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Quantifying the Persistence of Pro-Smoking Media Effects on College Students' Smoking Risk

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Abstract

Purpose—To quantify the persistence of pro-smoking media exposure effects on college students' intentions to smoke and smoking refusal self-efficacy.

Method—A total of 134 college students (ages 18–24) were enrolled in an ecological momentary assessment study in which they carried handheld data collection devices for three weeks and reported their exposures to pro-smoking media as they occurred in the real world. Smoking intentions and smoking refusal self-efficacy were assessed after each exposure to pro-smoking media and at random prompts during each day of the three-week assessment period. A generalized additive model was used to determine how long the effect of an exposure to pro-smoking media persisted.

Results—The effect of pro-smoking media exposures persisted for 7 days. After exposure, smoking intentions immediately increased (0.56; 95% confidence interval [CI]: [0.26, 0.87]) and then steadily decreased (−0.12; 95% CI: [−0.19, −0.05]) each day for 7 days, while smoking refusal self-efficacy immediately decreased (−0.42; 95% CI: [−0.75, −0.10]) and then steadily increased (0.09; 95% CI: [0.02, 0.16]) each day for 7 days. Daily changes occurring after 7 days were not statistically significant, suggesting that smoking intentions and refusal self-efficacy had stabilized and were no longer affected by pro-smoking media exposure.

Conclusions—Exposures to pro-smoking media may have strong implications for emerging young adults smoking risk as the impact of an individual exposure appears to persist for at least a week.

Keywords

Cigarette advertising; movies; smoking; persistence

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Authors' contribution: All the listed authors were part of the team that conceptualized and designed the study. They all drafted different parts of the initial manuscript, reviewed or revised it and approved the final manuscript as submitted.

Implications and contribution: Pro-smoking media exposure increases college students' smoking risks and these effects persist for seven days after initial exposure before leveling off. As such, pro-smoking media exposure is likely to have an impact on behavior even if opportunities to act on one's heighted intentions or weakened self-efficacy happen several days later.

In 2010, emerging young adults aged 18–25 years reported the highest prevalence of current cigarette smoking (34.2%) compared to high school seniors (23.2%) or adults aged ≥26 years (22.8%) and there is convincing evidence that exposure to pro-tobacco media is associated with increased tobacco use in young adults.[1] Numerous studies have demonstrated that greater exposure to tobacco industry-sponsored promotion (e.g., point-of-sale displays, magazine advertising) and portrayals of tobacco use in movies is associated with an increased risk for initiation of and progression toward regular tobacco use among young adults.[1–3] Yet, there is little understanding of *how* exposure to pro-smoking media increases young adults' risk of future smoking [4].

According to cognitive social learning and decision-making theories, cognitive and affective factors are engaged at the time of exposure thus creating the susceptibility to smoke when an opportunity to do so arises.[3, 5–8] Implicit in these theories is the notion that the effects of pro-smoking media on attitudes and beliefs persist and conceivably accumulate over time. Specifically, because there is often a lag between exposure to pro-smoking media and the opportunity to smoke, the effects of pro-smoking media exposure must persist beyond the moment of exposure if they are to have implications for whether smoking actually occurs.

To date, no studies have directly demonstrated the persistence of pro-smoking media's impact on the attitudes and beliefs thought to mediate the effect of pro-smoking media on behavior. Numerous experimental studies have shown a causal effect of pro-smoking media (e.g., portrayals of smoking in movies, magazine ads) on attitudes and beliefs directly following exposure. [9–12] These experimental studies are important because they provide compelling evidence that attitudes and beliefs are, in fact, engaged at the time of exposure to pro-smoking media. They provide no indication, however, of how long these exposure effects persist. Moreover, these studies expose participants to pro-smoking media in the artificial context of the laboratory and thus lack ecological validity. Prospective, correlational field studies that measure prior exposure to pro-smoking media at baseline and link that exposure to attitudes and beliefs measured at follow-up provide evidence that is consistent with the idea that exposure creates an enduring susceptibility to smoke.[13–15] However, these studies, which typically measure changes in youths' attitudes and beliefs several months after their exposure to pro-smoking media, assume rather than demonstrate the endurance of pro-smoking media's effects on these hypothetical mediators.

