RESEARCH COMMUNICATION

# Smoking Trajectories among Koreans in Seoul and California: Exemplifying a Common Error in Age Parameterization

**Jon-Patrick Allem[1]*, John W Ayers[2,3], Jennifer B Unger[1], Veronica L Irvin[4], C Richard Hofstetter[4,5], Melbourne F Hovell[4]**

## Abstract

**Immigration to a nation with a stronger anti-smoking environment has been hypothesized to make smoking less common. However, little is known about how environments influence risk of smoking across the lifecourse. Research suggested a linear decline in smoking over the lifecourse but these associations, in fact, might not be linear. This study assessed the possible nonlinear associations between age and smoking and examined how these associations differed by environment through comparing Koreans in Seoul, South Korea and Korean Americans in California, United States. Data were drawn from population based telephone surveys of Korean adults in Seoul (N=500) and California (N=2,830) from 2001-2002. Locally weighted scatterplot smoothing (lowess) was used to approximate the association between age and smoking with multivariable spline logistic regressions, including adjustment for confounds used to draw population inferences. Smoking differed across the lifecourse between Korean and Korean American men. The association between age and smoking peaked around 35 years among Korean and Korean American men. From 18 to 35 the probability of smoking was 57% higher (95%CI, 40 to 71) among Korean men versus 8% (95%CI, 3 to 19) higher among Korean American men. A similar difference in age after 35, from 40 to 57 years of age, was associated with a 2% (95%CI, 0 to 10) and 20% (95%CI, 16 to 25) lower probability of smoking among Korean and Korean American men. A nonlinear pattern was also observed among Korean American women. Social role transitions provide plausible explanations for the decline in smoking after 35. Investigators should be mindful of nonlinearities in age when attempting to understand tobacco use.**

**Keywords:** South Koreans' health - Korean Americans' health - age - tobacco control - immigration - smoking

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## Introduction

Immigration to a nation with a stronger anti-smoking environment has been hypothesized to make smoking less common (Zhu et al., 2007). However, little is known about how environments influence risk of smoking across the lifecourse (Kuh et al., 2003; Constantine et al., 2010). The Korean and Korean American populations provide excellent case studies for evaluating such questions as the two populations each reside in regions with distinct socio-cultural contexts e.g., different tobacco control policies and social norms pertaining to smoking. Demographic traits, such as age, have strong theoretical associations with health (Link & Phelan, 1995) but research suggested age is often employed as a predictor without meaningful rationale e.g., creating a dummy indicator for young versus old (Chen et al., 2007). Recent research on Koreans, (Cho et al., 2008) and initial research on Korean Americans, (Hofstetter et al., 2007) suggested a linear decline in smoking over the lifecourse but these associations, in fact, might not be linear. This study assessed the possible nonlinear associations between age and smoking and examined how these associations differed by environment.

Social norms are individuals' perceptions of how people usually behave and which behaviors are likely to be socially reinforced (Cialdini et al., 1991; Rimal, 2008). South Korean social norms have been characterized as conducive toward smoking for men (Lee, 2003) but not for women (Ayers et al., 2010). For instance, laws restrict tobacco marketing toward women and women who do smoke have been stigmatized for decades (Lee et al., 2009). The norms in place for men have been, in part, attributed to the fact that the government controls the tobacco market (Corrao et al., 2000; Kang et al., 2003; Jee et al., 2004; Do & Park, 2009; Allem et al., 2012). In 1995 South Korea enacted its first dedicated tobacco control policy, the National Health Promotion Act (NHPA), which restricted smoking in specific public places and cigarette sales to minors (Park et al., 2004; Khang et al., 2009). Most provisions, however, were poorly enforced (Chung et al.,

*[1]University of Southern California Keck School of Medicine, Los Angeles, [2]Children's Hospital Informatics Program at the Harvard-MIT Division of Health Sciences and Technology, [3]Harvard Medical School, Boston MA, [4]Center for Behavioral Epidemiology and Community Health, [5]Department of Political Science, San Diego State University, San Diego, CA, USA *For correspondence: allem@usc.edu*

2009). What is more, South Korea has a high smoking prevalence, where 60-72% of men and 3-6% of women smoke (Khang & Cho, 2006; Cho et al., 2008).

