables associated with smoking uptake behavior. However, category 1 studies did suggest factors important to smoking at higher rates or stages. These included being male, white, holding positive attitudes toward smoking, concerns with body weight, affect regulation, perceptions of accessibility, parental smoking, parental approval and permissive attitudes toward smoking, and number of smoking friends. As posited in theory, by the time an adolescent begins to try or experiment with cigarettes, they begin to hold more positive attitudes toward smoking (Virgili et al., 1991; Wang et al., 1996; Robinson et al., 1997; Hill et al., 1998; Pallonen et al., 1998).

However, several findings did not support the theoretical assumptions of stages in this category of studies. Friend smoking was presumed to provide social modeling in the contemplation/preparatory stages, and association with smoking friends was presumed to be important for initiation and experimenting. In this review, the number of smoking friends was also predictive of regular smoking (Palmer, 1970; Flay et al., 1983; Jackson and Henriksen, 1997; Robinson et al., 1997). Affect regulation, more often associated with dependence or addiction in theory, has been identified to occur even at the experimental and regular stages of smoking behavior (Wang et al., 1996; Pallonen et al., 1998). In theory, the number of family members who smoke, perceptions of permissive parental attitudes toward smoking, and parental approval of smoking have been suggested to be important factors related to social modeling in the preparatory, initiation, and experimenting stages. However, parent and family influences were found repeatedly to be of major importance in stages of smoking greater than experimental (Siddiqui et al., unpublished data; Palmer, 1970; Hunter et al., 1982; Flay et al., 1983; Wang et al., 1996; Jackson and Henriksen, 1997; Robinson et al., 1997; Mott et al., 2000). In a similar vein, family smoking has theoretically been posited to contribute to the accessibility of cigarettes for adolescents in the experimental stage. However, accessibility was also an important variable related to regular cigarette use (Jackson and Henriksen, 1997; Robinson et al., 1997).

Category 2 studies provided across-study replication related to predictors of smoking onset and higher levels of smoking. Tolerance for deviance or antisocial behavior was uniquely related to smoking onset (Reynolds and Nichols, 1976; Krohn et al., 1983; Chassin et al., 1984). Being cool, tough, and independent may be
associated with tolerance for deviance, and theoretically associated with the preparatory stage, and as a precursor for initiation of smoking. Being female with parental smoking and parental approval of smoking was also related to onset (Chassin et al., 1986; Flay et al., 1994). This finding may reflect the interpersonal sensitivity and social modelling aspects of the preparatory stage, as the adolescent transitions from non-smoking to onset. Other empirical findings across studies suggest that previous smoking, early smoking onset, normative beliefs and prevalence estimates, the degree of parental involvement and support, low educational achievement, and commitment to employment are variables uniquely associated with higher level smoking. However, all category 3 studies aggregated stages of use greater than tried, thereby providing a very murky picture when attempting to assess empirical findings in the light of theoretical definitions of smoking stages.

Across category 3 studies, a lack of commitment not to smoke (susceptibility) was related to the non-smoking to experimental transition, and is reflective of the preparatory and initiation stages (Pierce et al., 1996; Distefan et al., 1998). However, intentions to smoke in the future (susceptibility) was also related to the experimenting to regular use transition (Choi et al., 1997; Distefan, 1998), and did not differentiate initial stages of smoking from more advanced levels. Other individual variables such as early smoking onset and prior smoking (Stanton et al., 1991; Choi et al., 1997; Flint et al., 1998) were related to the experimental to the regular use transition, and may reflect the movement toward physiological reinforcement associated with regular smoking. Being Caucasian and male was associated with the experimental to regular use transition (Pierce et al., 1996; Choi et al., 1997; Distefan et al., 1998; Flint et al., 1998), but theoretical explanation for these findings cannot be clearly delineated. Parent and family smoking were important for the non-smoking to trying, and trying to experimental stage transition (Pierce et al., 1996; Distefan et al., 1998). These findings reflect the theoretical importance of these variables related to the preparatory and experimental stages. However, the importance of family smoking for regular use was clearly an important replicated empirical finding (Pierce et al., 1996; Choi et al., 1997; Flay et al., 1998). Friend smoking and school performance have been theorized to be less important for regular or higher levels of smoking as compared to initiation. However, friend smoking, and school performance were found to be important in the non-smoking to experimenting transition and for the experimenting to regular smoking transition in four studies (Lawrence and Rubinson, 1986; Pierce et al., 1996; Choi et al., 1997; Distefan et al., 1998). Finally, in several studies, a trend was observed suggesting that females who have a smoking and smoking supportive social network (friends and family members) transitioned from experimental to regular smoking (Wang et al., 1997; Flay et al., 1998). This suggests that females may display a greater social sensitivity to the smoking environment than males.

