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REVIEW

Demographic Predictors of False Negative Self-Reported Tobacco Use Status in an Insurance Applicant Population

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Objectives.—To identify and quantify demographic correlates of false-negative self-reporting of tobacco use in life insurance applicants.

Background.— Several studies have assessed the sensitivity of self-reporting for tobacco use in various populations, but statistical examination of the causes of misreporting has been rarer. The very large (488,000 confirmed tobacco users) sample size, US-wide geographic scope, and unique incentive structure of the life insurance application process permit more robust and insurance industry-specific results in this study.

Methods.—Approximately 6.2 million life insurance applicants for whom both tobacco-use interview questions and a confirmatory urine cotinine test were completed between 1999 and 2012 were evaluated for consistency between self-reported and laboratory-confirmed tobacco-use status. The data set was subjected to logistic regression to identify predictors of false negative self-reports (FNSR).

Results.—False-negative self-reporting was found to be strongly associated with male gender, applicant ages of less than 30 or greater than 60, and low cotinine positivity rates in the applicant's state of residence. Policy face value was also moderately predictive, values above $500,000 associated with moderately higher FNSR.

Conclusions.—The findings imply that FNSR in life insurance applicants may be the result of complex interactions among financial incentives, geography and presumptive peer groups, and gender.

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INTRODUCTION

With over 45 million smokers in the United States, tobacco use is among the most common preventable causes of serious illness and premature mortality in otherwise healthy populations.[1] In insurance underwriting, accurate knowledge of applicant tobacco use patterns is indispensable to effective risk assessment, and has a very direct role in

pricing, as tobacco users will typically pay 2 to 4 times the premiums of their non-user peers for comparable levels of coverage.[2] This substantial price disparity represents an obvious financial incentive for the misreporting of tobacco use. Less tangible influences may include the applicant's perceived social stigma. Previous studies[3,4] have considered the validity of self-reported tobacco use in various populations and settings, and while sensitivity is generally moderate (averaging 87% across all methodologies in one meta-analysis[4]), it is also highly responsive to interview method and subject knowledge of biochemical confirmation, among other factors.[5]

The life insurance application process represents a unique confluence of incentives for applicant reporting accuracy. Even mid-market tobacco users who are able to successfully conceal their habit would typically realize annual premium savings of over $1000. Applicants for fully underwritten products will generally be aware that their responses to tobacco-use questionnaires will be confirmed biochemically. This study draws upon the self-reported tobacco-use status, laboratory confirmed urine cotinine concentrations, and demographic profiles of 6.2 million life insurance applicants processed between 1999 and 2012 to determine the applicant attributes most predictive of false-negative self-reporting (FNSR).

METHODS

Data

Between September 1999 and September 2012, 6.2 million life insurance interview records were collected by ExamOne, Inc. (Lenexa, KS) and matched to urine cotinine results from urine samples collected contemporaneously. Interviews were conducted by a paramedical examiner in the course of sample collection (which typically included serum as well as urine); the tobacco-relevant questions are provided in their entirety in Table 1. For the purposes of this analysis, an applicant was considered a self-reported, non-tobacco user only upon answering negatively to all of the questions listed. Question wording remained consistent throughout the period studied. Applicant gender, date of birth, address, and policy face value sought were also recorded at the time of application. Policy type (eg, term, universal, whole life, etc) and term were not available. Tobacco use was biochemically confirmed by urine cotinine testing using a cutoff of 0.5 μg/ml (both quantitative and qualitative results were collected). Laboratory testing was performed by ExamOne, Inc. All records were de-identified prior to any analysis.

Table 1. Tobacco-Related Interview Questions

1	Do you use tobacco in any form?
2	If yes, what type of product(s) have you used?
2a	Cigarette?
2b	Cigar ?
2c	Pipe?
2d	Smokeless?
3	Are you currently using a nicotine delivery system?
4	Has the proposed insured used nicotine in the past 12 months?

