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Exposure to Workplace Smoking Bans and Continuity of Daily Smoking Patterns on Workdays and Weekends

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Abstract

Introduction—Individuals may compensate for workplace smoking bans by smoking more before or after work, or escaping bans to smoke, but no studies have conducted a detailed, quantitative analysis of such compensatory behaviors using real-time data.

Methods—124 daily smokers documented smoking occasions over 3 weeks using ecological momentary assessment (EMA), and provided information on real-world exposure to smoking restrictions and type of workplace smoking policy (full, partial, or no bans). Mixed modeling and generalized estimating equations assessed effects of time of day, weekday (vs weekend), and workplace policy on mean cigarettes per hour (CPH) and reports of changing location to smoke.

Results—Individuals were most likely to change locations to smoke during business hours, regardless of work policy, and frequency of EMA reports of restrictions at work was associated with increased likelihood of changing locations to smoke (OR=1.11, 95% CI 1.05 – 1.16; $p < .0001$). Workplace smoking policy, time block, and weekday/weekend interacted to predict CPH ($p < .01$), such that individuals with partial work bans –but not those with full bans – smoked more at night (9pm – bed) on weekdays compared to weekends.

Conclusions—There was little evidence that full bans interfered with subjects' smoking during business hours across weekdays and weekends. Smokers largely compensate for exposure to workplace smoking bans by escaping restrictions during business hours. Better understanding the

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Conflict of Interest: Dr. Dunbar has no competing interests to disclose. Dr. Chandra consults for Chrono Therapeutics on smoking cessation products. Dr. Shiffman provides consulting services on tobacco harm minimization (including nicotine replacement therapy and digital vapor products) to Nicovum USA, RJ Reynolds Vapor Company, and RAI Services Company, all subsidiaries of Reynolds American, Inc. In the past three years, PinneyAssociates has consulted to GlaxoSmithKline Consumer Healthcare on smoking cessation and NJOY on electronic cigarettes. SS also owns an interest in intellectual property for a novel nicotine medication, which has been optioned by Nicovum USA. None of these parties played any role in sponsorship, design, analysis, or reporting of this work, nor have they been made aware of it or reviewed it.

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effects of smoking bans on smoking behavior may help to improve their effectiveness and yield insights into determinants of smoking in more restrictive environments.

Keywords

workplace smoking policy; smoking behavior; compensation; tobacco control

Introduction

Daily smokers are thought to smoke consistently throughout the day to maintain nicotine levels in a preferred range (Benowitz, 1991) and avoid dips in nicotine that may provoke withdrawal symptoms (“trough avoidance”; Russell, 1971). This is expected to produce relatively consistent consumption of cigarettes -and nicotine intake- each day (Benowitz, 1992). Such stereotypic smoking behavior, along with difficulty abstaining from smoking, is considered to be a hallmark of nicotine dependence (Shadel, Shiffman, Niaura, Nichter, & Abrams, 2000; Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991; Shiffman, Waters, & Hickcox, 2004).

Yet, many smokers confront a direct challenge to this “core” feature of nicotine dependence on a daily basis. Enforced abstinence – in the form of workplace smoking restrictions – has become a regular occurrence for most smokers in the United States (Centers for Disease Control and Prevention, 2011; Collins & Procter, 2011). Importantly, workplace smoking bans appear to change behavior, as evidenced by increased cessation attempts and reduced smoking prevalence following implementation (Levy & Friend, 2003), and reduced environmental tobacco smoke in explicitly restricted spaces (Eriksen & Cerak, 2008). Exposure to bans thus poses a barrier the consistent, “withdrawal-avoidance” pattern of smoking that is thought to characterize dependent daily smokers (Benowitz, 1988; Eissenberg, 2000; Benowitz, 2008). It is therefore surprising that bans reduce smoking by only 1-3 cigarettes per day among continuing smokers (Bauer, Hyland, Li, Steger, & Cummings, 2005; Brownson, Hopkins, & Wakefield, 2002; Fichtenberg & Glantz, 2002).

