Journal of Applied Developmental Psychology 104 (2026) 101952

Contents lists available at ScienceDirect

Journal of Applied Developmental Psychology

journal homepage: www.elsevier.com/locate/jappdp

Dual peer processes in adolescent smoking initiation and frequency: Close-friend modeling and anti-smoking influence

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ARTICLE INFO

Keywords:
Peer influence
Substance use
Cigarettes
Adolescence

ABSTRACT

Peers' attitudes and behaviors are among the most robust determinants of adolescents' smoking behaviors. Although researchers have largely examined the negative role peer influence plays, this study examined how the larger peer group can play a prosocial role in advocating for reductions in smoking, even after accounting for the behavioral modeling of adolescents' closest friends. This study examined how closest friends' actual smoking behavior and perceived peer influence to reduce smoking were associated with adolescents' smoking initiation and frequency from ages 13–17.

Data were collected from 1999 to 2004 in the United States, where participants ($N = 184$; 54% female; 58% White, 29% Black) reported annually on their own cigarette use and their peer group's influence not to smoke, while participants' best friends reported on their own cigarette use. Discrete time survival analyses assessed predictors of initiation, while a bivariate latent curve model assessed predictors of cigarette smoking frequency.

Having a best friend who smokes was prospectively associated with roughly triple the odds of adolescents' own smoking initiation, while influence not to smoke was unrelated to initiation. However, the latent curve model revealed that adolescents who perceived greater peer influence not to smoke tended to smoke less over time throughout adolescence. Best friends' smoking frequency was also positively associated with adolescents' own smoking frequency,

Results suggest that neither knowing the specific best friendship norms nor the greater peer group norms is sufficient, but rather both additively contribute to shape adolescents' cigarette use patterns.

Adolescent cigarette use is deleterious across multiple facets of biological development, an idea that is well supported by decades of research (Holliday & Gould, 2016; Leslie, 2020). Indeed, tobacco consumption is associated with a myriad of poor neurological and physiological outcomes, such as altered neural development (Laviolette, 2021), poorer lung capacity (Thacher et al., 2018), and a higher likelihood of both lung cancer (St Claire et al., 2020) and mortality (Le Foll et al., 2022). Further, both *when* one begins smoking, and *how much* one smokes are important; both an earlier onset and an increased frequency of cigarette use in adolescence are concomitantly associated with poorer outcomes across the lifespan (Colyer-Patel et al., 2023; Jha, 2020).

There are numerous factors that may shape adolescents' decisions to begin and continue using tobacco products, including social, personal, and societal determinants (Littlecott et al., 2023). At their core, adolescents may hold their own beliefs about smoking, but are also highly susceptible to external influences. Indeed, the influence of adolescents' closest friends is among the strongest predictors of changes in adolescents' own behaviors (Giletta et al., 2021), including cigarette smoking (East et al., 2021). Not only do adolescents select potential friendship candidates based on existing similarities (e.g., selection effects; Montgomery et al., 2020), but they additionally become more alike over time across a variety of outcomes and behaviors (e.g., socialization effects; Ragan, 2020). The socialization process occurs in part through the communication of youth's perception of their peers' *attitudes* towards a certain behavior (i.e., injunctive norms) and youth's perception of their peers' level of actual engagement in a certain behavior (i.e., descriptive norms) (Cialdini et al., 1991; Prentice & Miller, 1993; Veenstra & Lodder, 2022).

In prior work, measures of injunctive norms have assessed whether adolescents perceive their friends to approve of smoking generally (Elek

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https://doi.org/10.1016/j.appdev.2026.101952
Received 19 September 2025; Received in revised form 24 March 2026; Accepted 13 April 2026
Available online 16 April 2026

et al., 2006), how friends directly pressure them to smoke cigarettes (Michell & West, 1996), or the age at which such behaviors are considered acceptable (Field & Prinstein, 2023). These self-report measures examine how peers' pro-cigarette smoking attitudes influence adolescents' own behavior and are robustly effective in this pursuit; in all cases, permissive or pro-smoking norms communicated by peers are associated with increased cigarette smoking.

However, there has been a recent push to move beyond studying the maladaptive nature of peer influence, and instead examine how peer influence can be leveraged to increase engagement in healthy and pro-social behavior (Allen, 2024; Laursen, 2018; Van Hoorn et al., 2016). Yet, such distinctions are rarely made within the tobacco literature. It is unclear, for example, whether intervention efforts to limit exposure to pro-cigarette attitudes would be more or less effective than efforts promoting the communication of *anti*-cigarette attitudes in reducing youths' tobacco consumption. Although peer influence to smoke more and influence to smoke less may, in many cases, function almost identically (as reciprocal opposites), it is also quite possible that influence to smoke less is indeed a unique process. Peers' anti-smoking attitudes are rarely captured by researchers, but may represent a potentially fruitful strategy to limit adolescent tobacco use (Smith et al., 2007).

Descriptive norms have typically been evaluated via participants' self-reports of friends' smoking status and frequency. These perceptions of close friends' smoking behaviors reveal that maintaining close friendships with peers who smoke doubles adolescents' risk for initiating smoking themselves (Alexander et al., 2001; Jeon & Goodson, 2015), as well as predicts increasing smoking frequency (Harakeh et al., 2007; Vu et al., 2025; Yong et al., 2023). Descriptive norms have been found to explain substantial variance in adolescent cigarette consumption suggesting that *perceptions* of friends' behavior may be most relevant to cigarette use (Vitória et al., 2011). However, there may be issues with relying on perceived behavior to evaluate peer influence processes rather than the examination of *actual* behavior (Deutsch et al., 2015). The use of self-reported perceptions introduces method variance issues that are difficult to overcome without surveying the potential source of influence directly. Indeed, previous work has demonstrated that there are discrepancies between adolescents' perceptions of peer norms, and their friends' actual attitudes and behaviors (Prinstein & Wang, 2005). These discrepancies may be particularly problematic because the magnitude of these discrepancies may not be random, but rather the result of an adolescents' cognitive biases and attitudes towards the behavior.

To reconcile these methodological issues, researchers have collected data on best friends' *actual* cigarette use, to ensure that associations between perceived peer behavior and adolescents' own behavior are not driven by bias. Recent meta-analyses (Giletta et al., 2021; Watts et al., 2024) and review papers (Henneberger et al., 2021) examining the socialization of substance use among best friends have revealed somewhat mixed effects for tobacco use. There is fairly consistent evidence for *selection* effects explaining substantial variance in adolescent tobacco use (e.g., DeLay et al., 2013; Huisman & Bruggeman, 2012; Kiuru et al., 2010), but evidence for socialization has proven elusive with some studies finding peer influence effects (e.g., Huisman & Bruggeman, 2012; Mercken et al., 2010; Mercken et al., 2012; Ragan, 2016; Wang et al., 2016) but others not (Huang et al., 2014a, b; Huisman & Bruggeman, 2012; Pearson et al., 2006). However, the studies reviewed above did not differentiate between peer influence towards cigarette use *initiation* vs. *frequency*.

Beginning and continuing risk behaviors are often conflated in studies that only examine peer influence towards behavioral *frequency*; yet it is at the point of initiation of cigarette smoking that the risk of long-term addiction skyrockets. It may also be that the magnitude of peer influence needed to begin a behavior may be greater than the magnitude needed to slightly increase the frequency of a behavior. For example, to begin smoking requires procedural knowledge and a means of gaining access to cigarettes, which peers may be critical to providing, whereas changes in frequency of smoking among existing smokers may only require small shifts in attitude. In the context of tobacco use, it is currently unclear how best friends' actual smoking patterns differentially influence different stages of tobacco use (e.g., initiation vs. continuity; Schaefer et al., 2013).