Demonstrating the persistence of pro-smoking media effects requires repeated measurement of the attitudes and beliefs thought to be engaged by these media. Ideally, these measurements should begin directly following exposure to pro-smoking media and be repeated at frequent intervals thereafter. Ecological Momentary Assessment (EMA) methods are well-suited to providing precisely these kinds of data.[16, 17] EMA solicits data from respondents at the time of exposure and in real world contexts in which they naturally encounter pro-smoking media, providing repeated, sensitive and ecologically valid assessment of cognitive processes engaged by media. We have used EMA to examine exposure outlets and changes in college students' future smoking risk as a function of their exposure to a variety of pro-smoking media. In prior papers, we reported that nearly 66% of encounters of pro-smoking media occurred at point-of-sale locations (33% at convenience stores, 25% at outside or window stores/gas stations, 7% at grocery or tobacco stores), 20% via exposure in movies and on TV, and the remaining 14% occurring at bars/restaurants, in magazines, on the internet and on other media outlets. We also demonstrated that students' future smoking risk was higher in moments directly following exposure to pro-smoking media than at randomly sampled moments of non-exposure.[18, 19] This paper extends those findings by evaluating the duration of these exposure effects. In particular, we assessed the persistence of pro-smoking media exposure effects on college students' intentions to smoke and smoking-refusal self-efficacy (i.e., indices of future smoking risk).

Methods

Participants

Participants were 134 undergraduate college students, ages 18–24 years, recruited through newspaper advertisements around the city of Pittsburgh as described elsewhere.[19] The sample was 37% male and 66% Caucasian. We characterized participants' smoking status as either Never Smokers (n = 52; never smoking a cigarette, even a puff) or Ever Smokers (n = 82; any level of smoking in the past, even if they had not smoked in the past month (experimenters) or if they reported smoking in the past month (current).[20] We combined experimental and current smokers into an Ever Smokers group because the number of current smokers was small (n=13). Only 37% of Ever Smokers reported smoking in the past month. Ever Smokers who smoked in the past month smoked an average of 6 days in the past month (SD = 4.4) and an average of 2.2 (SD = 1.3) cigarettes on the days that they smoked.

Procedure

The study was approved by RAND's Human Subjects Protection Committee. Data collection took place between June 2010 and January 2011. At a baseline session, participants provided written informed consent to participate in the study, completed a demographic and smoking history survey, and were trained to use a handheld data collection device (Palm devices) to record information about their exposure to pro-tobacco media. Training consisted of a detailed, 60-minute oral presentation accompanied by electronic slides. Each participant was given a Palm® Treo 755p device at the start of the training so that they could practice data entry prior to going into the field. Participants were instructed to turn the device on when they woke up in the morning and off at night when they went to sleep, carry the device with them at all times, initiate data entry each time they encountered pro-tobacco media, and respond to random prompts when issued by the device (see below).

Participants carried the Palm devices with them for 21 consecutive days. Participants provided descriptive information about each encounter with pro-smoking media, including the channel of exposure (in a magazine, on a billboard, outside of a convenience store or gas station, inside a grocery store, inside or on the window of a convenience store or gas station, in a tobacco store, in a bar or restaurant, via direct mailing or coupon, at a sponsored event, in a movie, on television, on the radio, and on the internet). Immediately after each exposure, participants answered questions about their smoking intentions and smoking refusal self-efficacy (see details below). Participants similarly reported their smoking intentions and refusal self-efficacy in response to control prompts that occurred randomly three times per day. The Palm device automatically recorded the time of each data entry, whether in response to an exposure or random prompt.

Participants were paid $8 for each day of EMA assessment ($168 total), and $10 each for the baseline and an end-of-study visit. They were paid an additional $2/day if they responded to all of the random control prompts on that day within two minutes of the prompt. Thus, participants could be paid $230 if they completed all aspects of the study and adhered closely to the study protocol.

Measures

Smoking intentions—After each pro-smoking media exposure and random prompt, participants indicated their intention to smoke by completing a 3-item scale adapted from Choi et al.[20] and shown to predict smoking: "Do you think you will try a cigarette anytime soon?", "Do you think you will smoke a cigarette anytime in the next year?"; and "If one of your best friends offered you a cigarette, would you smoke it?" Responses were made on a 1

(Definitely Not) to 10 (Definitely Yes) scale and averaged ($\alpha = 0.94$) to produce a smoking intention scale score (range: 1 – 10), where higher scores indicate stronger intentions to smoke.

Smoking refusal self-efficacy—After each exposure to pro-smoking media and at random prompts, participants also rated their confidence to refuse smoking using an adapted four-item measure.[21, 22] Participants judged their ability to resist smoking under the following circumstances: (a) your best friend is smoking, (b) your date is smoking, (c) you are bored at a party, and (d) all your friends at a party are smoking. Ratings were made on a four-point scale with the following endpoints: "I would definitely smoke (1)" and "I would definitely not smoke (4)." Responses to these four items were averaged to form a single measure of refusal self-efficacy ($\alpha = 0.93$), where higher scores indicate stronger refusal self-efficacy.