The fact that restrictions have modest effects on cigarette consumption suggests that individuals compensate for bans in some manner. For example, as with other barriers to achieving preferred levels of consumption (e.g., filter vents, reduced tar and/or nicotine), individuals may alter their topography (Evans & Farrelly, 1998; Scherer & Lee, 2014) and smoke cigarettes “harder” on workdays when restrictions are lifted (i.e., during work breaks) (Chapman, Haddad, & Sindhusake, 1997), which could help to maintain nicotine above trough levels during restricted work periods. Alternatively, smokers could achieve preferred levels of consumption by changing *when* they smoke on workdays, by: (1) increased smoking before work (Baile, Gilbertini, Ulschak, Snow-Antle, & Hann, 1991; Meade & Wald, 1977) to “pre-load,” to help tolerate subsequent exposure to restrictions (at least, for a few hours, given nicotine’s plasma half-life of approximately two hours) (Benowitz, 1988, 2008); (2) increased smoking after work (Baile et al., 1991; Centers for Disease Control, 1990; Meade & Wald, 1977), which could equalize total consumption, but cannot undo any discomfort experienced by abstaining during the work day; and/or, (3) escaping restrictions and changing locations to smoke during business hours (Borland, Cappiello, & Owen, 1997;

Borland & Owen, 1995), which could maintain preferred smoking rates and facilitate nicotine trough avoidance. To date, however, no studies have conducted a detailed assessment of the association between exposure to workplace bans and such compensatory behaviors.

This study examines the association between workplace smoking bans, temporal smoking patterns, and reports of changing locations to smoke during business hours among daily smokers. Assuming compliance with workplace policies, full indoor smoking bans were expected to be associated with less smoking during business hours on workdays compared to non-workdays. Because severity of nicotine dependence and nicotine clearance rate were expected to correlate with individuals' ability to tolerate enforced periods of abstinence (Benowitz, 1988, 1991; Heatherton et al., 1991), these factors were examined as moderators of the relationships between workplace policy, smoking patterns, and reports of changing location to smoke.

Material and Methods

Sample

This sample largely overlaps with that described by Shiffman and colleagues (2014). Subjects were 124 community volunteers in Pittsburgh, PA who participated in a study on smoking patterns between November 2007 and April 2010. All volunteers completed an initial screening to determine eligibility, which required them to smoke between 5 and 30 cigarettes each day, have been smoking for at least three years, be over 21 years of age, and have no current intention to quit.

Procedure

All study procedures were approved by the University of Pittsburgh Institutional Review Board, and informed consent was obtained prior to initiating the study. Procedures are described in detail elsewhere (Shiffman et al., 2014). Briefly, subjects completed baseline questionnaires on demographics, smoking patterns, and nicotine dependence, and provided up to eight urine samples (on separate visits, Shiffman, Dunbar, & Benowitz, 2012), which were analyzed for nicotine metabolites (i.e., cotinine and 3-hydroxycotinine). Individuals recorded their smoking over a three-week monitoring period using Ecological Momentary Assessment (EMA) (Stone & Shiffman, 1994). Participants reported all smoking events in real time on electronic diaries (EDs). Approximately four cigarettes per day and three non-smoking occasions per day were randomly selected for more intensive assessments of current context, including activity (e.g., “working?”), location (e.g., “at work?”; “at home?”) and smoking regulations (e.g., “smoking forbidden?”), among others. Participants could earn up to \$295 for study participation, which included completing EMA monitoring (and returning the ED), questionnaires, as well as up to six cue-reactivity sessions (see Shiffman et al., 2013).

Data Reduction

Of 192 individuals who completed EMA, 142 participants provided information on smoking policies at their workplace. Students (n=12) and six individuals with irregular (e.g., shift

work) and/or unidentifiable work schedules (e.g., no instances of being ‘at work’ in EMA) were excluded from analyses, yielding a sample of 124 daily smokers with 5 days of EMA data. Data were collected throughout the waking day, as defined by participant-reported wake and bedtimes each day. Overall, individuals contributed a total of 1,692 days (1,186 workweek days; 506 weekend days), recorded 25,957 cigarettes, and reported situational data on a total of 14,767 smoking ($n=8,039$) and non-smoking ($n=6,728$) occasions, over an average of 20.57 ($SD=4.00$) days. Data were organized hierarchically, with time blocks nested within days, and days nested within subjects.

Measures

Time of Day and Day of Week—Business hours were defined by socially conventional business hours (i.e., 9am-5pm, Monday-Friday). Analyses on EMA reports of being “at work” suggested that most individuals’ work schedules (87%) followed expected workweek patterns.

Participants self-reported their wake time and bed time each day, which defined the waking day. The following within-day time blocks were examined: *Pre-work*: waketime-8:59am; *Work*: 9am-4:59pm; *Post-work*: 5pm-8:59pm; *Night*: 9pm – bedtime. Day of week was categorized as *weekday* (Monday-Friday) or *weekend* (Saturday and Sunday).