Analysis

Among records examined, the confirmed cotinine positivity rate was 8.8%; the sensitivity of self-reported tobacco use was 80.7%, with a FNSR rate of 19.3% (see Tables 2a and 2b). Among confirmed smokers, 68% were male, with an average age of 42.5 and an average policy face amount of $322,000. Cotinine positivity rates varied widely by state of residence and moderately by year of collection - from 2.7% (Utah, 2003) to 21.6% (West Virginia, 2001). As FNSR is by definition possible only in laboratory confirmed tobacco users, the total population of modelable applicants with a complete set of independent variables was 545,970, of which 105,452 met our criteria for FNSR.

The final set of independent variables is provided in Table 3. MALE is a dummy

Table 2a. Urine Cotinine Confirmation by Self-Reported Status

	Urine Confirmation		
Self-Reported Tobacco Status	Cotinine Negative	Cotinine Positive	Totals
Non-User	5,138,248	105,452	**5,243,700**
User	498,426	440,518	**938,944**
Totals	**5,636,674**	**545,970**	**6,182,644**

Sensitivity = (Cotinine-Positive Self-Reported Users)/(All Cotinine Positives) = 80.7%
FNSR= (Cotinine-Positive Self-Reported Non-Users)/(All Cotinine Positives)=19.3%

Table 2b. Urine Cotinine Confirmation by Self-Reported Status (Percent)

	Urine Confirmation		
Self-Reported Tobacco Status	Cotinine Negative	Cotinine Positive	Totals
Non-User	83.1	1.7	**84.80%**
User	8.1	7.1	**15.20%**
Totals	**91.2%**	**8.8%**	**100%**

Boolean variable assigned a value of 1 in males and 0 in females. STATEYEAR_COT is the mean cotinine confirmation rate for an applicant's state in his/her processing year. For ease of interpretation, certain variables have been scaled to provide an approximate order-of-magnitude equivalence. Thus, STATEYEAR_COT_2 is equal to STATEYEAR_COT X STATEYEAR_COT X 100.

Predictive relationships were identified by logistic regression in SAS 9.1.3 SP4. As earlier stated, FNSR was defined as a consistent set

Table 3. Independent Variables

Variable Name	Scaling Factor	Description
MALE	1	1 if Male, 0 if Female
APPAGE	1	Applicant Age at Applicantion
APPAGE_2	1	$APPAGE^2$
APPAGE_3	1	$APPAGE^3$
POLICY_SIZE	0.001	Policy Face Value
POLICY_SIZE_2	1	$POLICY\_SIZE^2$
POLICY_SIZE_3	1	$POLICY\_SIZE^3$
STATEYEAR_COT	1	Cotinine Positivity Rate in Applicant State in Year of Application
STATEYEAR_COT_2	100	$STATEYEAR\_COT^2$
STATEYEAR_COT_3	1000	$STATEYEAR\_COT^3$

The final set of independent variables is provided in table 3. MALE is a dummy Boolean variable assigned a value of 1 in males and 0 in females. STATEYEAR_COT is the mean cotinine confirmation rate for an applicant's state in his or her processing year. For ease of interpretation, certain variables have been scaled to provide an approximate order-of-magnitude equivalence. Thus, STATEYEAR_COT_2 is equal to STATEYEAR_COT X STATEYEAR_COT X 100.

Table 4. Final Model Parameters

Variable	Parameter Estimate	Standard Error	Odds Ratio	p-value
INTERCEPT	1.7603	0.099	NA	<.0001
MALE	0.0859	0.00796	1.09	<.0001
APPAGE	−0.0964	0.00502	0.908	<.0001
APPAGE_2	0.00133	0.000113	1.001	<.0001
APPAGE_3	−3.79E-06	8.12E-07	1	<.0001
POLICY_SIZE	0.000152	8.40E-06	1	<.0001
POLICY_SIZE_2	−7.79E-09	7.17E-10	1	<.0001
POLICY_SIZE_3	6.99E-14	8.19E-15	1	<.0001
STATEYEAR_COT	−26.3256	1.9759	<0.001	<.0001
STATEYEAR_COT_2	1.2587	0.1791	3.521	<.0001
STATEYEAR_COT_3	−0.1735	0.0516	0.841	0.0008

of negative responses to all questions in Table 1, accompanied by a positive laboratory tested urine cotinine screen. The final model was selected by stepwise regression, with a variable admission p-value cutoff of 0.25, and an exclusion cutoff of 0.05.