In the category 4 studies, the rate of transition from trier to experimental and experimental to regular use was related to increased age (Fergusson and Horwood, 1995), and the proportion of trying, experimental, and regular users was found to increase or remain constant over time (Hu et al., unpublished data; Rowe et al., 1996). Furthermore, prior smoking intensity was related to the transition from regular to established smoking in two studies (Patton et al., 1998a,b). These findings may be supported theoretically by the inference that adolescents who progress to regular smoking may be moving toward established smoking and dependence. Subsequently, smoking is less affected by extrinsic characteristics of the smoking environment and more related to internal motivations. Theoretically, smoking models were identified to be important in the initiation stage, and perhaps less so in the experimental stage. However, the presence of smoking peers was the most important predictor of the rate of transition and progression from non-smoking to trying, and trying to experimenting across several studies (Rowe et al., 1996; Hu et al., 2000). Across two samples, prevalence estimates of peer use and alcohol use were important in predicting the tried to experimental transition (Hu et al., unpublished data). Furthermore, marijuana use was predictive of all transitions from trying to regular use (Hu et al., unpublished data). These findings have not been clearly addressed by theory. However, the replication of this finding across two samples bolsters our confidence in its validity. Parental smoking was an important predictor of the transition from experimental to regular/established smoking in three category 4 studies (Hu et al., unpublished data; Patton et al., 1998a,b). Even though parental smoking has most often been associated with preparation and experimentation, these empirical findings suggest that it is equally important, if not more so, for regular and established smoking.

4.2. Gaps in our knowledge

4.2.1. Theoretical stages and issues of measurement

Across the categories of studies, many variables were found to replicate in relation to a specific stage or stage transition. However, few variables were found that uniquely predicted a specific stage or stage transition. This finding is isomorphic to the lack of precision inherent in the theoretical definitions of stages. For example, parental smoking is important both to the preparatory stage and the experimental stage. Friend smoking may serve as a social modelling agent in the preparatory stage and has been associated with the
initiation stage. Furthermore, the social aspects (potentially inclusive of smoking friends) of smoking are also important in the stage of regular use as adolescents smoke at parties and other social gatherings. Therefore, to expect unique predictors of stage transitions may be unrealistic. With the re-labelling of stage definitions (Table 3), the measurement of stages was more inclusive and potentially increased the probability of finding patterns in the literature. However, the lack of construct validity related to the measurement of theoretical stage, along with the variety of predictor variables investigated, may have reduced the likelihood of finding unique predictors of stages and transitions.

Observations of smoking behavior and previous research have informed theory construction related to the definition of stages (Leventhal and Cleary, 1980; Flay et al., 1983; Stern et al., 1987; Pierce et al., 1995; Wills et al., 1995). However, this review of the literature suggests that a valid and reliable measure of smoking stages is paramount to the future of smoking stage research. A valid and reliable measure of stages is necessary in order for our empirical findings to reliably inform theory development and subsequently guide the development of prevention and intervention efforts. Heal (1985) argued that “many, probably most, scientific advances have been accomplished by sound observation and measurement and nothing more”. In the arena of smoking research, only the transtheoretical model approach to stages has been tested utilizing the Stages of Acquisition Questionnaire on adolescents (Stern et al., 1987) and appears to be the only measure of stages for which there is evidence of its validity and reliability. No other psychometrically acceptable measure of the smoking uptake process exists (Choi et al., 1997).