Exposure to Bans—Participants reported the stringency of their workplace smoking policy using items from the Current Population Survey Tobacco Use Supplement) (US Department of Commerce, Census Bureau, 2008): ‘no ban’ (“smoking allowed in all work areas”), ‘partial ban’ (“smoking allowed only in some indoor areas; for example, a break room”), and ‘full ban’ (“smoking forbidden in all indoor areas at work”). Participants also reported their home smoking policy: ‘no ban’ (“smoking allowed anywhere”), ‘partial ban’ (“smoking allowed only in some indoor areas”), and ‘full ban’ (“smoking not allowed anywhere indoors”).

Real-world exposure to work bans was assessed as the within-subject percentage of non-smoking EMA observations in which smoking was “forbidden by law” when a participant reported being “at work”. Percentages were arcsine-transformed (Cohen et al., 2003) and re-scaled for analyses, such that one unit corresponded to 10 percentage points.

Smoking Rate—Smoking rate was defined as number of cigarettes per hour (CPH) by counting the number of smoking records from EMA data during each clock hour during the waking day. If a participant was awake for <30 minutes during the first waking clock hour, cigarettes during this period were counted in the next clock hour. If bedtime occurred <30 minutes into the last waking hour, cigarettes were similarly counted in the preceding clock hour.

Changing Locations to Smoke—EMA smoking assessments recorded whether or not participants changed location in order to smoke (“Did you change location to smoke?” Yes/No).

Nicotine Dependence—Nicotine dependence measures assessing constructs related to withdrawal-avoidance were examined as moderators. These included: Fagerstrom Test of Nicotine Dependence (FTND; Heatherton et al., 1991), which assesses features of physical dependence and withdrawal avoidance; Nicotine Dependence Syndrome Scale (NDSS) *Drive* subscale, which assesses craving, withdrawal-avoidance, and compulsion to smoke (Shiffman, Waters, & Hickcox, 2004); and NDSS *Continuity* subscale, which assesses regularity of smoking over time (Shiffman, Waters, & Hickcox, 2004).

Rate of Nicotine Clearance—Urine samples were assayed for cotinine and 3-hydroxycotinine using liquid chromatography-tandem mass spectrometry. One sample was analyzed per participant, using the sample provided when smoking was most representative of an individual's typical consumption (see Shiffman, Dunbar, & Benowitz, 2014). Rate of nicotine clearance was defined as urinary *nicotine metabolite ratio* (NMR; 3-hydroxycotinine:cotinine), a reliable proxy for the nicotine clearance rate (Shiffman, Dunbar, & Benowitz, 2014).

Participant Characteristics—Participants reported a range of demographic characteristics, including age, race, gender, income, and occupation type (recoded as “white collar” [e.g., legal occupations, business and financial operations occupations], “blue collar” [e.g., construction and extraction occupations, transportation and material moving occupations], or “other” [e.g., food preparation and serving occupations, building maintenance occupations]) (U.S. Department of Labor, 2010). They also reported on several factors related to work and home smoking environments, including home smoking policy, partner smoking status, number of smokers in the household, and number of coworkers who smoke.

Data Analysis

Outcomes were aggregated for analyses within time blocks for each subject-day (e.g., as means or ‘present/absent’ indicators). For analyses of the binary/count changing locations to smoke variables, the *Work* time block was treated as two 4-hour bins (9am-12:59pm; 1pm – 4:59pm) for consistency in duration across time blocks. Chi square tests were used to assess associations between participant characteristics (e.g., type of workplace ban and type of home ban). Linear mixed modeling assessed the relationships between type of workplace ban, time block, weekday/weekend and mean smoking rate. Models specified random intercepts across subjects; otherwise, predictors were assessed as fixed effects. Generalized Estimating Equations (with logit link) assessed likelihood of changing locations to smoke across time. Models examined effects of time block, weekday/weekend, type of workplace smoking policy, and their interaction, on outcomes. Analyses of the effects of EMA percent of restricted observations at work on smoking rate and likelihood of changing locations to smoke were constrained to the *Work* time block on weekdays. Analyses were conducted using SAS 9.4 (SAS Institute, Cary, NC), and controlled for the following participant characteristics expected to relate to smoking patterns: gender, race, occupation type, number of coworkers who smoke, partner smoking status, number of smokers in household, and home smoking policy.