Korean immigration to the United States (US) is steadily increasing, with 1.41 million, mostly first-generation, in the US by 2011 (United States Census Bureau, 2011). One-third of Korean Americans live in California, (Korean American Coalition – Census Information Center, 2003) where smoking norms are in stark contrast compared to South Korea. The US has a relatively hostile environment towards smoking (Stuber et al., 2008; Bell et al., 2010) and California has been described as especially adverse towards smokers (Pierce et al., 2011), reporting the strongest anti-smoking sentiment of all 50 states (Alamar & Glantz, 2006). California's environment may be attributed to the 1988 California Tobacco Control Program (CTCP), which provided comprehensive policy-oriented tobacco control (Gilpin et al., 2004). Korean American men smoke less than, and women similar to, their Korean counterparts, as 27-39% of Korean American men and 3-8% of women in California smoke (Kim et al., 2000; Hofstetter et al., 2004).

One way to assess how environments influence risk of smoking across the lifecourse is to estimate mean trajectories of cigarette use by analyzing age and smoking status for each respective population. Herein we compare a linear model and a curvilinear model to demonstrate the misspecifications that can be made when forcing a linear model onto nonlinear data.

## Materials and Methods

*Seoul Sample*

Interviews were completed with 500 adults in Seoul (Ayers et al., 2010). Numbers distributed across the 27 telephone districts were produced by randomly sampling from directories proportional to the number in each telephone region. A constant was then added to each number and the list was randomly sorted. This procedure also captured unlisted numbers. Interviews were conducted by trained graduate students, supervised by a co-investigator, at Myongi University during 2002. Up to five callbacks were made until interviews were completed, the target refused, or the number was found to be nonresidential. The cooperation rate was 41%, which is comparable to meta-analysis of other studies, 48% (SD=20.1), though lower than the exceptionally high cooperation rate achieved in California (Baruch, 1999). Mean ages for women and men were about 38 and 37 respectively.

*California Sample*

Interviews were completed with 2,830 Korean Americans in California from 2001 to 2002. The sampling frame included all residential telephones with Korean surnames (N=108,843) drawn from telephone directories, marketing registries, warranty cards, etc., including unlisted numbers, randomly sorted. All potential respondents were screened to ensure they were Korean. English or Korean was used during the interview based on the respondent's preference. Up to seven callbacks were made, and a specially trained interviewer attempted refusal conversions. The cooperation rate was 86%, 95% of whom were first-generation. Mean ages for women and men were about 46 and 47 respectively. Respondents had lived in the US on average for about 17 years (SD=10).

The survey instruments were developed in English and translated into Korean with the assistance of co-investigators in Seoul and California. The process included repeated fore and back translations, focus groups, and questionnaire piloting. Calls were typically made on weekday afternoons and evenings and all day on weekends. Respondents within each household were randomly selected using the most recent birthday procedure (Frey, 1989).

These data closely represent population data and weighting made no difference in the conclusions. Institutional Review Boards at San Diego State and Myongi Universities approved all study procedures.

*Measures*

Current smoking status was computed using Centers for Disease Control and Prevention criteria; persons who reported having smoked 100 cigarettes in their lifetime and currently smoke everyday or some days were classified as smokers, while others were classified as nonsmokers. Age, Education and Time in US were all measured in years.

*Analysis Plan*

All analyses were stratified between men and women, since gender differences in smoking have been well documented (Ayers et al., 2010; Hofstetter et al., 2010; Hofstetter et al., 2007; Hofstetter et al., 2004; Ji et al., 2005). Herein the focus is on estimating differences across environments; however, additional analyses were computed to estimate significant differences across genders and environments following procedures described elsewhere (Aiken & West, 1992). The highest 1.5% of age values were recoded as the 98.5% value (82). The later adjustment did not alter the conclusions but prevented us from extrapolating to a very small elderly population where very few cases were observed.

In step one, bivariable associations between age and smoking were plotted using locally weighted scatter plot smoothing (lowess) as described by Cleveland (Cleveland, 1979). Lowess is a desirable smoothing method because it tends to follow the data. A .80 bandwidth was used so that the associations grossly fit the general trends. Alternative bandwidths (e.g., .67 and .90) produced similar patterns. In step two, spline logistic regressions with knots to approximate the association between age and smoking status were computed for Koreans and Korean Americans. A knot at 35 years of age was determined the most appropriate after age alterations produced similar results e.g., knot at 33 or knot at 37. An interaction term by population was used to test for differences in environments. In other words, the interaction term by population indicated how age before or at 35 differed for Korean Americans relative to Koreans. To ensure the findings were not spurious due to obvious confounds, the analysis included adjustments for education and exposure

to California and the broader US environment as indicated by years spent in the US for both Korean and Korean Americans. To ease interpretation, predicted probability of smoking was calculated using the estimates from the multivariable analysis by simulation using 1000 randomly drawn sets of estimates from a sampling distribution with mean equal to the maximum likelihood point estimates and variance equal to the variance covariance matrix of the estimates, with covariates held at their mean values (King et al., 2000). All tests presented were two-tailed p<0.05.