The majority of peer influence work to date has focused on adolescents' best friends as the primary source of influence, *perhaps because they are theorized to be among their most potent socializing sources* (Thornberry, 1996). Relatively less work, however, has examined how other peer socializing sources influence adolescent behavior, particularly in reference to tobacco use. Sparse work suggests, however, that youth may conform to cigarette use norms communicated by popular peers (Field & Prinstein, 2023), romantic partners (Mermelstein et al., 2009), and by the larger peer group or social network (Smith et al., 2007). Together, these findings suggest that adolescents are embedded in multiple peer contexts, which may simultaneously, but differentially, shape tobacco use.

Importantly, the routes of transmission may differ across socializing sources, as youth may be motivated to conform to different types of peers for different reasons. According to the Influence Compatibility Model (Laursen & Veenstra, 2021), adolescents conform to their *close friend's* behavior to minimize differences, increase similarity, and thus maximize friendship compatibility. Further, unlike the larger peer group, socialization between close friends is primarily transmitted in private dyadic settings (Allen et al., 2012; Laursen & Veenstra, 2021), or through reinforcement of behaviors via non-verbal body language (e.g., Dishion et al., 1996). Dyadic settings allow for the observational learning required for initiating smoking (Social Learning Theory, Bandura, 1977), such as the procedural knowledge of *how* to light a cigarette or effectively inhale. Thus, not only do best friends provide information on how to smoke, but smoking status likely confers compatibility; *how much* an adolescent's best friend smokes may be less relevant to compatibility than *whether* they smoke at all.

In contrast, influence from the broader peer group may operate through adolescents' adjustment to group-level stereotypes, norms, or attitudes. Social identity theory (Tajfel & Turner, 1986) suggests that individuals use group membership as a means of identity development, likewise, the prototype/willingness model suggests that youth derive self-esteem from similarity with representative group members (Abrams et al., 1990; Gibbons et al., 2020). Thus, fluctuations in smoking behavior may be particularly calibrated to what is normative among the peer group. Smoking *more* than what is normative may confer a deviant or delinquent reputation within the larger network, thus placing adolescents' more distal peers in a prime position to communicate *anti*-smoking norms which are designed to moderate or reduce smoking frequency. Together, these frameworks suggest that best friends' behavioral modeling may be most relevant for smoking initiation, whereas normative influence from the broader peer group may be most relevant to regulating smoking frequency.

Accordingly, previous work has suggested that best friends are more influential than other types of peers regarding *initiating* cigarette use (Field & Prinstein, 2023). However, previous work has largely relied on participants' reported perceptions of friends' smoking, rarely separated smoking initiation from frequency, and has primarily focused on peer influence and or pressure to engage in cigarette use and other risk-behaviors, rather than influence to *abstain* from cigarette use.

The current study

The main objective of the current study was to examine whether perceived peer influence not to smoke predicts delayed initiation and reduced smoking frequency, even after accounting for the behavioral modeling of adolescents' closest friends. The current study utilized annual reports of (1) adolescents' best friends' actual smoking behavior and (2) perceptions of peers' influence to abstain from cigarette use, to evaluate peer influence effects towards adolescents' own smoking

initiation and frequency over a 5-year period from 13 to 17 years-old. A face-valid indicator of peer influence towards *not* smoking will be used, by simply asking adolescents whether and to what extent they perceive this influence from peers. A similarly face-valid approach will be utilized to survey adolescents' own smoking behavior, as well as surveying their best friends' smoking behavior; through self- and best friend- report.

Results from the current study may be useful to practitioners seeking to reduce substance use during adolescence. While burgeoning work suggests that peer-led interventions are effective in reducing smoking behavior among adolescents (MacArthur et al., 2016), less is known about which peer processes may be most effective, including whether adolescents are most influenced by friends' smoking behavior, perceived peer influence not to smoke, or both. By clarifying these distinct processes, study findings may help inform when, for whom, and through which peer processes intervention efforts may be most effective.

Hypotheses

1. We hypothesized that best friends' actual smoking behavior would predict a greater likelihood of adolescents' smoking onset, and higher levels of smoking frequency across adolescence.
2. We hypothesized that perceived peer influence not to smoke would predict lower smoking frequency across adolescence. Specifically, adolescents who reported greater increases over time in perceived peer influence not to smoke were expected to show smaller increases in their own smoking over time. Consistent with prior work suggesting that perceived norms are less predictive of onset than frequency (Field & Prinstein, 2023), we expected perceived peer influence not to smoke to show a weaker association with smoking onset.
3. We hypothesized that best friends' smoking behavior would be more strongly associated with cigarette onset than perceived influence not to smoke, whereas both peer processes would be relevant to smoking frequency.

Support for these hypotheses would suggest that behavioral modeling and perceived influence not to smoke are distinct peer influence processes potentially responsible for unique variance in smoking outcomes.

Method

Participants

This study was part of a longitudinal investigation of social development across adolescence and young adulthood. Participants included 184 adolescents (85 boys and 99 girls) residing in the southeastern United States. Participants were assessed annually from 1999 to 2004; this study utilizes assessments with friends at age 13 ($M_{age} = 13.35$, $SD = 0.64$) through age 18 ($M_{age} = 18.38$, $SD = 1.04$). Participants were originally recruited from the seventh and eighth grades of a public middle school drawing from suburban and urban populations in the Southeastern United States. Students were recruited via an initial mailing to all parents of students in the school along with follow-up contact efforts at school lunches. Families of adolescents who indicated interest in the study were contacted by telephone. Of all students eligible for participation, 63% agreed to participate either as target participants or as friends who participated by filling out surveys regarding their relationship to a target teen. Once a student participated as a friend, they were no longer eligible to be a primary participant.

The sample was racially and socioeconomically diverse: 107 adolescents (58%) identified themselves as White, 53 (29%) as Black, 15 (8%) as Multiracial, and 9 (5%) as being from other identity groups, which approximately mirrors the distribution of the catchment area for the school from which the sample was drawn. Adolescents' parents reported an annual median family income in the $40,000–$59,999 range, relative to a national median household income of approximately $39,000 at the time.

Each year, target adolescents nominated their closest friend as of the time of assessment to be included in survey and observational measures with them in the study. The same peer participated in subsequent years, on average, 42.3% of the time (min = 35.9%, max 45.5%). All best friend dyads identified as same-gender.

Attrition across the study was relatively low. Of the 184 adolescents enrolled at baseline, 87.0% remained at Wave 2 ($n = 160$), 85.3% at Wave 3 ($n = 157$), 91.5% at Wave 4 ($n = 150$), and 89.7% at Wave 5 ($n = 165$). To evaluate selective attrition, we compared participants who were retained versus missing at each wave on all study variables. Across Waves 2–5, only one significant difference emerged: participants who were missing at Wave 3 reported significantly higher income at Wave 2 than participants who remained in the study (mean difference = −0.66, $t = -2.23$, $p = .041$; equal variances assumed). No other demographic or study variable differentiated retained from missing participants at any wave, suggesting that attrition was minimal and largely nonselective.