RESULTS

Parameter estimates, standard errors, odds ratio estimates, and p-values for all final model variables are provided in Table 4. The global Chi-Square statistic was 5123.88

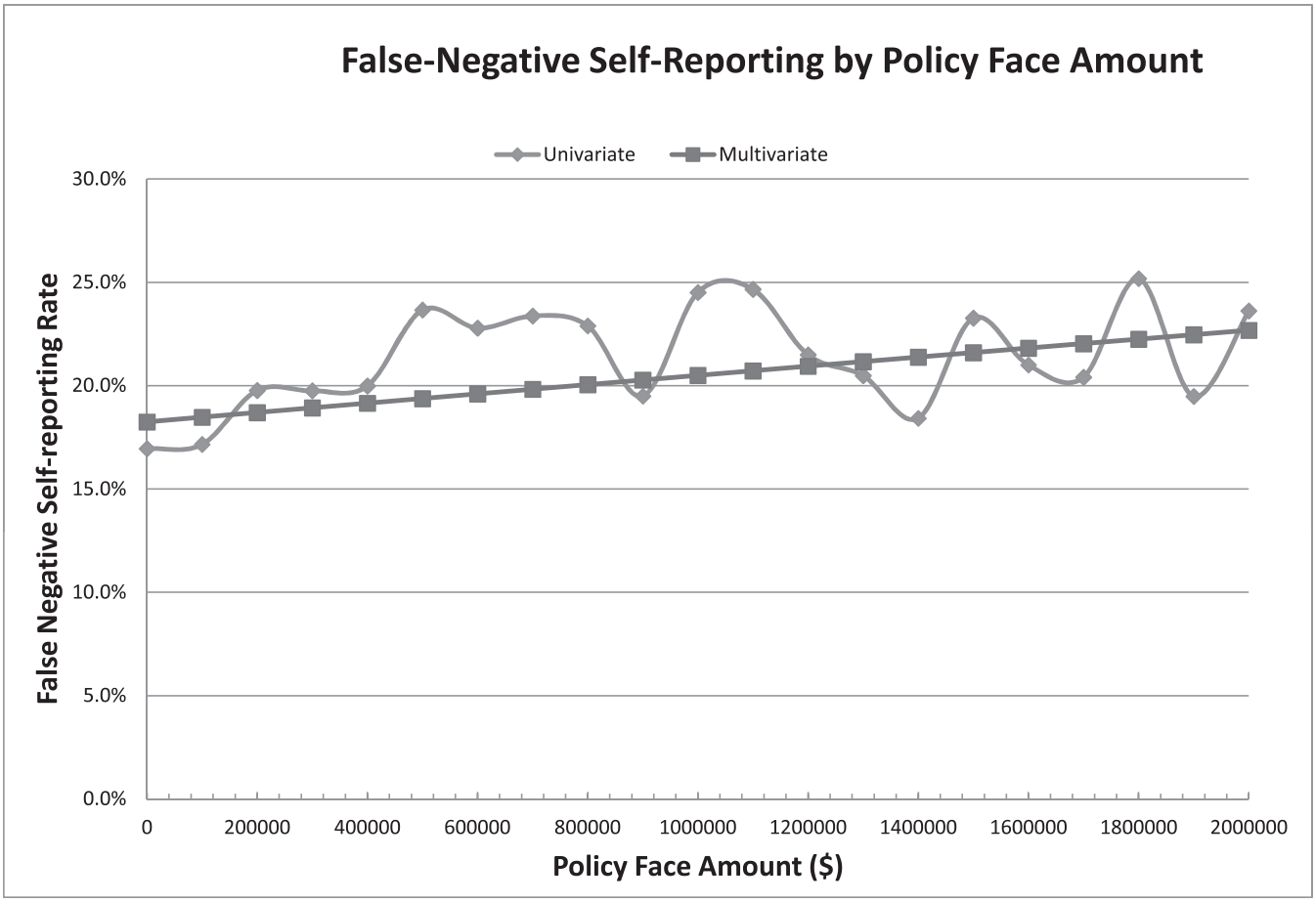

Figure 1. *False-negative self-reporting increases moderately between face values of <$100,000 and $500,000, but remains comparatively constant thereafter.*