Results

Sample Characteristics

Smoking and demographic information is summarized in Table 1. Individuals averaged 39.96 (SD = 10.69) years old, were 67% Caucasian, and smoked 10.90 (SD = 6.38) cigarettes per day (CPD). Approximately half of the sample reported full indoor work bans (52%); 31% reported partial bans, and 18% reported no bans. In contrast, most individuals (60%) reported no indoor home ban; 23% reported partial bans and 18% reported full indoor home bans. Work and home smoking policy were not significantly associated ($p = .36$). Workplace policy was significantly associated with occupational status ($\chi^2_{df=5} = 24.92$, $p < .0001$): among individuals with 'white collar' occupations, most reported full workplace bans (84%), whereas less than half of participants with 'blue collar' (37%) or other occupations (48%) reported full bans. Type of workplace ban was unrelated to average cigarettes per day, nicotine dependence (FTND; NDSS Drive, NDSS Continuity), or NMR (all $p > .15$).

Smoking was allowed on 91% of all EMA smoking assessments and 83% of non-smoking assessments. Individuals infrequently reported violating workplace smoking restrictions: 1.76% ($n = 93$) of recorded smoking occurred when legal restrictions *were* in place; 55 of these instances occurred at work. Type of workplace ban was loosely associated with real-world reports of exposure to restrictions. On average, among individuals with full bans, half of non-smoking reports recorded at work occurred when smoking was forbidden (Mean of within-subject mean percent = 50% [SE = 0.06]); in contrast, among those with partial bans, approximately one quarter of non-smoking reports at work occurred when smoking was forbidden (26% [SE = 0.08]). Individuals with no work bans reported that smoking was forbidden in slightly less than half of non-smoking reports at work (41% [SE = 0.12]).

Temporal Smoking Patterns

Across all days, smoking rate decreased between Pre-Work and Work hours, rose between Work and Post-Work hours, and peaked in the Night hours. Figure 1 shows the model-based least square mean estimates of CPH across time blocks on weekdays and weekends. Adjusting for time of day, participants demonstrated slightly higher mean smoking rates on weekdays (Mean CPH = 0.88 [SE = 0.04]) compared to weekends (Mean CPH = 0.84 [SE = 0.04]; $p < .05$). Across all individuals, temporal patterns did not differ on weekdays and weekends (i.e., no significant time block by weekday/weekend interaction; $p = .26$).

There was a significant workplace policy $\times$ time block $\times$ weekday/weekend interaction on CPH ($p < .01$), such that individuals with partial work bans demonstrated increased smoking in the Night time block on weekdays versus weekends, and relative to individuals with no ban. Figure 2 shows the least square mean estimates of CPH within each time block on weekdays and weekends by type of workplace policy. Work policy did not affect subjects' smoking rates during Work hours (Figure 2). Nicotine dependence and NMR did not moderate these relationships (all $p > .16$).

Likelihood of Changing Locations to Smoke

Individuals reported changing locations to smoke in 31% of assessed smoking occasions. Rates of changing location to smoke differed on weekdays compared to weekends. Figure 3 shows mean counts for changing location to smoke across time blocks. Across all days, changing locations to smoke was significantly more likely during the Work time block relative to the Pre-Work (OR = 1.75 [95% CI: 1.33 – 2.30]; $p < .0001$), Post-Work (OR = 1.21 [1.01 – 1.45]; $p = .04$), or Night (OR = 1.60 [1.27 – 2.02]; $p < .0001$) time blocks. There was also a significant time block $\times$ day interaction ($p < .05$), such that individuals were more likely to change location to smoke during Work hours on weekdays compared to Work hours on weekends (OR = 1.45 [1.16 – 1.83]; $p < .001$).

Work policy was unrelated to likelihood of changing locations to smoke during the Work time blocks across weekdays and weekends (i.e., within Work time blocks, work policy $\times$ weekday/weekend interaction was not significant; $p = .48$). Nicotine dependence and NMR did not moderate this relationship (all $p > .19$).

Smokers who reported greater frequency of restrictions at work in EMA were more likely to report changing locations to smoke during business hours: a 10% increase in percent EMA-reported work restrictions was associated with a 11% increase in likelihood of changing locations to smoke during the Work time block on weekdays (OR = 1.11 [1.05 – 1.16]; $p < .0001$). Dependence and NMR did not moderate this relationship (all $p > .38$).