A small portion of participants were excluded from the survival analysis if their time-of-onset could not be accurately determined. See Fig. 1 for a flowchart detailing exclusionary criteria. *t*-tests and chi-square tests (where applicable) revealed no significant differences between participants included or excluded from survival analyses on any demographic variables.

To ensure that the analysis of frequency was not simply replicating the findings from the survival analysis, adolescents were only included in the analysis of frequency if they reported having *ever* smoked from Waves 1–5. Because the time of onset was less relevant to this analysis, individuals who were previously deemed to be left- or interval-censored were still included in this analysis; the final sample for the latent curve model included 117 adolescents who do or would eventually smoke (63.6% of total).

Procedures

In the initial introduction and throughout each session, confidentiality was explained to all participants, and adolescents were told that their parents would not be informed of any of the answers they provided. A Confidentiality Certificate issued by the U.S. Department of Health and Human Services protected all data from subpoena by federal, state, and local courts.

Measures

Friendship nomination

At each age, participants also nominated the person they currently identified as "the peer to whom they were closest" to be included in the study. Close friends within adolescence were specified to be same-gender friends, but the same friend need not be specified across different waves. Friends were close in age to participants (i.e., their average age differed by less than a month from target adolescents' ages). The same peer participated in subsequent years, on average, 42.3% of the time (min = 35.9%, max 45.5%), and filled out a limited self- and friend-report packet about the adolescent enrolled in the study.

Substance use

Cigarette use onset and frequency of use were measured at Times 1–5. One item assessed the frequency of cigarette use (i.e., "How often have you smoked cigarettes in the last 30 days?") - (*0 for 0 cigarettes, 1 for 1–5 cigarettes a day or less, 2 up to about half a pack a day, 3 for about half a pack a day or more)*. This process was repeated for adolescents' *best friends* who also reported on their cigarette use annually. Cigarette use onset was assessed annually by asking whether adolescents have ever smoked (*No = 0, Yes = 1*). Adolescents were only included in the latent curve model if they reported having smoked at least once throughout the study.

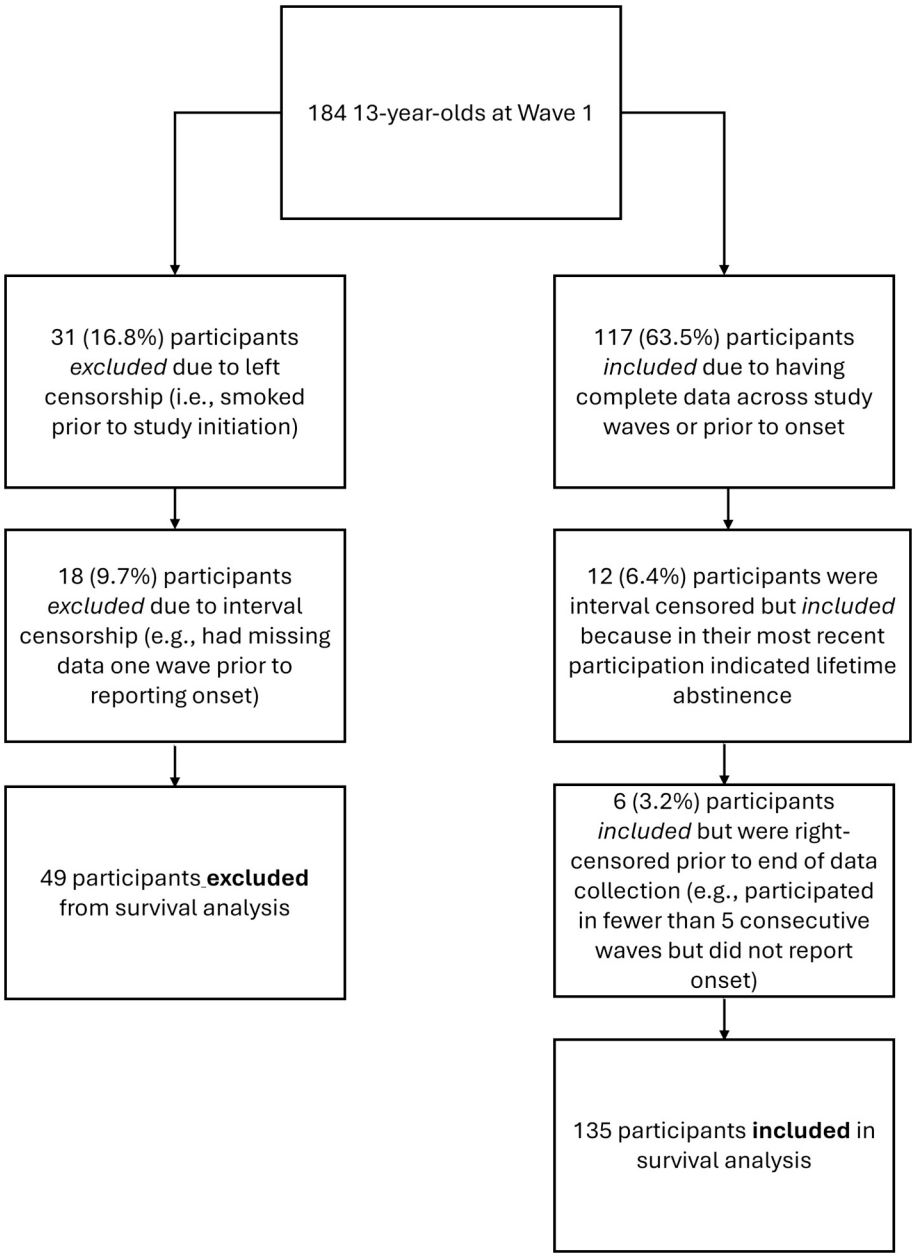

Fig. 1. Survival analysis flowchart.
Note. Participants who reported onset prior to their missing data were still included in survival analyses; substance use onset is a nonrepeatable event, thus, these later timepoints would be marked as missing even in the presence of complete data (Willett & Singer, 1993).

Onset for cigarette use was coded by identifying the first time point at which adolescents reported using cigarettes (coded as 1). A participant was considered right censored and coded as abstinent (coded as 0) if they reported no substance use throughout all waves of data collection. Because substance use onset is a nonrepeatable event, each subsequent timepoint after the participant's onset was coded as missing (Willett & Singer, 1993). Using these data, a 'Timepoint at First Onset' variable was coded per participant per substance. Thus, the first time point represents substance use onset up any time up until Wave 1, the second time point represents substance use onset between Wave 1 and Wave 2, and so on.

Perceived peer influence not to smoke

Perceived peer influence was measured via self-report at Time 1 – Time 5. One item assessed the magnitude of adolescents' perceptions of their friends' influence to *not* smoke (i.e., "My friends are _____ part of the reason that I do not smoke) – (*1 = a BIG, 2 = a MEDIUM, 3 = a SMALL, 4 = NOT at all a)*. Scores were reverse scored such that higher scores indicated higher perceived influence towards abstaining from cigarette use. All adolescents regardless of smoking status answered this question at all waves. Indeed, once adolescents begin smoking that does not guarantee they will continue smoking or smoke with ever-increasing frequency; this measure was designed to capture both potential friend influence on abstinent youths' decision to continue to *not* smoke, as well as examine how smokers' friends may contribute towards them smoking *less*. To assess whether this assessment of anti-smoking influence is at least moderately stable over time, we assessed test-retest reliability and found moderate autocorrelations from Waves 1 to Wave 5 (see Table 1). Autocorrelations ranged from $r = 0.35^{**}$ - 0.58^{**}, with larger correlations occurring in later waves.