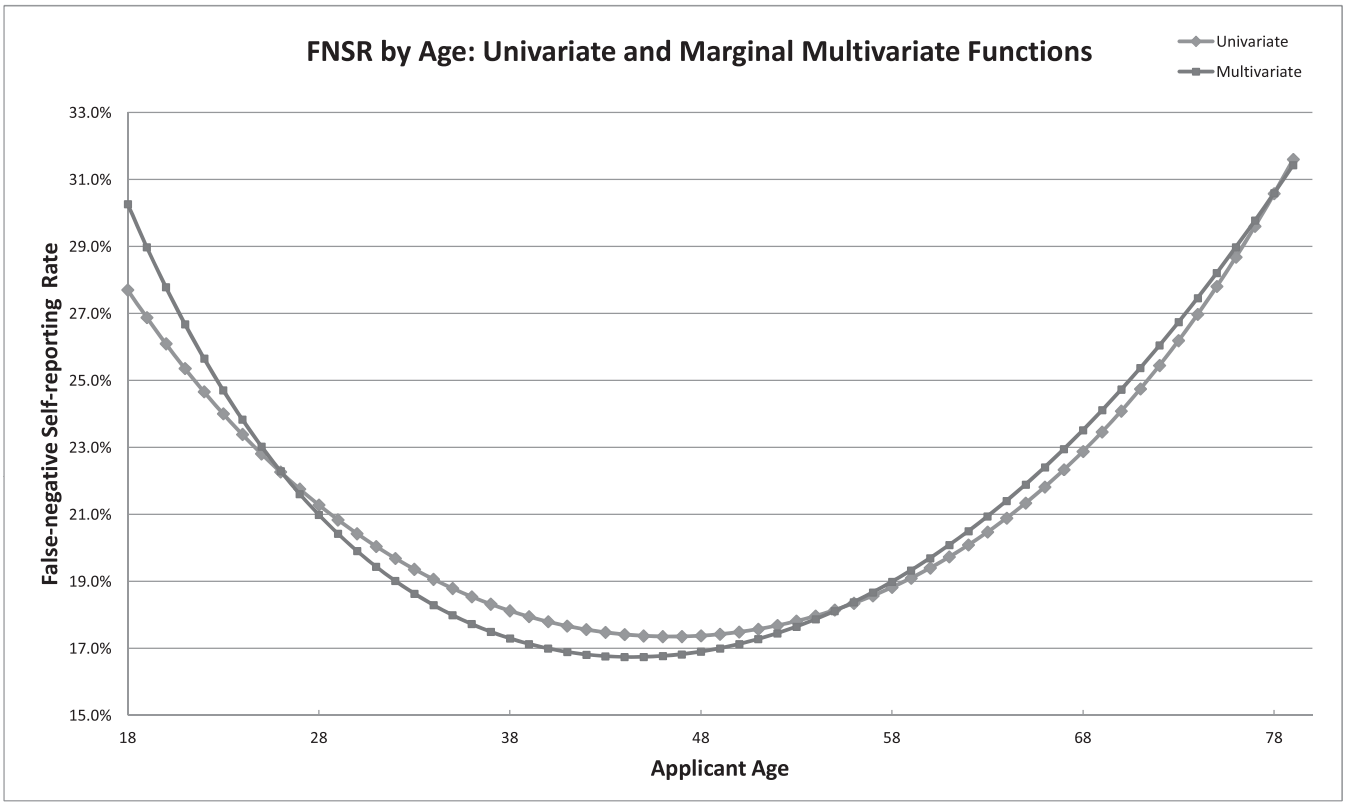

Figure 2. *The univariate relationship between age and FNSR is little changed in a multivariate context. False-negative self-reporting rates are highest below age 30 and above age 60, reaching a minimum in middle age.*

(df=10), yielding an aggregate model p-value of well under 10^{-5}. The model C-statistic was 0.577. Male applicants were modestly more likely to have a false-negative self-report of tobacco use (FNSR), with a male/female odds ratio corresponding to the difference between FNSR rates of 18.9% and 20.3% at mean policy values and age. Figures 1 and 2 provide graphical representations of the univariate and marginal multivariate risk functions for face value and applicant age. For consistency, all multivariate functions have been computed at the population averages.