Discussion

This is the first study to use real-time EMA records of smoking behavior to quantitatively assess the relationship between exposure to workplace smoking bans, temporal smoking patterns and compensatory ‘escape’ behavior during business hours. Individuals largely adhered to smoking regulations, abstaining from smoking when it was forbidden. Surprisingly, the reported stringency of work bans was unrelated to smoking rates during business hours. Findings suggest that smokers may largely compensate for exposure to bans by escaping restricted settings throughout the workday to smoke. Individuals were most likely to change location to smoke during business hours on weekdays, and likelihood of changing locations was associated with higher proportions of within-subject EMA assessments in which smoking was reported to be forbidden at work.

Smoking was lowest from 9am to 5pm, consistent with reports from previous studies (Baile et al. 1991; Borland, Chapman, Owen, & Hill, 1990; Chandra, Shiffman, Scharf, Dang, & Shadel, 2007). However, this “daily dip” (Chandra et al., 2007) in smoking rate during business hours did not differ across weekdays and weekends, nor did stringency of workplace ban influence this pattern. This, combined with evidence that smokers were most likely to change locations to smoke during typical business hours on weekdays (vs. weekends), suggests that smokers periodically escape workplace bans to maintain smoking rates comparable to those on weekends. Findings are consistent with the view that daily smokers strive to maintain roughly consistent smoking rates (and potentially, nicotine intake), to avoid nicotine troughs and nicotine withdrawal (Benowitz, 1988, 1991), even when facing smoking restrictions. Besides allowing smokers to maintain “dependent”

smoking patterns on workdays, regularly leaving work to smoke during business hours has significant consequences in lost work productivity (Berman, Crane, Seiber, & Munur, 2014). Our findings are also consistent with the perspective that workplace smoking bans alone may be insufficient to reduce employee smoking.

It is also possible that the observed “daily dip” in smoking may be due to factors other than exposure to explicit bans, such as social norms or daytime activity. Other studies have shown a relationship between circadian patterns of substance use and typical business hours. For example, Phillips and colleagues (2013) reported that cocaine use (notably, banned at *all* hours) was lower between 9am and 5pm and increased in the evening hours, even among those who did not work. Moreover, the more frequent “escape” behavior observed during business hours on weekdays may reflect a desire to “take a break” from work-related activities, rather than a desire to avoid nicotine troughs. Although we were unable to assess motivations for escape behavior, the finding that greater EMA exposure to bans at work correlated with more frequent reports of changing locations to smoke suggests that workplace bans *can* influence how often individuals take “smoke breaks” during business hours. More research is needed to better understand the ways in which individual, environmental, and policy factors might interact to shape smoking patterns during the workday.

Findings differed slightly when examining global self-reports of workplace bans compared to real-world EMA reports of exposure to restrictions at work. For example, global reports of stringency of work bans were unrelated to how often people changed locations to smoke during business hours, but those EMA-reported real-world exposure to restrictions *were* related to changing locations. Work sites may vary in enforcement and the ease with which restrictions can be circumvented (Jacobson & Wasserman, 1999; McMullen, Brownson, Luke, & Chiqui, 2005); broad categorizations (i.e., full vs. partial vs. no bans) may fail to capture this heterogeneity. Global reports of ban severity also fail to capture variability in individuals' exposure to workplace bans. For example, full indoor bans in the workplace may have little impact on individuals who frequently work outdoors. This highlights the importance of assessing exposure to actual policies in individuals' natural environments to understand the effects of such policies on behavior.

Contrary to expectations, individuals with partial -but with full- work bans increased their smoking at night after business hours on weekdays (vs weekends). This was not due to related variations in home smoking policies; work and home smoking policies were unrelated, and models adjusted for the stringency of home bans. Another possibility is that exposure to full bans during the workday may weaken associations between smoking and environmental cues (e.g., being indoors, stress, presence of others), whereas partial restrictions may function to maintain some of these associations. Such distal cues (Conklin, Robin, Perkins, Salkeld, & McClernon, 2008) may continue to function as stronger triggers for smoking outside of work for those with partial bans, resulting in higher smoking rates after work. More research is needed to assess the extent to which increasingly limited smoking environments may influence stimulus control over smoking behavior.

This study was subject to several limitations. Participants did not provide precise data on their physical location or presence/absence of restrictions at every moment over the course of the study – only when they were sampled at random during smoking and nonsmoking occasions. As such, the data allowed for ‘best-estimates,’ rather than precise measurements of participants’ environmental contexts, such as restrictions, during time blocks. Also, individuals may self-select into work environments that have policies they can tolerate, which could mask effects of work policies on behavior. However, there were no differences in CPD, dependence, or NMR across work policy groups, so this seems unlikely. Further, smoking bans have become increasingly common in the 7-10 years since the data were collected. Also, use of alternative nicotine products like e-cigarettes has grown; these products may or may not be covered under existing workplace bans, and supplemental use of other nicotine products could feasibly support nicotine maintenance during business hours. Additional longitudinal research is needed to understand how compensatory smoking behavior may change over time in response to evolving products and regulatory environments.