Table 1
Descriptive statistics and correlations among study variables.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Smoking W1	1.																	
2	Smoking W2	0.16*	1.																
3	Smoking W3	0.01	0.56**	1.															
4	Smoking W4	0.17*	0.49**	0.50**	1.														
5	Smoking W5	0.25**	0.34**	0.43**	0.63**	1.													
6	Friend Smoking W1	0.17*	0.41**	0.07	0.11	0.08	1.												
7	Friend Smoking W2	0.25**	0.30**	0.19*	0.03	−0.06	0.47**	1.											
8	Friend Smoking W3	0.17*	0.04	0.27**	0.37**	0.1	0.15	0.08	1.										
9	Friend Smoking W4	0.00	0.16	0.13	0.25**	0.27**	0.13	0.38**	0.39**	1.									
10	Friend Smoking W5	−0.08	0.11	0.26*	0.38**	0.33**	−0.09	−0.11	0.09	0.43**	1.								
11	Percentage of Poverty Line	−0.05	0.00	−0.06	−0.05	0.03	−0.15*	−0.13	−0.1	0.08	0.09	1.							
12	Gender	−0.02	−0.01	−0.03	−0.01	−0.11	0.1	0.14	0.09	0.05	−0.03	−0.14	1.						
13	Influence not to smoke W1	−0.18*	0.01	0.09	−0.01	−0.03	−0.02	−0.08	−0.1	0.02	0.15	0.02	0.02	1.					
14	Influence not to smoke W2	−0.05	−0.15	−0.07	−0.05	0.02	−0.09	−0.13	−0.09	−0.1	−0.04	−0.13	0.07	0.35**	1.				
15	Influence not to smoke W3	−0.06	−0.14	−0.27**	−0.15	−0.18*	−0.06	0.02	−0.1	−0.09	−0.07	−0.01	0.19*	0.19*	0.35**	1.			
16	Influence not to smoke W4	−0.01	−0.17*	−0.17*	−0.26**	−0.21*	−0.15	−0.07	−0.11	−0.19*	−0.17	−0.09	−0.02	0.24**	0.36**	0.40**	1.		
17	Influence not to smoke W5	−0.1	−0.16	−0.21**	−0.25**	−0.38**	−0.15	−0.02	−0.16	−0.24**	−0.31**	0.02	0.01	0.27**	0.21**	0.41**	0.58**	1.	
18	Parents' Problematic Substance Use	−0.12	0.05	0.05	0.05	0.1	0.08	−0.03	0.03	0.04	0.29*	−0.09	0.00	−0.05	0.01	−0.11	−0.05	−0.18*	1.

Covariates

Adolescents self-reported on their gender (1 = Male, 2 = Female), and adolescents parents reported their household's annual income. Income was assessed as a percentage of federal poverty line, as that measure takes into account total household annual income relative to the number of people supported by that income.

Parents' problematic substance use
Parents' alcohol and drug use was measured via adolescents' mother's and father's self-report using the *Cut down, Annoy, Guilty, "Eye Opener"* scale (CAGE; Beresford et al., 1982; Smart et al., 1991). Four binary items assessed problematic alcohol use, and four binary items assessed problematic drug use among parents. Example items include: *Have you felt the need to cut down on your drinking in the past year?; Have you been annoyed by criticism of your drug use in the past year?*. Scores were averaged to calculate a total problematic substance use composite. To maximize sample size within the current study, mother's and father's problematic substance use was averaged to create a *parent's* problematic substance use score.

Data analysis

Descriptive statistics included computation of means and standard deviations. In addition, Pearson correlations were conducted among all study variables to examine bivariate associations.

To evaluate the hypothesis that adolescents' best friends' actual cigarette use and adolescents' perceived friends' influence would be associated with their own onset of cigarette use, a discrete-time survival analysis was conducted. The survival analyses utilized the dichotomized annual cigarette use onset data ('1' represented onset, '0' represented abstinence) as recommended by Willett and Singer (1993).

An unconditional survival model first was fit to determine the extent to which survival rates differed over time, with study wave (e.g., annual unit of time) as the sole predictor for substance use onset (Willett & Singer, 1993). This model was extended to a univariate model per predictor (i.e., best friend's actual cigarette use, perceived friends' influence) to evaluate the proportionality assumption. Proportionality was assessed separately for each covariate in a univariate model by including an interaction term between time and each predictor. No study variable violated the proportionality assumption.

Finally, a multivariate survival model was estimated for cigarette use onset to examine the prospective associations among varying levels of best friends' cigarette use and perceived influence and the onset of adolescents' cigarette use. Unlike the univariate models, this final model allowed for the interpretation of the unique contribution of each predictor to onset controlling for the other.

To evaluate the final hypothesis, that best friends' actual smoking behavior, as well as perceived influence towards not smoking, would be associated over time with adolescents' own cigarette use frequency, a bivariate latent curve model with a time-varying covariate was utilized (See Fig. 2, for a visual representation of this model). Adolescents were only included in this analysis if they indicated having smoked at least once throughout the study waves. The bivariate latent curve model allows for the interpretation of whether and how the starting point and rate of change in each predictor is associated with the starting point and rate of change in adolescents' own smoking behavior.

Given the low incidence rate of smoking at Wave 1 the models failed to converge when including the first wave's data. Thus, these models were restricted from Wave 2 to 5, resulting in well-fitting models. First, the structure of each variables' growth between Waves 2 and 5 was assessed. In each case, an intercept only model was tested initially (factor loadings set to 1), such that the starting point for each variable was allowed to vary between persons, but the rate of change was held constant over time. Next a slope factor was added to evaluate the rate of change in each variable over time (factor loadings per Wave set to 0, 1,