On a univariate basis, FNSR increases modestly between 17.0% for face values of 0-$100,000 to 23.7% at $500,000, with little subsequent increase in FNSR through face values of up to $2 million. When controlling for age and gender, the relationship is mildly dampened, most likely due to the correlation between face value and male gender and older ages (Figure 1).

Whether interpreted univariately or in the multivariate context of the larger model, the relationship between FNSR and age is roughly parabolic (Figure 2), with FNSR rates for applicants below age 30 and above age 60 exceeding those for middle-aged applicants by more than a factor of 1.5 on average. Overall laboratory cotinine positivity decreases beginning at age 60 (Figure 3). There appears to be a negative correlation between state cotinine positivity levels and FNSR rates (Figure 4) and FNSR is substantially more prevalent in states with a confirmed cotinine positive rate of 5–8% than in those with rates of 10% or above. The R^2 of this relationship (0.3769) is moderate, and the residuals (distance from the trend line) indicate which states FNSR rates differ from those that would be projected on the basis of cotinine positivity alone (Figure 4). Utah, Idaho, South Dakota, and Wyoming, for instance, exhibit low cotinine-adjusted misreporting rates, while Puerto Rico, the

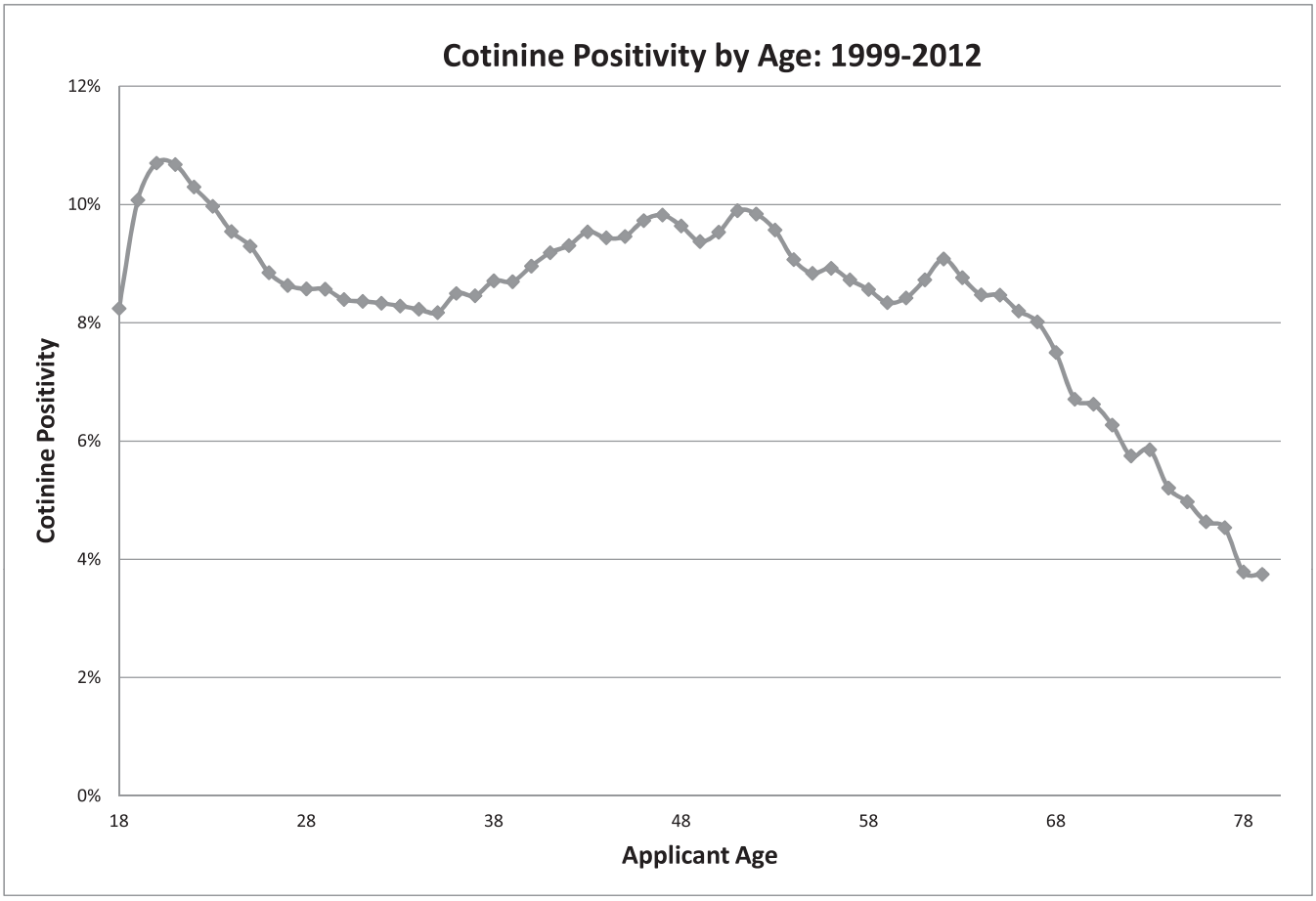

Figure 3. *Confirmed tobacco use rates are stable between 8% and 11% for applicant ages below 67, before beginning a rapid decline, which is negatively correlated with the false-negative self-reporting rate for this age group.*