Quantifying the Persistence of Pro-Smoking Media Exposure Effects

Our study design included continuous assessment of exposure to pro-smoking media and repeated measurement of outcomes (smoking intentions and smoking refusal self-efficacy) at times of exposure to pro-smoking media and at regularly occurring random prompts. Because the random prompts provided intermittent data on smoking intentions and refusal self-efficacy between pro-smoking media exposures (e.g., a pro-smoking media exposure event followed by several random prompt events), we quantified persistence as the length of time that exposure effects could be detected in the random assessments taken between one exposure to pro-smoking media and the next. In other words, persistence was operationalized as the time elapsed between the highest rating of smoking intention or lowest rating of refusal self-efficacy following an exposure to the point at which no further change in smoking intentions or smoking refusal self-efficacy was observed.

Statistical Analysis

Given that participants may have self-selected into circumstances where they were likely to be exposed to pro-smoking media (thus biasing our estimate of persistence), all fitted models included the following covariates: the day of the week (weekend vs. weekdays) on which an exposure or random prompt occurred, participant demographics (gender and race), and participant smoking status. These control variables have been shown to be associated with responses to smoking-related media.[19, 23, 24]

To limit extreme values and to reduce the effect of outliers, persistence was Winsorized[25] at 14 days. In other words, random prompts that occurred more than 14 days after an exposure to pro-smoking media (3% of all random prompts), with no intervening exposures, were treated as if it they occurred on the fourteenth day following exposure.

To assess whether smoking risk increases immediately after exposure to pro-smoking media, we fit multivariate linear regression models comparing smoking intentions and refusal self-efficacy directly following an exposure to pro-smoking media versus at subsequent random prompts while controlling for the covariates. If our hypothesis of the persistence of exposure effects is accurate, the exposure effect that is estimated by this model represents an underestimate of the true instantaneous impact of pro-smoking media as the measurements of intentions and refusal self-efficacy taken at random prompts will still reflect, to some degree, the persistent effect of the preceding exposures. To evaluate the persistence of effects of exposure to pro-smoking media, we used a semi-parametric Generalized Additive Modeling approach (GAM) [26, 27] to estimate the following model:

$$Smoking\ Risk_{it}=\beta_0+g(Persistence\ Time_{it})+\beta_2 X_{it}+\varepsilon_{it}$$

where the outcome variable, $SmokingRisk_{it}$, is person i's future smoking risk recorded at time t, $PersistenceTime_{it}$ is the time elapsed between one exposure to pro-smoking media and the subsequent random observations, and X_{it} represents a set of covariates. $PersistenceTime_{it}$ is operationalized in days based on the random prompts that occur between exposures. $PersistenceTime_{it}$ takes the value zero at the time of exposure, increases for example to 0.25, 0.5, 1 or 2 if subsequent intervening random prompt occur 6, 12, 24 or 48 hours later respectively, and then is reset to zero at the next exposure.

In this model, g( ) represents an unknown non-linear function, estimated non-parametrically using GAM. The empirical, non-linear function g( ) provides the flexibility to estimate temporal change in smoking risk following an exposure without having to rely on the assumption that change is constant (i.e., linear) over time from one exposure to the next. That is, the model makes no assumptions about the nature of the relationship between smoking risk and time since last exposure to pro-smoking media, and instead determines the relationship empirically.

A GAM plot[28] of $PersistenceTime_{it}$ on g($PersistenceTime_{it}$) provides a visual assessment of the persistence of an effect of pro-smoking media exposure on smoking risk. For ease of interpretation of the GAM plot, we used the method of recycled prediction [27] (a method of standardization) to rescale the persistence effect by estimating the model-adjusted smoking risk. We then identified in the rescaled GAM plot the point (threshold) at which the impact of pro-smoking media could no longer be detected in the random assessments.[27] Next, we constructed a piecewise linear model[28, 29] to examine the slope of persistence before and after the threshold identified in the GAM plot. All models accounted for clustering of outcomes within participants using the Huber-White sandwich estimator.[30, 31]

Secondarily, to assess the possibility that exposure may have a cumulative effect on smoking intentions and refusal self-efficacy, we tested whether intentions to smoke at specific exposures were higher (and refusal self-efficacy lower) when exposures occurred within one day of a preceding exposure than when exposures occurred four or more days following a preceding exposure. We chose four or more days to represent a long gap in exposures because four days was at least halfway to the point at which persistence was observed to be minimal.