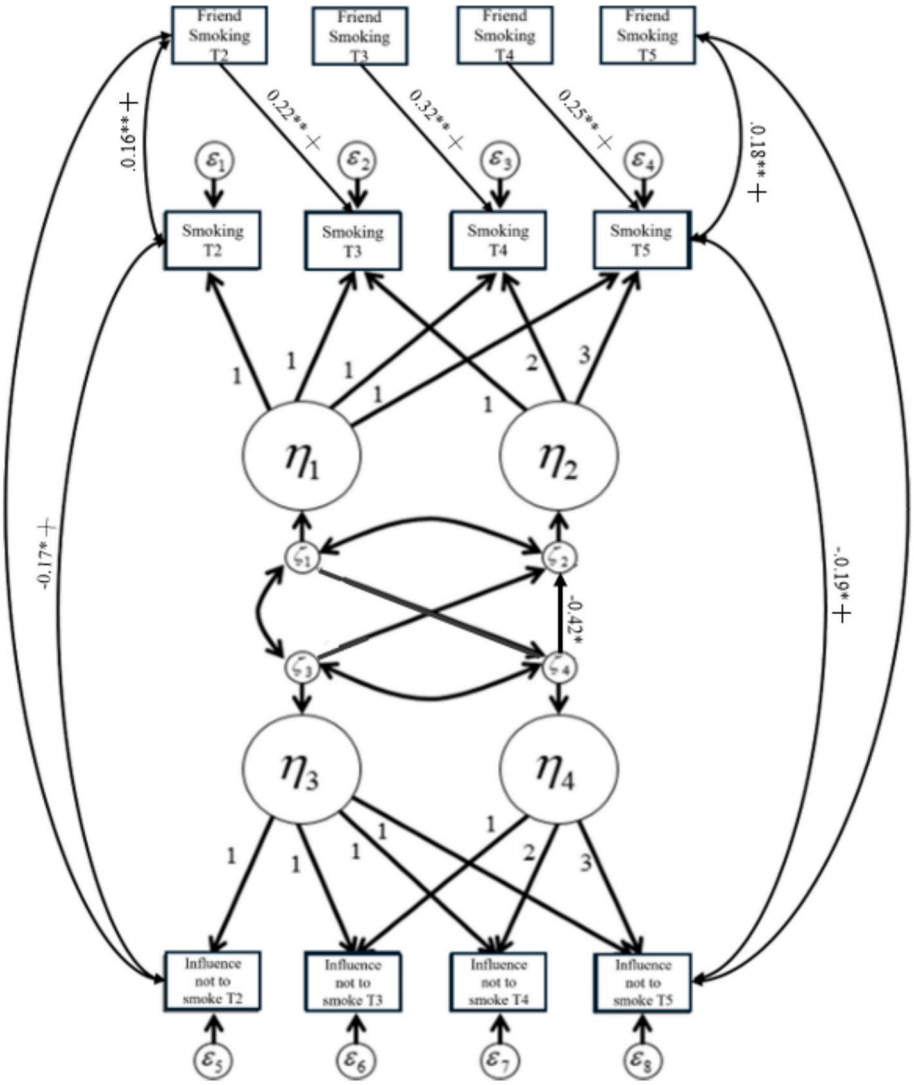

Fig. 2. Predicting cigarette smoking frequency: Bivariate latent curve model with time-varying covariate.
Note. * $p < .05$; ** $p < .01$. Only significant effects are included for ease of interpretation; a full list of coefficients is available in the supplement. The unstandardized Bs were constrained to equality at all timepoints, but construction of standardized betas utilizes unstandardized variances resulting in slightly different effects from wave-to-wave. ┼ = constrained to equality for model parsimony.

2, and 3, respectively), and likelihood ratio tests (LRTs) were conducted to evaluate whether this resulted in an improvement in model fit. Finally, in each case, it was examined whether the residuals should be constrained to equality for model parsimony.

As is detailed below, linear growth curve models best fit the trajectory of adolescents' own cigarette use and perceived influence from friends. However, neither an intercept-only nor slope factor fit the trajectory of best friends' smoking behavior; this is perhaps unsurprising given that in around 50% of cases, adolescents' chosen peer-reporter changed from year to year. Thus, this variable was used as a concurrent and lagged time-varying covariate (TVC). Next, these three variables were combined into a single bivariate latent growth curve model (e.g., cigarette smoking, perceived influence) with a TVC (best friend's smoking). In this final model, each within-variable latent factor was correlated with each other (e.g., intercepts and slopes). Between-variable correlations and regressions among latent factors, covariances between residuals, and associations among the TVC and the residuals were further examined. Thus, this final model evaluates how the starting point and rate of change in adolescents' own cigarette smoking is associated with the starting point and rate of change in their perceptions of their friends' influence not to smoke, while simultaneously evaluating the concurrent and lagged effects of best friends' actual smoking behavior on adolescents' own smoking behavior. Gender and poverty level were simultaneously assessed as time-invariant covariates (TICs). The heteroscedasticity of residuals per variable, as well as model constraints, were evaluated via LRTs described in the supplement.

Gender and income were included as covariates in all models. Parents' cigarette use was unavailable in the larger dataset, and thus parents' problematic substance use was evaluated as a covariate in post-hoc analyses. In all cases, parents' problematic substance use was unrelated to participants' cigarette use frequency and onset. Post-hoc models yielded an identical pattern of results; these models are available in Supplemental Material.

Results

Descriptive statistics and correlations

Table 1 presents the descriptive statistics and correlations among all study variables at all waves. Adolescents' own smoking frequencies, their best friends' smoking frequencies, as well as perceived influence not to smoke were autocorrelated at all waves with moderate effect size,

with the exception of best friends' smoking at Waves 3 & 4 which were not significantly associated. Concurrent correlations revealed that adolescents' own smoking frequency was positively associated with their best friends' smoking. There was significant variability in perceived influence not to smoke among both abstinent youth and smoking youth, as evidenced by a significant, yet modest correlation with youths' actual smoking behavior (with the exception of Wave 2). All analyses reported below were conducted with and without the use of log- transformed variables to account for skewness in cigarette use frequency. Unsurprisingly, the earliest two Waves used in the latent growth curve were the most skewed (W2: 3.7; W3: 2.94) while the final two Waves fell within reasonable limits (W4: 1.58; W5: 1.45). Both examinations yielded an identical pattern of results, and thus, results from untransformed data are reported for ease of presentation. Further, while maximum likelihood was utilized to assess likelihood ratio tests, maximum likelihood with robust standard errors was utilized to interpret and estimate the final model. All permutations of transformations and estimation type yielded identical patterns of results.

Cigarette use onset: multivariate discrete-time survival analyses

The first aim of the study was to evaluate the hypothesis that adolescents' best friends' *actual* smoking would be significantly predictive of adolescents' own smoking initiation, while adolescents' *perceived* influence from friends not to smoke would be protective (i.e., would decrease the odds of smoking initiation). To evaluate this hypothesis, two initial univariate discrete-time survival models were conducted, and then these models were collapsed into a conditional model to examine the relative effects of each peer influence mechanism on the outcome. As discussed, the proportionality assumption was evaluated independently for each variable and revealed no violations. Prior to fitting the survival models, a life table was created to extract survival and hazard probabilities to examine sample-wide patterns of cigarette initiation. Fig. 3 depicts the survival probability for cigarette use by wave for participants in the sample. The figure illustrates that as youth progress through adolescence, their probability of remaining abstinent decreases year-to-year until roughly age 17. Indeed, approximately 81% of adolescents were abstinent by age 13, a rate that decreased to 34% by age 17.

Univariate and multivariate discrete-time survival analyses revealed an identical pattern of effects and provide partial support for study hypotheses. In both cases, adolescents' best friend's cigarette use was significantly associated with the probability of adolescents' own cigarette use initiation; indeed, compared to youth whose friends did not ever smoke cigarettes, youth with friends who smoke are roughly three times more likely to begin smoking themselves (see Table 2). Contrasting hypotheses, friends' influence to *not* smoke did not significantly reduce the likelihood of adolescent cigarette use, although the effect was in the hypothesized direction (see Table 2).

Table 2
Uni- and multivariate discrete-time survival analyses.