## Results

Smoking was more common among Korean men 60% (95%CI, 54 to 67) versus Korean American men 32% (95%CI, 29 to 34). Similarly, smoking was more common among Korean women 6% (95%CI, 3 to 9) versus Korean American women 4% (95%CI, 3 to 6).

The association between age and smoking peaked around age 35 among Korean and Korean American men (Figure 1A). Increases in age trended toward a higher probability of smoking until about 35 and thereafter increases in age trended toward a lower probability of smoking. The probability of smoking was generally lower among Korean Americans, relative to Koreans with a nonlinear pattern consistent in both South Korea and California. A nonlinear pattern was observed among Korean American women, where the highest probability of smoking was at 18 years and increases in age trended toward a much lower probability of smoking before 35 and increases in age were associated with a relatively consistent, though decreasing, probability of smoking after 35 (Figure 1B). Among Korean women, the pattern of association differed somewhat where the probability of smoking was stable early in life with increases in age trending toward a lower probability of smoking later in life.

*Estimating smoking trajectories*

Estimates suggested the increasing and decreasing trends between age and smoking differed significantly at and before 35, versus after, among Korean (z=6.00, p<.001) and Korean American men (4.05, p<.001), using spline logistic regressions with a knot at 35 years. These patterns also differed significantly across environments, based on an interaction between nation and age, where the positive association between age and smoking before or at 35 was stronger and the negative association after 35 was weaker among Korean versus Korean American men. For example, from 18 to 35 the probability of smoking was 57% higher (95%CI, 40 to 71) among Korean men versus 8% (95%CI, 3 to 19) higher among Korean American men. A similar difference in age after 35, from 40 to 57 years of age, was associated with a 2% (95%CI, 0 to 10) and 20% (95%CI, 16 to 25) lower probability of smoking among Korean and Korean American men.

Among women, the patterns before and at versus after 35 years of age were similar (z=0.96, p<.33) among Koreans and significantly different (z=2.86, p<.004)