Results

Descriptive Information

We excluded from our analysis data from six participants (4%) who reported no exposure to pro-smoking media. Across the 21-day EMA monitoring period, the remaining 128 participants reported an average of 8.60 (*SD*=7.86) exposures to pro-smoking media. Consistent with rates observed in other EMA studies of college students, [32] participants in this study responded to 83% of all random prompts within two minutes of being prompted. In total, participants responded to 6,779 random prompts and reported 1,112 exposures to pro-smoking media over the course of the study. Data from random prompts that occurred before a participant recorded any exposure to pro-smoking media (856 or 13% of all random prompts) were dropped from the analysis because those data were not relevant to estimating persistence as defined by our statistical model. Data from 66 random prompts (1% of all random prompts) and 8 exposures (1% of all exposures) were dropped because participants failed to complete outcome assessments at those prompts/exposures. Finally, data collected

at 168 random prompts (2% of all random prompts) were excluded because participants reported that they were in the presence of pro-smoking media at those randomly sampled moments. On average, 11.5 (SD=11.17) random assessments occurred between exposures to pro-smoking media.

Estimating the instantaneous and persistence of exposure effects

Table 1 reports the instantaneous effect of exposure to pro-smoking media on smoking risk. As this table shows, participants' smoking intentions significantly increased (β = 0.56, 95% CI [0.26, 0.87]) and their smoking refusal self-efficacy significantly decreased (β = −0.42, 95% CI [−0.75, −0.10]) directly following exposure. Figures 1 and 2 show the GAM-plot of the covariate-adjusted non-linear relationship between the time since the last exposure to pro-smoking media and participants' covariate-adjusted level of smoking intentions (Figure 1) and smoking refusal self-efficacy (Figure 2). Consistent with the results from the model of instantaneous exposure effects, the covariate-adjusted level of smoking intentions was highest immediately after exposure (3.07 on a 10-pt scale); it then declined steadily for seven days until it stabilized at 2.17. Results followed a similar pattern for smoking refusal self-efficacy: Participants' smoking refusal self-efficacy was lowest immediately after an exposure (8.34) and then increased steadily until it stabilized seven days later at 9.01.

Results of a piecewise linear model that was used to examine persistence of an exposure effect on participants' intentions to smoke up to and after 7 days post-exposure (i.e., the effect threshold that we observed in the GAM-plot) are reported in Table 1. The piecewise linear regression confirmed a daily decrease in the effect of exposure on intentions during the first seven days (β = −0.12, 95% CI [−0.19, −0.05]) but no change in the effect thereafter (β = 0.01, 95% CI [−0.08, 0.10]). The piecewise time trend and the covariates explained nearly 23% of the variability in participants smoking intentions. Similarly, following exposure to pro-smoking media, participants' smoking refusal self-efficacy steadily rebounded during the first seven days following exposure (β = 0.09, 95% CI [0.02, 0.16]); no consistent change in smoking refusal self-efficacy was evident thereafter (β=−0.01, 95% CI [−0.10, 0.08]). This model explained 16% of the variability observed in smoking refusal self-efficacy.

In both the instantaneous exposure impact and the persistence models, never smokers as compared with ever smokers tended on average to have weaker intentions to smoke (β= −2.20, 95% CI [−2.82, −1.58]) and greater smoking refusal self-efficacy (β=1.74, 95% CI [1.12, 2.36]).

Estimating cumulative effects of pro-smoking media exposures

On average, exposures that occurred within one day of a preceding exposure were associated with greater smoking risk when compare to exposures that happened four or more days following a preceding exposure. At exposures that occurred four or more days following a preceding exposure, participants' intention to smoke was lower (β= −0.92, 95% CI [−1.54, −0.30]) and their self-efficacy was higher (β= 0.55, 95% CI [−0.01, 1.11]) than at exposures that occurred within one day of another exposure. This analysis suggests the possibility of accumulation of effects when exposure events are closer to each other.

Discussion

Conceptual models of how exposure to pro-smoking media influences smoking behavior assume that exposure to pro-smoking media has an enduring effect on people's attitudes and beliefs. No study before ours, however, has tested this assumption directly or examined how long the effects of exposure to pro-smoking media persist. Our study demonstrates that the

effect of exposure to pro-smoking media on college students' smoking risk (as indexed by increased intentions to smoke and decreased smoking refusal self-efficacy[22, 33]) tends to persist for up to a week following exposure. This finding may help to explain the dose-response relationship between exposure to pro-smoking media and smoking uptake that has been found in other studies.[34] These results suggest that exposures that occur before the impact of prior exposures "wear off" could cause the risk of smoking to accumulate, thus increasing the chances that a young person will decide to smoke when presented with an opportunity to do so. In our three-week study, all participants were at some point exposed to pro-smoking media within seven days of a previous exposure, i.e., before the effects of the prior exposure had completely dissipated.