In conclusion, established daily smokers largely compensated for workplace bans by periodically escaping restrictions to smoke during business hours. Findings suggest that while bans may constrain the *environments* in which smoking occurs, they may have little effect on daily patterns of consumption, when individuals can readily escape to locations in which smoking is permissible. This is consistent with the position that environmental restrictions alone are insufficient to significantly reduce smoking. Understanding the contextual factors that constrain and facilitate smoking in more stringent policy climates may be instrumental in shaping more effective interventions to further reduce smoking.

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References

- Baile WF, Gibertini M, Ulschak F, Snow-Antle S, Hann D. Impact of a hospital smoking ban: changes in tobacco use and employee attitudes. *Addictive Behaviors*. 1991; 16(6):419–426. DOI: 10.1016/0306-4603(91)90050-R
- Bauer JE, Hyland A, Li Q, Steger C, Cummings KM. A longitudinal assessment of the impact of smoke-free worksite policies on tobacco use. *American Journal of Public Health*. 2005; 95(6):1024–1029. DOI: 10.2105/AJPH.2004.048678 [PubMed: 15914828]
- Benowitz NL. Pharmacologic aspects of cigarette smoking and nicotine addiction. *New England Journal of Medicine*. 1988; 319(20):1318–1330. DOI: 10.1056/NEJM198811173192005 [PubMed: 3054551]
- Benowitz NL. Pharmacodynamics of nicotine: Implications for rational treatment of nicotine addiction. *British Journal of Addiction*. 1991; 86(5):495–499. DOI: 10.1111/j.1360-0443.1991.tb01796.x
- Benowitz NL. Cigarette smoking and nicotine addiction. *The Medical Clinics of North America*. 1992; 76(2):415–437. [PubMed: 1548969]