	Univariate Models		Full Model	
	β (SE)	OR (95% CI)	β (SE)	OR (95% CI)
a. Cigarette Onset Survival Analysis				
Time 1[a]	0[a]	–	–	–
Time 2	0.25 (0.29)	1.28 (0.73–2.6)	0.33 (0.34)	1.35 (0.74–2.46)
Time 3	−0.27 (0.34)	0.76 (0.39–1.50)	−0.59 (0.39)	0.56 (0.26–1.19)
Time 4	0.05 (0.34)	1.05 (0.54–2.05)	0.44 (0.41)	0.65 (0.29–1.44)
Time 5	−0.81 (0.47)	0.45 (0.18–1.12)	−0.99 (0.50)	0.37 (0.14–1.00*)
Best Friend Having Ever Smoked [b]	0.82 (0.32)**	2.28 (1.22–4.24)**	1.04 (0.33)**	2.82 (1.47–5.39)**
Perceived Influence Not to Smoke	0.08 (0.12)	1.08 (0.86–1.35)	0.09 (0.12)	1.09 (0.86–1.39)
Percentage of Poverty Line	−0.01 (0.78)	0.99 (0.85–1.15)	0.15 (0.11)	1.16 (0.94–1.44)
Gender[a]	−0.05 (0.22)	0.96 (0.62–1.49)	−0.09 (0.30)	0.92 (0.51–1.66)

Note. * $p < .05$. ** $p < .01$. [a]1 = Male, 2 = Female.

Cigarette use frequency: bivariate latent curve model with a time-varying covariate

To examine the second study hypothesis, that adolescents' best friends' smoking behavior would be positively associated with smoking frequency while perceived influence from friends' to not smoke would be negatively associated, a bivariate latent curve model was fit. The final conditional model is visually displayed in Fig. 2.

Unconditional models

Prior to examining the full conditional model, the growth trajectories for each variable that changed over time (e.g., own smoking, best friends' smoking, and friends' influence) were determined via a series of likelihood ratio tests (LRTs). The change in chi-square at each step, as well as model fit for the unconditional models can be found in the supplement.

Participants' smoking frequency was best defined by a latent intercept and slope, with heteroscedastic residuals. There was a significant average intercept (M = 0.10, $p < .001$), and a significant average increase in the rate of cigarette use (M = 0.11, $p < .001$), but a nonsignificant correlation between the two ($r = -0.02$, $p = .831$). There was also significant variability in the intercept ($\sigma^2 = 0.13$, $p < .001$) and

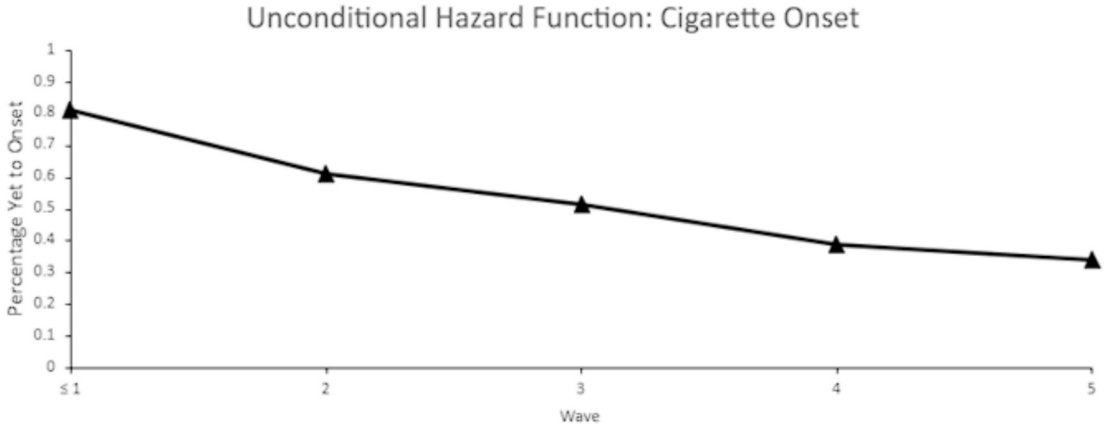

Fig. 3. Unconditional hazard function for cigarette use.

slope ($\sigma^2 = 0.04$, $p < .001$) indicating significant within-person differences in the starting points and rate of growth in cigarette smoking. An identical unconditional model best fit the data for influence not to smoke was fit; there was a significant average intercept ($M = 2.23$, $p < .001$), and a significant decrease in perceptions of influence not to smoke over time (slope factor; $M = -0.23$, $p < .001$), but a nonsignificant correlation between the two ($r = -0.12$, $p = .053$). There was also significant variability in the intercept ($\sigma2 = 0.68$, $p < .001$) and slope ($\sigma^2 = 0.12$, $p < .001$) indicating significant within-person differences in the starting points and rate of change in perceived influence not to smoke. Neither an intercept-only nor full linear growth curve model fit the data for best friends' smoking frequency (χ^2 (5) = 33.97, $p < .001$, RMSEA = 0.181 (90% CI: 0.126–0.241), CFI = 0.431, TLI = 0.317, and SRMR = 0.213); this is unsurprising given the potential for different reporters from year-to-year. However, as demonstrated by the means in Table 1, friends' smoking behavior increases from year-to-year on average.

Cigarette use frequency: building the conditional model

The unconditional models and covariates were combined into a single conditional model. Specifically, within-variable correlations between latent factors were modeled (e.g., intercepts and slopes), the cigarette smoking intercept and slope were regressed on two time-invariant covariates (gender and poverty level), and the intercept and slope for influence not to smoke. The slope for influence not to smoke was regressed on the intercept for adolescents' cigarette use, and both intercepts were also correlated with each other. Additionally, covariances between the residuals at each time point were introduced, and concurrent and one-year-lagged regressions were introduced between adolescents' best friends' smoking behavior and the residuals for adolescents' own smoking behavior (See Fig. 2 for a visual representation of this model, Table 3 and Supplemental Tables 1–2 for all standardized parameters).

This model fit the data well, (χ^2 (59) = 67.85, $p = .201$, RMSEA = 0.029 (90% CI: 0.00–0.056), CFI = 0.977, TLI = 0.971, and SRMR = 0.070), however, additional constraints were introduced to achieve optimal model parsimony. Specifically, the concurrent and lagged effects between best friends' smoking and adolescents' own smoking were constrained to equality, as were the lagged effects between friends' influence not to smoke and adolescents' own smoking. A stepwise description of these processes can be found in the supplement; this final model fit the data excellently, (χ^2 (64) = 70.65, $p = .265$, RMSEA = 0.030 (90% CI: 0.00–0.066), CFI = 0.965, TLI = 0.958, and SRMR = 0.083).

Table 3
Final conditional model: associations among the latent factors and controls.

Regressions		
Predictor	Outcome	β (SE)
Influence Intercept	Cigarette Slope	−0.12 (0.14)
Influence Slope	Cigarette Slope	−0.42 (0.14)*
Cigarette Intercept	Influence Slope	−0.09 (0.13)
Gender	Cigarette Intercept	0.03 (0.09)
Gender	Cigarette Slope	−0.18 (0.10)
Poverty	Cigarette Intercept	−0.04 (0.09)
Poverty	Cigarette Slope	−0.04 (0.10)
Correlations		
Variable 1	Variable 2	*r* (SE)
Influence Intercept	Influence Slope	−0.28 (0.11)
Cigarette Intercept	Cigarette Slope	−0.16 (0.15)
Influence Intercept	Cigarette Intercept	−0.09 (0.12)

Note. * = $p < .05$. Decisions as to use regression or correlations were made on the basis of hypotheses. Male = 1.

Model parameters

Associations among the latent variables can be found in Table 3, while the remaining associations can be found in the supplemental tables 1–2. Within-variable associations among the latent intercepts and slopes in the conditional model largely mirrored those revealed in the unconditional model. Gender and poverty level were further unrelated to the latent intercept and slope for cigarette smoking, but were retained in the final model nonetheless.