The question of how long the effects of pro-smoking media persist after exposure has important implications for regulatory policy and the development of interventions to inoculate young adults (and perhaps younger adolescents) from the effects of these media. The results of our study suggest that exposure to pro-smoking media is likely to have an impact on behavior even if opportunities to act (i.e., smoke) on one's heighted intentions or weakened self-efficacy happen relatively infrequently. Given the persistent effects of a single exposure to pro-smoking media on smoking risk a ban on tobacco advertising may be thought of as a most effective regulatory approach. Indeed, data from other countries suggest that comprehensive bans on tobacco advertising may protect youths from the effects of pro-smoking media.[35, 36] However, Fifth Amendment protections of commercial free speech make such bans in the United States unlikely.[37] As such, less restrictive and more creative tobacco marketing regulatory policies are needed in the United States. For example, anti-smoking messaging that is located more prominently in places where adolescents and young adults are likely to encounter pro-smoking media (e.g., at point-of-sale[38]) could dampen its potency. Regulatory science research that identifies effective tobacco marketing restrictions is needed to inform these sorts of policy-relevant strategies.

Use of EMA data to examine the persistence of effects of exposure to pro-smoking media represents a novel use of this type of data and further demonstrates its potential to enhance our understanding of how exposure to pro-smoking media may put youth at risk for smoking. In this study, emerging young adults reported their exposures to pro-smoking media as they occurred in the context of their daily lives and likewise recorded their reactions to those exposures at nearly the time that they experienced them. This assessment method gives us confidence in the reliability and ecological validity of our findings. Moreover, the design of our study in which we combined event-contingent recording of intentions to smoke and refusal self-efficacy with signal contingent recordings of these cognitions[16] allowed us to create a detailed portrait of individuals' standings on these variables between exposure events. This is precisely the type of information that is needed to examine the decay of exposure effects.

Nevertheless, our study did have several limitations. First, our study covered only a three week "snapshot" of college students' exposure to pro-smoking media and did not account for exposures to pro-smoking media that occurred prior to this snapshot. Second, even in the context of EMA data, exposures were self-triggered by study participants. As such, it is possible that additional pro-smoking media exposures were encountered but processed peripherally (i.e., outside of conscious awareness) and thus were not recorded.[39] Such self-selection, conscious or not, might explain some of the unexplained variation in the smoking risk outcomes. Third, although GAM is a useful method for understanding short-term effects of naturally occurring events, a limitation is that it depends on the subjective interpretation of a graphical display (the thresholds observed in this study were, however, reasonably clear). Finally, data used in this study are only correlational and can only be interpreted as such. Although our results fit with models of advertising and media effects, changes in

smoking risk that were observed cannot necessarily be assumed to be caused by exposure to pro-smoking media.

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Abbreviations

CI	confidence interval
EMA	ecological momentary assessment
GAM	generalized additive model
SD	standard deviation

References

1. U.S. Department of Health and Human Services (US DDHS). Preventing tobacco use among youth and young adults: a report of the surgeon general. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; 2012.
2. Riggotti NA, Moran SE, Wechsler H. US College students' exposure to tobacco promotions: Prevalence and association with tobacco use. Am J Public Health. 2005; 95:138–144. [PubMed: 15623874]
3. DiFranza J, Wellman RJ, Sargent J, et al. Tobacco promotion and the initiation of tobacco use: Assessing the evidence for causality. Pediatrics. 2006; 117:e1237–e1248. [PubMed: 16740823]
4. National Cancer Institute. The role of the media in promoting and reducing tobacco use (NIH Publication No. 07–6242). Bethesda, MD: U.S. Department of Health and Human Services, National Institutes of Health, National Cancer Institute; 2003.
5. Austin EW, Chen M, Grube JW. How does alcohol advertising influence underage drinking? The role of desirability, identification and skepticism. J Adolesc Health. 2006; 38:376–384. [PubMed: 16549298]
6. Heatherton TF, Sargent JD. Does watching smoking in movies promote teenage smoking? Curr Dir Psychol Sci. 2009; 18:63–67. [PubMed: 20160916]
7. Kardes, FR. Consumer judgment and decision processes. In: Wyer, RS.; Srull, TK., editors. Handbook of social cognition: Volume 2, Applications. Hillsdale, NJ: Erlbaum; 1994. p. 400-466.
8. Sargent JD, Dalton MA, Beach ML, et al. Viewing tobacco use in movies: does it shape attitudes that mediate adolescent smoking? Am J Prev Med. 2002; 22:137–145. [PubMed: 11897456]
9. Lochbuehler K, Sargent JD, Scholte RHJ, et al. Influence of smoking cues in movies on explicit smoking cognitions and implicit associations towards smoking among children. Pediatrics. 2012; 130(2):221–227.10.1542/peds.2011-1792 [PubMed: 22778302]
10. Pechmann C, Knight SJ. An experimental investigation of the joint effects of advertising and peers on adolescents' beliefs and intentions about cigarette consumption. J Consum Res. 2002; 29:5–19.
11. Shadel WG, Martino SC, Setodji C, et al. Motives for smoking in movies affect future smoking risk in middle school students: An experimental investigation. Drug Alcohol Depend. 2012; 123(1–3):66–71.10.1016/j.drugalcdep.2011.10.019 [PubMed: 22074766]
12. Shadel WG, Tharp-Taylor S, Fryer CS. Developmental maturity of the adolescent self-concept predicts smoking intentions following exposure to cigarette advertising. J Pediatr Psychol. 2008; 33:751–760. [PubMed: 18356185]
13. Tickle JJ, Hull JG, Sargent JD, et al. A structural equation model of social influences and exposure to media smoking on adolescent smoking. Basic and Applied Social Psychology. 2006; 28:117–129.