The study of progression in smoking behavior through a sequence of stages not only requires good measurement of the stages, but a stage conceptualization may also require the researcher to view developmental and developmental transitions as a function of time. In addition, many individual and environmental predictors of stages in smoking progression may change over time themselves. Studies by Ferguson and Horwood (1995), and Rowe et al. (1996) measured rates of transition between stages. Rowe et al. (1996) further identified that friend, and parental smoking influenced the rate of transition related to particular smoking stages. Future research should continue to incorporate measures of transition rates. The application of Latent Markov Modelling and Latent Transition Analysis (LTA) to stage sequential models of smoking represent two powerful approaches for assessing not only rate of transition, but variables that may influence the rate of transition across stages (Collins et al., 1997).

Utilizing proportional odds and multinomial logistic regression models, Hu et al. (2000) demonstrated that for males and females predictors of smoking behavior changed over time as smoking behavior increased to higher stages. However, proportional odds and multinomial logistic regression models do not address the issue of time or the rate at which an adolescent transitions from one stage to the next. Integrating knowledge related to rate of stage transition and stage variant and invariant predictors of these transitions is key to future research advances in the study of smoking stage progression.

The issue of ‘duration dependence’ or the concept that the time spent in a current stage determines the probability of a subsequent transition into the next stage (Featherman and Petersen, 1986), may be an important concept for future smoking research. Occasional smokers, including those individuals who do not smoke daily or those who smoke daily at a low rate, sometimes called ‘tobacco chippers’ (Shiffman, 1989; Owen et al., 1995; Hennrikus et al., 1996) may never progress to a smoking frequency suggestive of addiction or dependence. Measuring the amount of time an adolescent spends in a particular smoking stage before a transition occurs, and developing an understanding of the predictors of that transition, may help identify those who will transition into heavy smoking and who may be at greatest risk for smoking related health problems. Subsequently, future research should include survival analysis and hazard models that treat time as the outcome variable. Rather than only asking how rapidly an adolescent transitions over time, research inquiries can determine how much time must pass before a transition occurs (Willet and Singer, 1991). In addition, individual and environmental factors and interactions between these factors can be assessed as to their impact on the time before a smoking event or transition occurs. For example, Patton et al. (1998a,b) found that parental factors, and an interaction between depression, anxiety and peer use were predictors of time to smoking stage transitions.

4.2.2. Inter-individual differences in intra-individual change

Fisher et al. (1993) compared stages of smoking uptake with issues in child development research. Fisher et al. (1993) argued that intrinsic or individual characteristics and environmental factors interact to direct the development of smoking stages. Subsequently, these multiple individual and environmental influences result in inter-individual differences (differences between individuals) in intra-individual change (development within individuals). In adolescent smoking, differences between individuals in the rate of progression between stages, or the shape of the growth trajectory, represents this concept of inter-individual differences in intra-individual change.
A number of parallels can be drawn between cognitive development and the development of smoking uptake behavior. Multiple individual and environmental variables influence development. The sequential myelination of the brain and neural plasticity of the brain’s capacity to change with experience have been implicated in the progression of cognitive skill acquisition (Greenough et al., 1987; Case, 1992; Gunnar, 1998). Inter-individual differences in cognitive skill acquisition are also related to the child’s social world including peers (Saxe, 1988), parents (Siegler, 1991), teachers (Palincsar and Brown, 1984), and society as a whole (Vygotsky, 1978; Belmont, 1989; Rogoff, 1989). As in cognitive development, individual and environmental variables influence progression in cigarette smoking.

The development of smoking behavior may be affected by individual-specific psychophysiological responses to nicotine (Silverstein et al., 1982). Genetic influences have also been implicated in individual differences in nicotine sensitivity and smoking uptake behavior (Pomerleau, 1995), as well as nicotine metabolism (Seaton and Vesell, 1993). The development of smoking behavior may also be affected by broad sociocultural variables (Flay and Petraitis, 1994) such as advertising (Pierce et al., 1998), price, and social policy (Chaloupka and Wechsler, 1997). Furthermore, factors such as normative life events (e.g. school transitions, first job, development of dating relationships), non-normative life events (e.g. parental divorce, changing family structure), and different types of psychopathology, including depression (Breslau and Peterson, 1996; Patton et al., 1998b) anxiety (Patton et al., 1998b), and conduct disorder need to be included in future studies. All of these types of variables may greatly affect differences between individuals in smoking uptake behavior. In this present review of the literature, numerous psychosocial predictors have been identified that are related to smoking behavior, but much further research is needed to address the impact of biological, broad sociocultural, and developmental variables on smoking progression.