- Benowitz NL. Clinical pharmacology of nicotine: implications for understanding, preventing, and treating tobacco addiction. *Clinical Pharmacology and Therapeutics*. 2008; 83(4):531–541. DOI: 10.1038/clpt.2008.3 [PubMed: 18305452]
- Berman M, Crane R, Seiber E, Munur M. Estimating the cost of a smoking employee. *Tobacco Control*. 2014; 23(5):428–433. DOI: 10.1136/tobaccocontrol-2012-050888 [PubMed: 23733918]
- Borland R, Cappiello M, Owen N. Leaving work to smoke. *Addiction*. 1997; 92(10):1361–8. DOI: 10.1111/j.1360-0443.1997.tb02855.x [PubMed: 9489053]
- Borland R, Chapman S, Owen N, Hill D. Effects of workplace smoking bans on cigarette consumption. *American Journal of Public Health*. 1990; 80(2):178–180. DOI: 10.2105/AJPH.80.2.178 [PubMed: 2297062]
- Borland R, Owen N. Need to smoke in the context of workplace smoking bans. *Preventive Medicine*. 1995; 24(1):56–60. DOI: 10.1006/pmed.1995.1008 [PubMed: 7740016]
- Brownson RC, Hopkins DP, Wakefield MA. Effects of smoking restrictions in the workplace. *Annual Review of Public Health*. 2002; 23:333–348. DOI: 10.1146/annurev.publhealth.23.100901.140551
- Centers for Disease Control. Evaluation of an employee smoking policy--Pueblo, Colorado, 1989-90. *MMWR Morbidity and Mortal Weekly Report*. 1990; 39(38):673–676. [Accessed on November 24, 2016] <http://www.cdc.gov/mmwr/preview/mmwrhtml/00001784.htm>.
- Centers for Disease Control and Prevention. State smoke-free laws for work sites, restaurants, and bars--United States, 2000-2010. *MMWR Morbidity and Mortality Weekly Report*. 2011; 60(15):472–475. [Accessed on November 24, 2016] <http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6015a2.htm>. [PubMed: 21508923]
- Chandra S, Shiffman S, Scharf DM, Dang Q, Shadel WG. Daily smoking patterns, their determinants, and implications for quitting. *Experimental and Clinical Psychopharmacology*. 2007; 15(1):67–80. DOI: 10.1037/1064-1297.15.1.67 [PubMed: 17295586]
- Chapman S, Haddad S, Sindhusake D. Do workplace smoking bans cause smokers to smoke “harder”? Results from a naturalistic observational study. *Addiction*. 1997; 92(5):607–610. DOI: 10.1111/j.1360-0443.1997.tb02918.x [PubMed: 9219383]
- Cohen, J., Cohen, P., West, SG., Aiken, LS. *Applied multiple regression/correlation analysis for the behavioral sciences*. Mahwah, NJ: Lawrence Erlbaum Associates; 2003.
- Collins D, Procter A. Smoking's shrinking geographies. *Geography Compass*. 2011; 5:918–931. DOI: 10.1111/j.1749-8198.2011.00463.x
- Conklin CA, Robin N, Perkins KA, Salkeld RP, McClernon FJ. Proximal versus distal cues to smoke: the effects of environments on smokers' cue-reactivity. *Experimental and Clinical Psychopharmacology*. 2008; 16(3):207–214. DOI: 10.1037/1064-1297.16.3.207 [PubMed: 18540780]
- Eissenberg T. Measuring the emergence of tobacco dependence: the contribution of negative reinforcement models. *Addiction*. 2000; 99(S1):5–29. DOI: 10.1111/j.1360-0443.2004.00596.x
- Eriksen MP, Cerak RL. The diffusion and impact of clean indoor air laws. *Annual Review of Public Health*. 2008; 29:171–185. DOI: 10.1146/annurev.publhealth.29.020907.090920
- Evans WN, Farrelly MC. The compensating behavior of smokers: taxes, tar, and nicotine. *The Rand Journal of Economics*. 1998; 29(3):578–595. [Accessed on November 24, 2016] <http://www.jstor.org/stable/2556105>. [PubMed: 11794360]
- Fichtenberg CM, Glantz SA. Effect of smoke-free workplaces on smoking behaviour: systematic review. *British Medical Journal*. 2002; 325:188–194. doi: <http://dx.doi.org/10.1136/bmj.325.7357.188>. [PubMed: 12142305]
- Heatherton TF, Kozlowski LT, Frecker RC, Fagerstrom KO. The Fagerström Test for Nicotine Dependence: a revision of the Fagerström Tolerance Questionnaire. *British Journal of Addiction*. 1991; 86(9):1119–1127. DOI: 10.1111/j.1360-0443.1991.tb01879.x [PubMed: 1932883]
- Jacobson PD, Wasserman J. The implementation and enforcement of tobacco control laws: Policy implications for activists and the industry. *Journal of Health Politics, Policy, and Law*. 1999; 24(3):567–598. DOI: 10.1215/03616878-24-3-567
- Levy DT, Friend KB. The effects of clean indoor air laws: What do we know and what do we need to know? *Health Education Research*. 2003; 18(5):592–609. DOI: 10.1093/her/cyf045 [PubMed: 14572019]