District of Columbia, and South Carolina's FNSR incidence is greater than can be explained by tobacco use in isolation.

Quantitatively, confirmed tobacco users with positive cotinine screens who are false-negative, self-reported tobacco users (FNSR) present significantly lower urine cotinine levels than those who correctly self-report (Figure 5), with acknowledged self-reported users averaging 3.41 μg/ml (3.40–3.42), as compared to 2.60 (2.58–2.61) in FNSR. A disproportionate fraction of the FNSR group (26.8% vs 11.9%) showed urine concentrations of 0.5–1.0 μg/ml, within 0.5 μg/ml of the confirmation cutoff.

DISCUSSION

Age, policy face value, and cotinine positivity in state of residence appear to be statistically significant independent predictors of false-negative self-reporting of tobacco use in life insurance applicants.

Our analysis finds that cotinine-positive applicants from states with low relative cotinine positivity are the most likely to falsify their self-reported tobacco usage habits. FNSR rates peak in young adulthood and in the oldest age groups. A possible reason behind these findings (other than overt misrepresentation) may be that young adults self-identification as users remains ambivalent, while in old ages, embarrassment from non-compliance with medical orders to abandon the nicotine habit mounts.

While financial incentives might appear to be the obvious and dominant motive for false-negative self-reporting of tobacco use among life insurance applicants, the analysis of the available data suggest the possibility of an