14. Wills TA, Sargent JD, Stoolmiller M, et al. Movie exposure to smoking cues and adolescent smoking onset: A test for mediation through peer affiliations with adolescents in Northern New England. Health Psychol. 2007; 26:769–776. [PubMed: 18020850]
15. Wills TA, Sargent JD, Stoolmiller M, et al. Movie smoking exposure and smoking onset: A longitudinal study of mediation processes in a representative sample of US adolescents. Psychol Addict Behav. 2008; 22:269–277. [PubMed: 18540724]
16. Shiffman S. Ecological Momentary Assessment (EMA) in studies of substance use. Psychol Assess. 2009; 21:486–497. [PubMed: 19947783]
17. Stone AA, Shiffman S. Ecological momentary assessment (EMA) in behavioral medicine. Ann Behav Med. 1994; 16:199–202.
18. Shadel WG, Martino S, Setodji C, et al. Exposure to pro-smoking media on college students' future smoking risk. Health Psychol. 2012; 31:460–466. [PubMed: 22353027]
19. Martino SC, Scharf D, Setodji C, et al. Measuring exposure to pro-tobacco marketing and media: a field study using ecological momentary assessment. Nicotine Tob Res. 2012; 14:398–406. [PubMed: 22039076]
20. Choi WS, Gilpin E, Farkas A, Pierce J. Determining the probability of future smoking among adolescents. Addiction. 2001; 96:313–23. [PubMed: 11182877]
21. Ellickson P, Hays R. On becoming involved with drugs: Modeling adolescent drug use over time. Health Psychol. 1992; 11(6):377–385. [PubMed: 1286657]
22. Tucker JS, Ellickson PL, Klein DJ. Five-year prospective study of risk factors for daily smoking in adolescence among early nonsmokers and experimenters. J Appl Soc Psychol. 2002; 32:1588–1603.
23. DiRocco D, Shadel WG. Gender differences in adolescents' responses to themes of relaxation in cigarette advertising: Relationship to intentions to smoke. Addict Behav. 2007; 32:205–213. [PubMed: 16650623]
24. Hafez N, Ling PM. Finding the Kool Mixx: how Brown & Williamson used music marketing to sell cigarettes. Tob Control. 2006; 15:359–366. [PubMed: 16998169]
25. Shete S, Beasley TM, Etzel CJ, et al. Effect of winsorization on power and type 1 error of variance components and related methods of QTL detection. Behav Genet. 2004; 34(2):153–159. [PubMed: 14755180]
26. Hastie, T.; Tibshirani, R. Generalized additive models. New York, NY: Chapman and Hall; 1990.
27. Setodji CM, Scheuner M, Pankow JS, et al. A graphical method for assessing risk factor threshold values using the generalized additive model: The Multi-Ethnic Study of Atherosclerosis. Health Serv Outcomes Res Methodol. 2012; 12:62–79. [PubMed: 22593642]
28. Setodji CM, Le V, Schaack D. Using generalized additive modeling to empirically identify thresholds within the ITERS in relation to toddlers' cognitive development. Dev Psychol. 2012 Advance online publication. 10.1037/a0028738
29. Greene, WH. Econometric analysis. 4. Upper Saddle River, NJ: Prentice-Hall; 2000.
30. Huber, PJ. Proceedings of the Fifth Berkeley Symposium on Mathematical Statistics and Probability. Berkeley, CA: University of California Press; 1967. The behavior of maximum likelihood estimates under nonstandard conditions; p. 221-233.
31. White H. A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. Econometrica. 1980; 48(4):817–830.
32. Piasecki TM, Richardson AE, Smith SM. Self-monitored motives for smoking among college students. Psychol Addict Behav. 2007; 21:328–337. [PubMed: 17874883]
33. Shadel WG, Martino SC, Setodji C, et al. Exposure to pro-smoking media in college students: Does type of media channel differentially contribute to smoking risk? Ann Behav Med. 2013; 45(3):387–392. [PubMed: 23536120]
34. Wellman RJ, Sugarman DB, DiFranza JR, et al. The extent to which tobacco marketing and tobacco use in films contribute to children's use of tobacco. Arch Pediatr Adolesc Med. 2006; 160:1285–1296. [PubMed: 17146027]
35. Burton D, Graham JW, Johnson CA, et al. Perceptions of smoking prevalence by youth in countries with and without a tobacco advertising ban. J Health Commun. 2010; 15(6):656–664.10.1080/10810730.2010.499595 [PubMed: 20812125]