- McMullen KM, Brownson RC, Luke D, Chiqui J. Strength of clean indoor air laws and smoking related outcomes in the USA. *Tobacco Control*. 2005; 14(1):43–48. DOI: 10.1136/tc.2004.007880 [PubMed: 15735299]
- Meade TW, Wald NJ. Cigarette smoking patterns during the working day. *British Journal of Preventive and Social Medicine*. 1977; 31(1):25–29. DOI: 10.1136/jech.31.1.25 [PubMed: 856368]
- Phillips KA, Epstein DH, Preston KL. Daily temporal patterns of heroin and cocaine use and craving: relationship with business hours regardless of actual employment status. *Addictive Behaviors*. 2013; 38(10):2485–2491. DOI: 10.1016/j.addbeh.2013.05.010 [PubMed: 23770647]
- Russell MA. Cigarette smoking: natural history of a dependence disorder. *British Journal of Medical Psychology*. 1971; 44(1):1–16. DOI: 10.1111/j.2044-8341.1971.tb02141.x [PubMed: 5101052]
- Scherer G, Lee PN. Smoking behaviour and compensation: a review of the literature with meta-analysis. *Regulatory Toxicology and Pharmacology*. 2014; 70(3):615–628. DOI: 10.1016/j.yrtph.2014.09.008 [PubMed: 25277253]
- Shadel WG, Shiffman S, Niaura R, Nichter M, Abrams DB. Current models of nicotine dependence: what is known and what is needed to advance understanding of tobacco etiology among youth. *Drug and Alcohol Dependence*. 2000; 59(S1):9–22. DOI: 10.1016/S0376-8716(99)00162-3
- Shiffman S, Dunbar MS, Benowitz NL. A comparison of nicotine biomarkers and smoking behavior in daily and non-daily smokers. *Cancer Epidemiology, Biomarkers, and Prevention*. 2014; 23(7):1264–1272. DOI: 10.1158/1055-9965.EPI-13-1014
- Shiffman S, Dunbar MS, Li X, Scholl SM, Tindle HA, Anderson SJ, Ferguson SG. Smoking patterns and stimulus control in intermittent and daily smokers. *PLoS One*. 2014; 9(3):e89911.doi: 10.1371/journal.pone.0089911 [PubMed: 24599056]
- Shiffman S, Dunbar MS, Kirchner T, Li X, Tindle HA, Anderson SJ, Scholl SM. Smoker reactivity to cues: Effects on craving and on smoking behavior. *Journal of Abnormal Psychology*. 2013; 122(1):264–280. DOI: 10.1037/a0028339 [PubMed: 22708884]
- Shiffman S, Waters A, Hickcox M. The Nicotine Dependence Syndrome Scale: A multidimensional measure of nicotine dependence. *Nicotine & Tobacco Research*. 2004; 6(2):327–348. DOI: 10.1080/1462220042000202481 [PubMed: 15203807]
- Stone AA, Shiffman S. Ecological momentary assessment (EMA) in behavioral medicine. *Annals of Behavioral Medicine*. 1994; 16:199–202.
- U.S. Department of Commerce, Census Bureau. [Accessed on October 24, 2015] National Cancer Institute and Centers for Disease Control and Prevention Co-sponsored Tobacco Use Supplement to the Current Population Survey (2006-07). 2008. <https://cancercontrol.cancer.gov/brp/tcrb/tus-cps/>
- U.S. Department of Labor. [Accessed on October 24, 2015] Standard Occupational Classification System. Available at: <https://www.bls.gov/soc/>

Highlights

- Smoking bans may interfere with continuous ad libitum smoking on workdays.
- A detailed analysis of temporal smoking patterns and workplace bans is presented.
- Smokers escape bans to achieve consistent smoking patterns on workdays and weekends.
- Additional policy measures may be needed to reduce smoking during business hours.

Figure 1.

This figure shows mean smoking rate across time blocks on weekdays vs. weekends. Values are mixed model-based least square mean values of CPH, from a model examining time block $\times$ weekday/weekend interaction effects on cigarettes per hour. Error bars are model-based standard errors.

Figure 2.

This figure shows the workplace policy $\times$ time block $\times$ weekday/weekend interaction on smoking rate. Values are mixed model-based least square means of cigarettes per hour, from a single model examining the time block $\times$ weekday/weekend $\times$ work policy interaction effect on CPH, displayed within work policy group: a. No workplace indoor smoking ban, b. Partial workplace indoor smoking ban, c. Full workplace indoor smoking ban. Error bars are model-based standard errors. ** $p < .01$.

Figure 3.

This figure shows counts of changing location to smoke across time of day on weekdays and weekends. Values are means of within-subject mean counts of assessed smoking episodes in which individuals reported changing location to smoke within each time block. Error bars are standard errors of the mean.

Table 1

Sample characteristics.

	Mean (SD)/%
	<i>N=124</i>
Age	39.96 (10.69)
Gender (Male)	54.84%
Race	
Caucasian	66.94%
African American	29.84%
Other	3.23%
Occupation Type	
White Collar	30.65%
Blue Collar	37.10%
Other	32.26%
Income (<\$25,000/year)	40.32%
Workplace Smoking Policy	
<i>Full Ban</i>	51.61%
<i>Partial Ban</i>	30.65%
<i>Smoking Permitted</i>	17.74%
Home Smoking Policy	
<i>Full Ban</i>	17.74%
<i>Partial Ban</i>	22.58%
<i>Smoking Permitted</i>	59.68%
Cigarettes per Day (Real-Time EMA Report)	10.90 (6.38)
Nicotine Dependence	
<i>FTND</i>	5.14 (1.94)
<i>NDSS Drive</i>	-0.29 (1.12)
<i>NDSS Continuity</i>	-0.44 (1.11)

Note. EMA=Ecological Momentary Assessment.

FTND=Fagerstrom Test of Nicotine Dependence.

NDSS=Nicotine Dependence Syndrome Scale.