4.2.3. Does smoking progression consist of stages or is it continuous in nature?

The lack of consistent stage definitions in research on smoking progression makes it difficult to conclude that smoking does or does not progress through a series of stages. However, research in the field of cognitive development may inform developmental research efforts in smoking progression. The social constructivist approach of Piaget and Inhelder (1969) is a prototypical example of stage theory in the field of cognitive developmental research. However, numerous research findings clearly refute the concept that cognitive development occurs in stages, but rather is more continuous in nature and heavily dependent on individual and environmental factors (Rogoff and Morelli, 1989; Bailargeon and Devoss, 1991).

Willet (1997) has suggested that individual change should not be viewed in an incremental fashion, or as the difference between ‘before and after’. Rather individual change takes place continuously over time. Subsequently, future research should include multiple waves of data and avoid prospective designs that include only two measurement periods.

Furthermore, Willet (1997) advocates an individual growth curve approach to understanding change over time. Growth curve modelling of development allows for the assessment of individual change represented by straight-line, curvilinear, or discontinuous trajectories. Indeed, researchers have demonstrated continuous growth in adolescent substance use including cigarette smoking. Both initial levels and rate of growth in substance use (measures that include cigarette smoking) in adolescents have been related to age of adolescent, gender, and family factors, peer use and encouragement (Duncan and Duncan, 1996; Duncan et al., 1996, 1997). Only one study in category 4 addressed continuous growth trajectories unique to smoking. These researchers demonstrated inter-individual differences (between person differences) in intra-individual change (within person change) for progression in smoking behavior. Attitudes about cigarettes predicted differences among individuals related to initial levels of smoking and rates of growth in smoking behavior over time (Andrews and Duncan, 1998). Future research should address the possibility of other predictors of growth trajectories, and whether differential predictors of various types of growth trajectories or clusters of trajectories exist.

Furthermore, biological components of nicotine addiction such as nicotine metabolism and genetic factors should also be incorporated into these models of continuous growth trajectories. Including biological variables along with psychosocial risk factors would increase understanding related to the direct, indirect (Lorenz et al., 1997), and moderating effects (Muthen and Curran, 1997) of these variables on the characteristic trajectories of smoking uptake behavior in adolescents.

5. Conclusions

Observations of smoking behavior and previous research have informed theory construction related to the definition of stages (Leventhal and Cleary, 1980; Flay et al., 1983; Pierce et al., 1995; Wills et al., 1995), and suggested that different factors may be associated with different stages of smoking. However, this review of the literature does not provide any firm conclusions due to the lack of a consistent operational definition of smok-
ing stages across research studies. The need for a valid and reliable measure of smoking stages is paramount to the future of smoking stage research and theory development.

Future research efforts related to smoking stages should also be cognizant of the dynamic developmental nature of smoking progression. Statistical analytic procedures that incorporate measurement of rates of transition between stages and recognition of stage variant and stage invariant predictors of transitions are vital. Individual differences in smoking progression are the result of a myriad of cultural, psychosocial, biological, normative and non-normative social transitions, and psychopathology. Research findings from the field of cognitive development suggest that development may also be continuous in nature and lack incremental or stage-like qualities. Latent growth curve modelling has been recognized as a powerful approach for the identification of dynamic processes between smoking uptake behavior and multiple factors associated with increased smoking intensity. Future research should address the multiple predictors of growth trajectories, and whether differential predictors of various types of growth trajectories or clusters of trajectories exist.

Acknowledgements

This work was supported by the Robert Wood Johnson Foundation through the Research Network on the Etiology of Tobacco Dependence (TERN) and the National Institutes of Health (NIDA grant # DA10306 and NIAAA grant # AA11266).

References


Parent education attainment and adolescent cigarette smoking. J. Health Econ. 16, 359–373.