36. Galduróz JC, Fonseca AM, Noto AR, et al. Decrease in tobacco use among Brazilian students: a possible consequence of the ban on cigarette advertising? Addict Behav. 2007; 32:1309–1313. [PubMed: 17092655]

37. Calvert C, Allen-Brunner W, Locke CM. Playing politics or protecting children? Congressional action and first amendment analysis of the Family Smoking Prevention and Tobacco Control Act. Journal of Legislation. 2010; 36:201–248.

38. Henriksen L. Comprehensive tobacco marketing restrictions: promotion, packaging, price and place. Tob Control. 2012; 21:147–153.10.1136/tobaccocontrol-2011-050416 [PubMed: 22345238]

39. Dal Cin S, Gibson B, Zanna MP, Shumate R, Fong GT. Smoking in movies, implicit associations of smoking with the self, and intentions to smoke. Psychological Science. 2007; 18:559–563. [PubMed: 17614861]

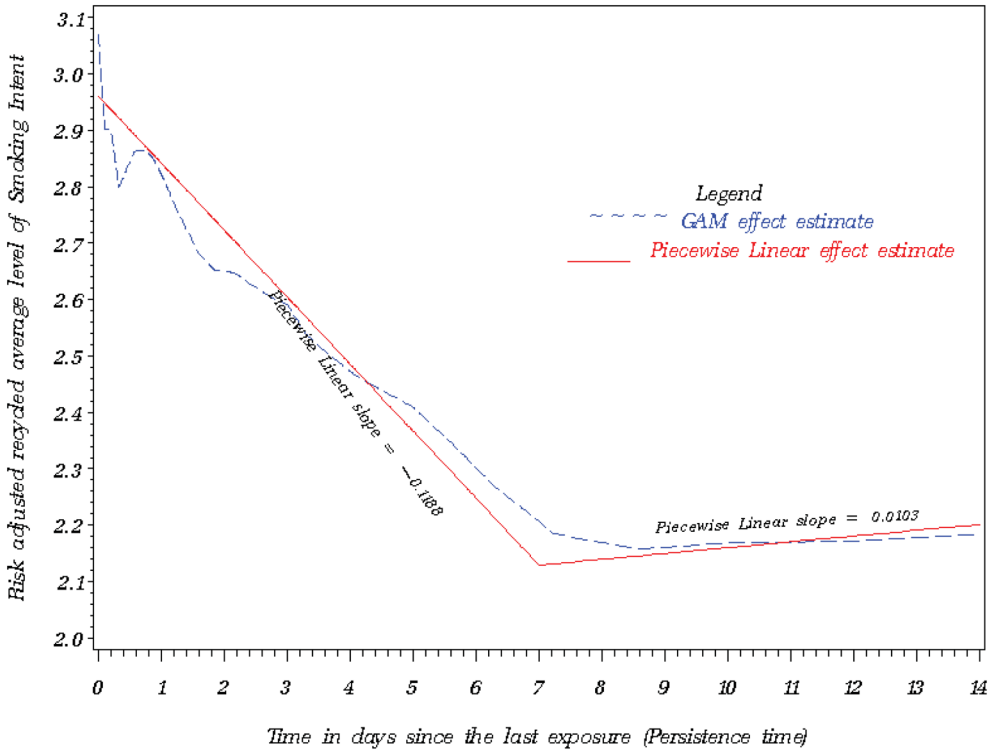

Figure 1.
Plot of the persistence of the impact of pro-smoking media exposure on smoking intention from a non-parametric GAM and a piecewise linear regression with a threshold at 7 days.