Bivariate associations among the latent factors

Consistent with the study's main hypothesis, the slope factor for perceived friends' influence not to smoke was significantly predictive of the slope factor for cigarette smoking (Table 3). Thus, adolescents who showed greater increases over time in their perceptions of friends' influence not to smoke also tended to exhibit a slower rate of increase in cigarette smoking over time. Conversely, the rate of change in cigarette smoking was unrelated to initial levels of influence to not smoke. Similarly, the rate of change in perceived influence from friends to abstain from cigarettes was not associated with initial levels of cigarette smoking. Lastly, both the rate of change and initial levels of cigarette smoking were unrelated to either gender or poverty levels.

Concurrent and prospective associations among residuals

Above and beyond the underlying trajectories for both cigarette smoking and friends' influence not to smoke, as well as the association at the latent factor level, there were significant negative covariances between these sets of residuals (*r*s range from −0.39 to −0.17; $p = .011$). Thus, the greater the magnitude of friends' influence to not smoke, the less adolescents smoked at a particular wave. The unstandardized covariances were constrained to equality at all timepoints, but construction of standardized betas utilizes unstandardized variances resulting in slightly different effects from wave-to-wave.

Consistent with hypotheses, there were additional concurrent (B = 0.18, βs = 0.16–0.20, $p < .001$) and one-year-lagged effects (B = 0.34, βs = 0.22–0.32, $p < .001$) between adolescents' best friends' cigarette consumption and participants' own smoking behavior. These effects reveal that best friends' smoking behavior is both concurrently and longitudinally associated with adolescents' own smoking frequency, suggesting that adolescents model their own cigarette use off of their friends' prior and current cigarette use. These effects were present above and beyond the effects of influence not to smoke (at both the latent factor and residual level), suggesting that these are two distinct peer influence mechanisms explaining unique variance in adolescent cigarette consumption.

Discussion

Theory, anecdote, and public health initiatives have suggested for decades that peer influence is responsible for the contagion of maladaptive risk-behaviors including alcohol use, marijuana use, sexual risk-behavior, and cigarette use (Chassin et al., 2004; Giletta et al., 2021). Results from the current study provide partial support by revealing that adolescents' best friends' influence is more potent than was previously thought with regards to smoking initiation. However, these results further elucidate the complexity of peer influence; peers' attempts to reduce adolescents' smoking *frequency* are fruitful, even after accounting for the effects of witnessing their best friends, who are reputed to be adolescents' most potent socializing source, smoke.

Smoking initiation

An initial goal of the study was to examine how best friends' actual smoking status and friends' perceived influence towards not smoking were prospectively associated with the likelihood of adolescents' own smoking initiation. Previous work in this domain has often been only

retrospective (e.g., asking adolescents when they began smoking), has examined these associations either cross-sectionally or with a one-year lag, and has utilized adolescents' perceptions of their best friends' smoking. The consensus from these data is that adolescents' best friends' smoking status is associated with roughly double likelihood of adolescents' own smoking initiation (Alexander et al., 2001; Jeon & Goodson, 2015). Results from the current study, utilizing prospective multi-reporter methodology, suggest that having a friend who smokes *prior to one's own initiation* predicted triple the likelihood an adolescent would begin smoking. This finding provides an advance over previous work relying on perceptions of peers' behavior; individuals tend to project the frequencies of their own behaviors onto others, thereby potentially misestimating alignment between their own and others' behavioral frequency (Gottfredson & Hirschi, 1987). Further, even among studies which utilize best friends' actual behavior (e.g., Deutsch et al., 2015), a one-year lag is not great enough to capture a meaningful portion of the sample's cigarette initiation without substantial right-censorship. Thus, while collecting data from multiple sources of influence over multiple timepoints can be laborious and expensive, results from the current study suggest that this may be a worthwhile pursuit.

Results further revealed that peers' influence not to smoke was not significantly associated with adolescents' own smoking initiation. One potential explanation is that youth who do not smoke, or have not communicated intentions or desires to smoke, are not overtly influenced to not smoke by peers. Indeed, if an adolescent has shown no indication of engaging in the behavior there is likely no stimulus to trigger peer influence towards or away from a behavior (e.g., smoking). Alternatively, it may be that the *source of influence* is most relevant to the gap in significance between these two mechanisms (Laursen & Faur, 2022). Comparable to this study, previous work has revealed that only best friends', but not popular peers', injunctive norms towards cigarette use were associated with onset (Field & Prinstein, 2023). These data suggest that when determining whether to engage in a behavior, the bigger social determinant may be *who* is communicating those attitudes towards that behavior. When considering both studies, best friends' actual cigarette use and perceived norms were predictive of onset, where the peer groups' general influence to not smoke and popular peers' perceived norms were not. This pattern of effects suggests that the magnitude of influence needed for an adolescent to engage in a behavior may be larger than the magnitude needed for an adolescent to *maintain or change the frequency* of that behavior. Such influence may need to be communicated by a close friend: an individual with whom adolescents derive self-worth from heightened similarity with (Laursen & Veenstra, 2021). While more empirical work is needed to fully understand how peer influence may function differently across distinct sources, it may be that the forms and functions of best friends' influence differ from those of the broader peer groups' influence. Indeed, each sources' influence may have differing routes of transmission: best friends' influence may be closely grounded in behaviors and attitudes communicated in private dyadic settings (Allen et al., 2012). This environment may be more conducive to learning unfamiliar behaviors, as adolescents may be more comfortable with the vulnerability of inexperience with close friends who may be eager to share their procedural knowledge of an unfamiliar activity, such as the act of lighting the cigarette or properly inhaling. The peer group's influence, in contrast, may be better understood as adjusting behavior to better represent group-level stereotypes (Abrams et al., 1990; Ajzen & Manstead, 2007; Hill et al., 1977), and thus may better reflect the appropriate *frequency* or number of cigarettes needed to achieve group-level homophily.

Smoking frequency

The second goal of the study was to examine how best friends' actual smoking frequency as well as their friends' influence towards not smoking were associated with their own smoking frequency. Unsurprisingly, best friends' actual smoking behavior was associated with increases in adolescents' own smoking behavior, both concurrently and prospectively, even over and above adolescents' underlying smoking trajectory. In other words, best friends' current smoking predicted greater future relative increases in youths' own smoking than would be expected by their trajectory alone. Yet, because these associations occurred at the residual level rather than at the latent factor level, it is only responsible for *deviations* from the trajectory, rather than for shifts in the trajectory itself. In contrast, greater increases in perceived peer influence not to smoke significantly predicted smaller increases in youths' own smoking across adolescence. Indeed, these two trajectories *traveled through time* together, such that the more youth perceived influence to not smoke, the less they smoked throughout adolescence. This study is among the first to suggest that peers' attitudes towards abstinence may be worth elevating, as they may be responsible for meaningful shifts in adolescents' own smoking behavior throughout adolescence.

Attempts from adults and public health initiatives to reduce adolescent smoking have been inconsistent (Alsahli et al., 2025; Gardner et al., 2024), perhaps because as adolescents age, they become more resistant to influence from parents and non-familial adults, and more susceptible to influence from peers (Steinberg & Monahan, 2007). Thus, it may be that the same message that adults have been communicating to adolescents for years, may be more effectively articulated by close friends (Laursen & Veenstra, 2021) or their popular peers (Field & Prinstein, 2023); results from the current study suggest that more general peer group norms towards abstaining from risk-behaviors may be a fruitful approach.