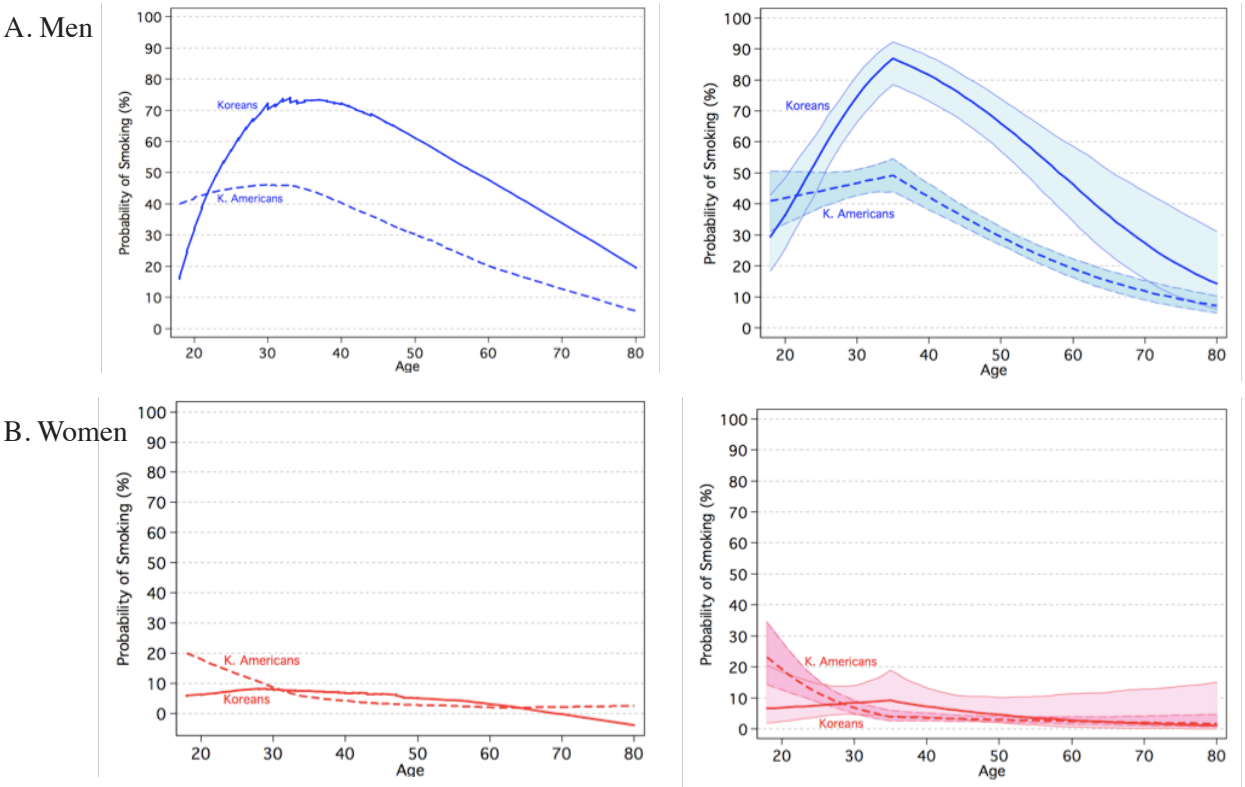


**Figure 1. Mean Smoking Trajectories among Koreans in Seoul, South Korea and Korean Americans in California, United States.** (a) and (b) show bivariable lowess smoothing plots (bandwidth=0.80) between age and current smoking status. The later presents estimates produced by simulating the probabilities using 1000 randomly drawn sets of estimates from the coefficient covariance matrix of the spline-logistic regression model with a single knot at 35 years of age with covariates held at their means. US is indicated by a dashed and Korea a solid line.

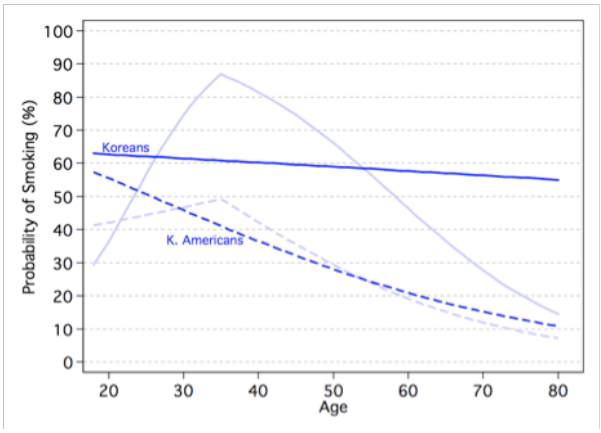


**Figure 2. Linear Regression Yields Invalid Estimates, a Case with Men.** The background replicates the mean trends among men shown in Figure 1A with emboldened trends shown from estimates of the same model where the spline terms for age were replaced by a single continuous age indicator.

among Korean Americans. From 18 to 35 years of age the probability of smoking was 19% (95%CI, 9 to 31) lower among Korean American women versus 2% higher among Korean women. A difference in age after 35, from 40 to 57 years of age, was associated with a less than 1% (95%CI, 0 to 2) and close to 0% (95%CI, 0 to 1) lower probability of smoking among Korean and Korean American women. Observed differences across environments were subtle and insignificant for Korean and Korean American women.

*Exemplifying a common error*

Herein we used nonlinear modeling strategies to estimate mean trajectories for smoking among adults of Korean descent living in distinct environments. However, a relevant application question is to what extent we would have under- or over-estimated smoking risks using traditional linear strategies (Figure 2)? The incorrect model assumes that differences in age from 18 to 35 or 40 to 57 produces a consistent 2% decrease in the probability of smoking that was not statistically significant (z=-0.61, p<.54) among Korean men. Among Korean American men the model assumes a consistent 11% (95%CI, 7 to 15) lower probability of smoking that would have been interpreted as statistically significant (z=9.45, p<.01). As these demonstrate, a linear model would have yielded invalid estimates of the association. A similar pattern was observed for women, where the estimates suggested a consistent negative trend for Korean American women [not shown]. Only for Korean women did a linear model produce estimates similar to that of the spline regression. Therefore a linear model analysis would have been incorrect 75% of time.

## Discussion

For Korean American men the probability of smoking was consistently lower than that among Korean men for each value of age. These patterns suggested that while the mean smoking trajectories followed a similar pattern, the environment (socio-cultural context) in California had a strong suppression effect on smoking trajectories. On the other hand, women's exposure was associated with mutations in their mean trajectory so the patterns differed in shape between Korean American and Korean women. The visual patterns suggested the environment in California had a mutating effect on women's smoking trajectories, where Korean women had similarly low probabilities of smoking.