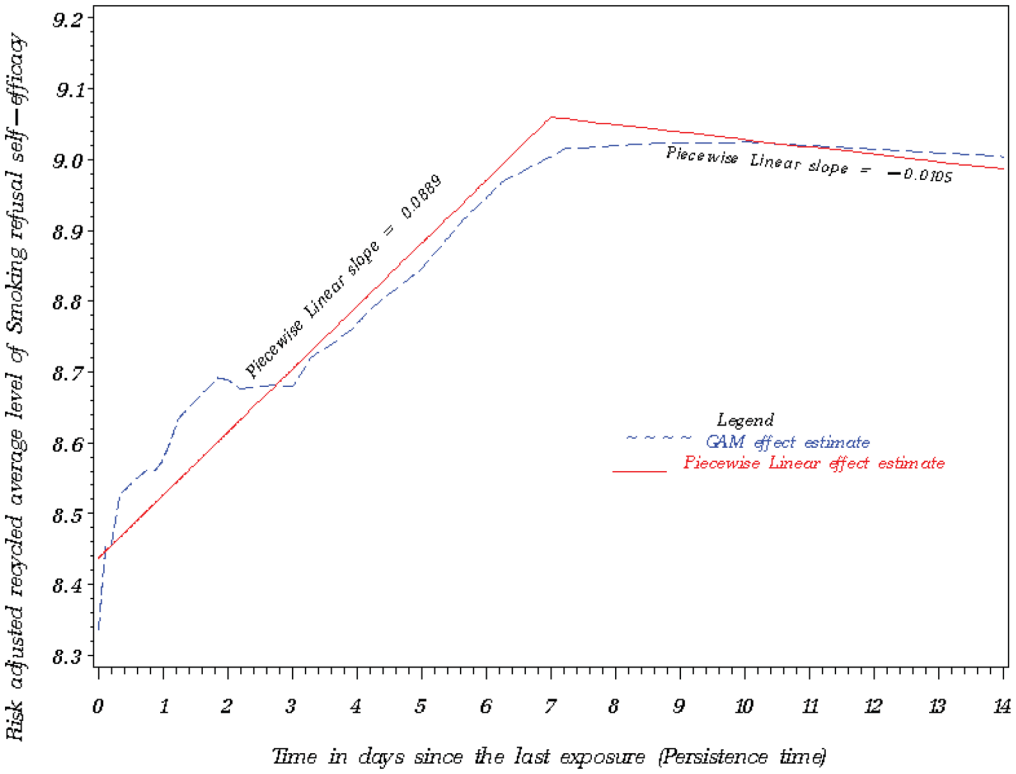

Figure 2.
Plot of the persistence of the impact of pro-smoking media exposure on smoking refusal self-efficacy from a non-parametric GAM and a piecewise linear regression with a threshold at 7 days.

Table 1

Multivariate linear models predicting smoking intention and smoking refusal self-efficacy from exposure to pro-smoking media, and their persistence over time as estimated by piecewise linear regression

	Smoking intention				Smoking refusal self-efficacy			
	Instant exposure impact (R^2 = 0.2206)		Exposure Persistence (R^2 = 0.2294)		Instant exposure impact (R^2 = 0.1565)		Exposure Persistence (R^2 = 0.1623)	
Variables	***b* (95% CI)**	***p***	***b* (95% CI)**	***p***	***b* (95% CI)**	***p***	***b* (95% CI)**	***p***
Continuous Persistence time[a]								
Slope between 0 and 7 days			−0.12 (−0.19, −0.05)	0.002			0.09 (0.02, 0.16)	0.02
Slope for more than 7 days			0.01 (−0.08, 0.10)	0.83			−0.01 (−0.10, 0.08)	0.81
Pro-smoking media Exposure[b]	0.56 (0.26, 0.87)	< 0.001			−0.42 (−0.75, −0.10)	0.01		
Never smoker[c]	−2.23 (−2.86, −1.59)	< 0.001	−2.20 (−2.82, −1.58)	< 0.001	1.76 (1.13, 2.39)	< 0.001	1.74 (1.12, 2.36)	< 0.001
Gender: Male	0.12 (−0.65, 0.89)	0.76	0.12 (−0.65, 0.88)	0.76	0.14 (−0.58, 0.86)	0.70	0.14 (−0.57, 0.86)	0.70
Racial/ethnic minority status[d]	−0.01 (−0.77, 0.74)	0.98	−0.05 (−0.78, 0.68)	0.90	−0.18 (−0.93, 0.57)	0.63	−0.16 (−0.90, 0.59)	0.68
Weekend[e]	0.02 (−0.06, 0.09)	0.66	−0.01 (−0.09, 0.07)	0.83	0.00 (−0.07, 0.07)	0.99	0.02 (−0.06, 0.10)	0.63

Note. Number of observations = 6793

[a] Continuous persistence time from the last exposure in days

[b] Versus random prompt

[c] Ever smoker is the reference category

[d] Compared with non-Hispanic White