Practical implications

Burgeoning work has further found support for *peer-led* interventions, which utilize the reputation and influence of same-age peers to attempt to reduce health risk behavior. A recent meta-analysis revealed that, across ten studies, the presence of peer-led interventions resulted in a 22% lower chance of having smoked compared to controls (MacArthur et al., 2016), although there was evidence of heterogeneity in the interventions' efficacy. A potential source of this heterogeneity may be in the *stage* of tobacco use, as results from the current study suggest that anti-smoking peer norms were relatively unrelated to smoking initiation, but were powerful correlates of decreased smoking frequency among tobacco users. With regards to initiation, adolescents with close friends who did *not* smoke were roughly three times less likely to begin smoking.

Together, these findings suggest that different peers may be better utilized for potential interventions across differing stages of tobacco use. If the goal of intervention is to decrease the chances of smoking initiation, the most at-risk adolescents are those with close friends who smoke. For these adolescents, increasing resistance to peer influence through targeting meaningful moderators such as lower self-esteem (Field et al., 2024) or compromised autonomy (Allen et al., 2006) may be most beneficial (Hansen & Graham, 1991). For adolescents who have *already* begun smoking, a more promising avenue to reduce tobacco use may lie in elevating anti-smoking attitudes communicated by influential peers, such as those who are highly liked or perceived to be popular (Helms et al., 2014). Results from the current study suggest that to reduce smoking frequency, practitioners can potentially leverage *perceptions* of smoking norms held at the schoolwide or friend-group level. Foundational psychological research suggests that pluralistic ignorance, or the misperception that others engage in behaviors at greater rates than one does, explains meaningful variance in substance use outcomes (see Sargent & Newman, 2021 for a review). Thus, norm-based interventions should not only clarify the *actual* rates of cigarette smoking among youth, but also highlight prosocial anti-smoking attitudes held by influential members across the social network. Such peer components could be embedded within existing school-based anti-smoking programs or community prevention initiatives, while being mindful that the

efficacy of these prevention efforts may depend on *if* and *how much* they smoke.

Limitations and future directions

While this study's strengths include a diverse community sample, multiple reporters and study waves, and the examinations of both cigarette-use onset and frequency there are several opportunities for future work to improve upon. Perhaps most notably, these data were collected between 1999 and 2004. Replication of these exact findings with a comparable sample size may prove difficult with modern samples, given declines in adolescent cigarette use and the advent of electronic nicotine delivery devices. However, while the nicotine landscape has shifted in the last 20 years, the peer influence processes driving these associations likely have not. Relatedly, a second notable limitation is the examination of cigarette use, rather than peer influence effects towards e-cigarette or vape use. However, e-cigarette use is significantly predictive of later cigarette use (Staff et al., 2020), and peer influence mechanisms have previously been found to be nearly identical among alcohol, marijuana, and cigarette use (Field & Prinstein, 2023), suggesting that peer influence effects towards each 'soft' substance may roughly mirror each other. Thus, it may be that the patterns of influence revealed towards cigarettes, may equally apply to marijuana, alcohol, and other nicotine delivery devices such as vapes or nicotine pouches; nonetheless, empirical comparisons of the social determinants of cigarettes and e-cigarettes are required.

A third notable limitation is that the regressed slopes in the latent growth curve could not examine the fully lagged effects typically examined within studies of peer influence. Thus, although our findings suggest these two variables are tightly linked throughout adolescence, they cannot distinguish the direction of causal processes (i.e., peers could be influencing smoking behavior or vice versa). A fourth limitation is that the current study could not elucidate the exact mechanism at play with influence not to smoke. Adolescents' peers could be limiting their own smoking through direct peer pressure (Kobus, 2003), through reinforcement of nonverbal behavioral cues (Dishion et al., 1996), or through potential social sanctions (e.g., friendship dissolution or isolation; Hartl et al., 2015), but the current study could not isolate the specific pathway of influence, as future work should. Relatedly, while we were able to compare the relative influence of best friends and the general peer group, we could not isolate the mechanisms of influence and the source of influence. It may be that best friends' influence not to smoke would also not predict onset, or that the smoking status of the adolescents' broader peer milieu may predict onset; this is a ripe area for future work. In the same vein, future work should examine whether influence to smoke and influence not to smoke do indeed represent two distinct continua, or different ends of the same continuum.

Notably, only about 42.3% of best friend nominations remained stable across waves in the current study, indicating substantial annual turnover in close friendships. While this likely has implications for peer influence processes, this level of turnover is consistent with previous descriptive work examining friendship stability. Friendships are relatively short-lived in adolescence; only about 50% of school-based friendships survive to the year's end (Meter & Card, 2016), and even fewer are maintained across transitional periods such as the shift from middle school to high-school (Benner, 2011; McMillan et al., 2025). Nonetheless, friendship stability likely moderates peer influence effects. For example, previous work suggests that more enduring friendships tend to show stronger socialization effects for substance use and related behaviors (Brechwald & Prinstein, 2011; Poulin & Chan, 2010). While we are limited by our sample size, future work could explicitly test whether friendship stability moderates peer influence effects towards both cigarette use onset and frequency.

Additional work should further survey youth younger than 13 years-of-age. Peer influence susceptibility may differ from childhood to adolescence (Steinberg & Monahan, 2007), as does the importance ascribed to friendships relative to parental relationships (Larson et al., 1996), and thus more work is needed to capture the full timeline of cigarette smoking initiation and frequency. Relatedly, the current sample was limited to 184 participants – which is deemed adequate for both survival analyses and latent growth curve models – but nonetheless may have been played a role in the null effects viewed in either model.

Conclusions

Despite these limitations, results from the current study suggest that influence from both best friends' and the broader peer group are both significantly predictive of adolescent cigarette consumption. To understand an individual's risk for cigarette use (and perhaps substance use more broadly), neither knowing the specific best friendship norms and behaviors nor the greater peer group norms is sufficient, but rather both additively contribute to understanding adolescents' future substance use patterns. Each also has unique routes of potential transmission that should be the focus of future empirical work. With further replication and confirmation, these results potentially suggest that when applying prevention efforts, attention should be paid to smoking status and attitudes of both adolescents' close friends as well as the larger peer group, recognizing that each may play a unique role depending on the smoking stage/status of a target adolescent.

Author note

Informed consent was obtained from all the participants in accordance with approved human subjects procedures and all aspects of the study were approved by the University's Institutional Review Board. The ethics approval statement is not applicable. Materials reported here have not been published nor are under consideration at another journal.

CRediT authorship contribution statement

Nathan H. Field: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Meghan A. Costello:** Writing – review & editing, Writing – original draft, Project administration, Data curation. **Lauren Breeden:** Writing – review & editing, Writing – original draft, Project administration. **Joseph P. Allen:** Writing – review & editing, Writing – original draft, Supervision, Investigation, Funding acquisition, Data curation.

Declaration of competing interest

None.

Acknowledgements

This study was supported by grants from the Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD) and the National Institute of Mental Health (NIMH) (5R37HD058305-23, R01HD058305-16A1, R01-MH58066). This study could not have been completed without years' worth of research assistants and associates' aid with data collection, nor without our dedicated community sample, and thus, we are very grateful for their efforts and contributions.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appdev.2026.101952.

Data availability

Data are not available, but analysis code are available upon request to the first author. This study was not preregistered.

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