Social role transitions provide plausible explanations for the decline in smoking after 35 (Oesterle et al., 2011). For example, attainment of postsecondary education (Gilman et al., 2008) and marriage (Merline et al., 2008) have been associated with reduced cigarette use. Even though about 20% continue to smoke, most women regularly quit smoking when they become pregnant, (Hemsing et al., 2011) and both spouses often quit (Aveyard et al., 2005). On the other hand, it could be a cohort effect with people born after the 1964 Report on Smoking and Health by the Surgeon General being less likely to smoke in California and abroad (Chen et al., 2011).

Most studies have attempted to elucidate the patterns of association between immigration and health by focusing on individual markers like acculturation (Lee et al., 2000; Zhang & Wang, 2008; Unger, 2012). Instead, this work focused on differences in population risk distributions in age, by estimating mean trajectories. In doing so, this study may be relevant to almost all smoking studies, among Koreans, Korean Americans or otherwise, by demonstrating effective strategies to estimate the association between age and smoking behaviors. Prior studies have shown increased acculturation for men decreased the likelihood of smoking however the inverse association occurs for women (Hofstetter et al., 2007; An et al., 2008; Choi et al., 2008). Koreans who immigrate to California have been found to be three times more likely to quit smoking compared to their Korean counterparts (Zhu et al., 2007). US smoking norms have been described to decrease the risk of cigarette initiation among other target populations once they immigrate (Stoddard, 2009).

Prior research has described the problems with categorizing age into groups without meaningful rationale e.g., young versus old (Chen et al., 2007). Chen and colleagues (2007) found the dichotomization of age generally leads to a biased odds ratio. A literature search on Korean or Korean American smoking, using PubMed, suggested that almost the entirety of prior work on Korean and Korean Americans categorizeds age without meaningful rationale.

We found 8 studies that polychotomized age (Cho et al., 2004: 2008; Jee et al., 2004; Park et al., 2004; 2009: 2010; Khang & Cho, 2006; Chung et al., 2009), 4 dichotomized (Kim et al., 2000; Juon et al., 2003; Ma et al., 2006; Myung et al., 2010), 1 treated age as continuous, (Hofstetter et al., 2007), 3 that did not specify or could not discern (Kim et al., 2005a; 2005b; Lee et al., 2010) and 1 that employed a similar procedure to the one described herein, however this study was conducted by some of the present authors (Ayers et al., 2010). These studies suggested that while demographic traits, have strong theoretical associations with health (Link & Phelan, 1995) previous studies have been limited and might provide inaccurate conclusions.

We are unaware of observational studies that assess the relative association between age and smoking which use robust analyses sensitive to nonlinearities. The patterns described were derived from one of the largest population-based studies of Korean Americans and their health. Moreover, a concurrent sample in Seoul, South Korea allowed for consistent comparison with similar research methods. The multisite design captures the natural differences between environments that would be hard to replicate in an experimental setting. The patterns here were cross-sectional and therefore may not be used for causal inference. But their use was consistent with the purpose of the study to explore nonlinear associations between age and smoking and how varying environments influence such associations. Cotinine levels were not measured to validate smoking behavior however meta-analyses show self-reports are valid (Patrick et al., 1994). Findings from this study may not extend to other groups Asian or otherwise who immigrate to the US. This study attributed the differences between smoking trajectories to factors in the environmental such as social norms, however social norms were not explicitly measured. The stark contrast in smoking norms between the US and South Korean however is well covered in the literature. Social norms could influence smoking initiation and smoking cessation differently. Due to data restrictions this study could not explore these associations by identifying when respondents started to smoke-before or after immigration. This study assessed patterns of different cohorts of people born at different times, etc. therefore could estimate the probability of smoking at age 35, however cannot estimate what will happen to a current 35-year old over the next 10 years.

This study identified the groups at highest risk of smoking based on age, an obvious demographic trait that may be used for intervention development or intervention targeting. While smokers of all ages should always be advised to quit, the targeting of anti-smoking health campaigns might be most efficacious if aimed toward people under the age of 35. Intervention programs developed in the United States are often translated in other countries (Zheng et al., 2004; Sussman & Sun, 2009). Our multisite research design allows for intervention targeting to be understood in multiple locations and suggested that social norms and public policy influence optimal intervention time points.

Investigators should be mindful of nonlinearities in age when attempting to understand tobacco use or cessation. Imminent research should also explore how different environments influence smoking initiation and cessation differently. Korean American respondents were predominantly first generation residents of California. Future studies should explore how generations change smoking patterns from one cohort to the next. Finally, future research should explore the specific mechanisms to explain why smoking patterns change around 35.

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