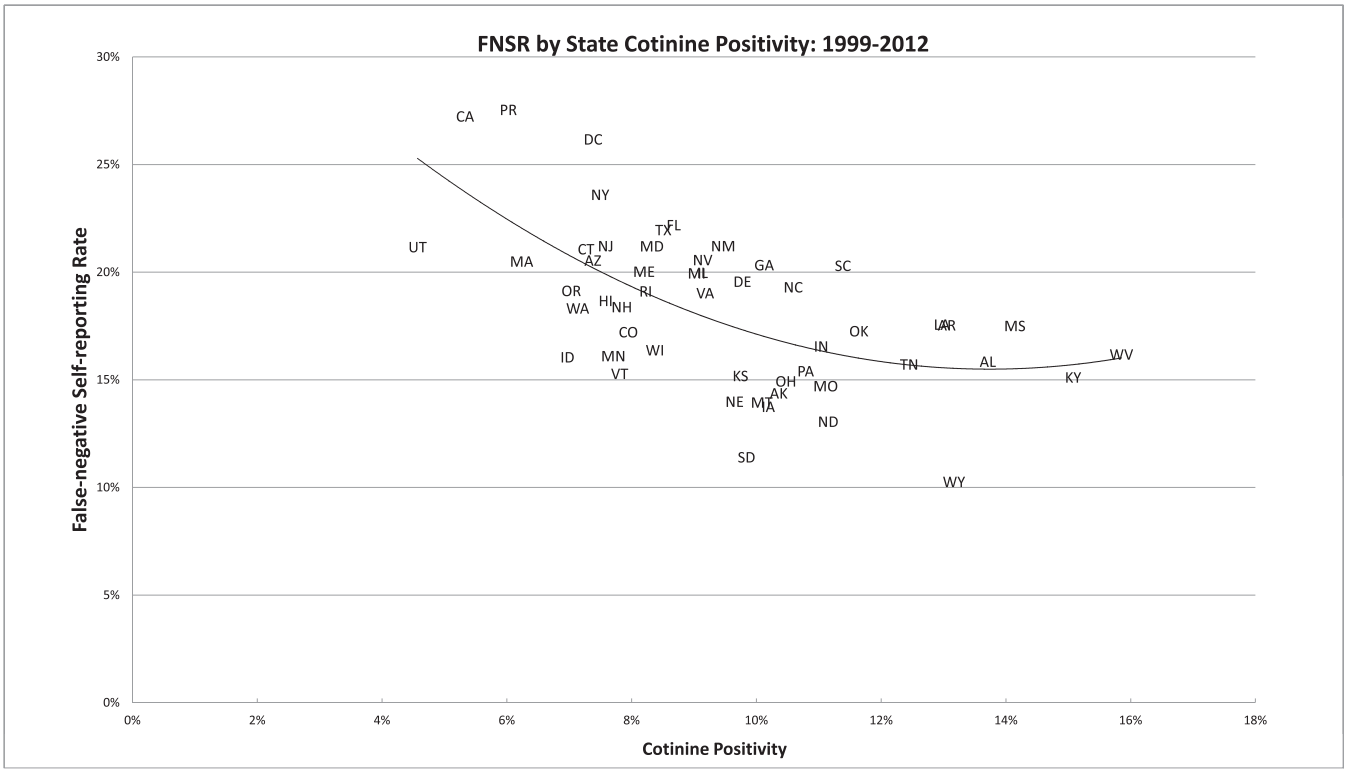

Figure 4. *False-negative self-reporting declines with increasing state-level cotinine positivity rates.*

additional subtle set of causal relationships, in which social and psychological issues of stigma and self-identification are potentially as relevant as simple cost-consciousness. Policy face value does indeed exhibit a statistically significant independent correlation with FNSR, but the absolute magnitude of this effect is moderate, and comparable to that attributable to age or state of residence.

The quantitative urine cotinine distributions show mean urine cotinine concentrations are low among self-reported non-tobacco users. This could be interpreted as either the unsuccessful attempts of habitual tobacco users to abstain prior to insurance testing, or the accurate profile of a low-frequency tobacco use population experiencing sincere ambivalence regarding self-identification as ''nicotine users.''

The model utilized in this study is statistically robust, but was unable to reflect the universe of factors plausibly contributing to FNSR. Potentially biasing omitted variables are numerous, but could include such elusive factors as agent-applicant and interviewer-applicant interactions, spousal attitudes to tobacco use (in married individuals), familiarity with the underwriting process (eg, knowledge of pending urine cotinine confirmation), and preferred tobacco product identity and usage patterns. To the extent that any of these variables are correlated with the actual model input variables, risk coefficients and significance levels would vary. Future studies can build upon these findings.

CONCLUSIONS

Age, gender, policy face value, and mean cotinine positivity in state of residence are statistically significant independent predictors of false-negative self-reporting of tobacco-use in life insurance applicants. While the majority of biochemically confirmed tobacco users accurately report their status (self-reporting sensitivity is 80.7%), the remaining large minority of false-negative self-reporting cases would be more than sufficient to undermine the pricing assumptions of most

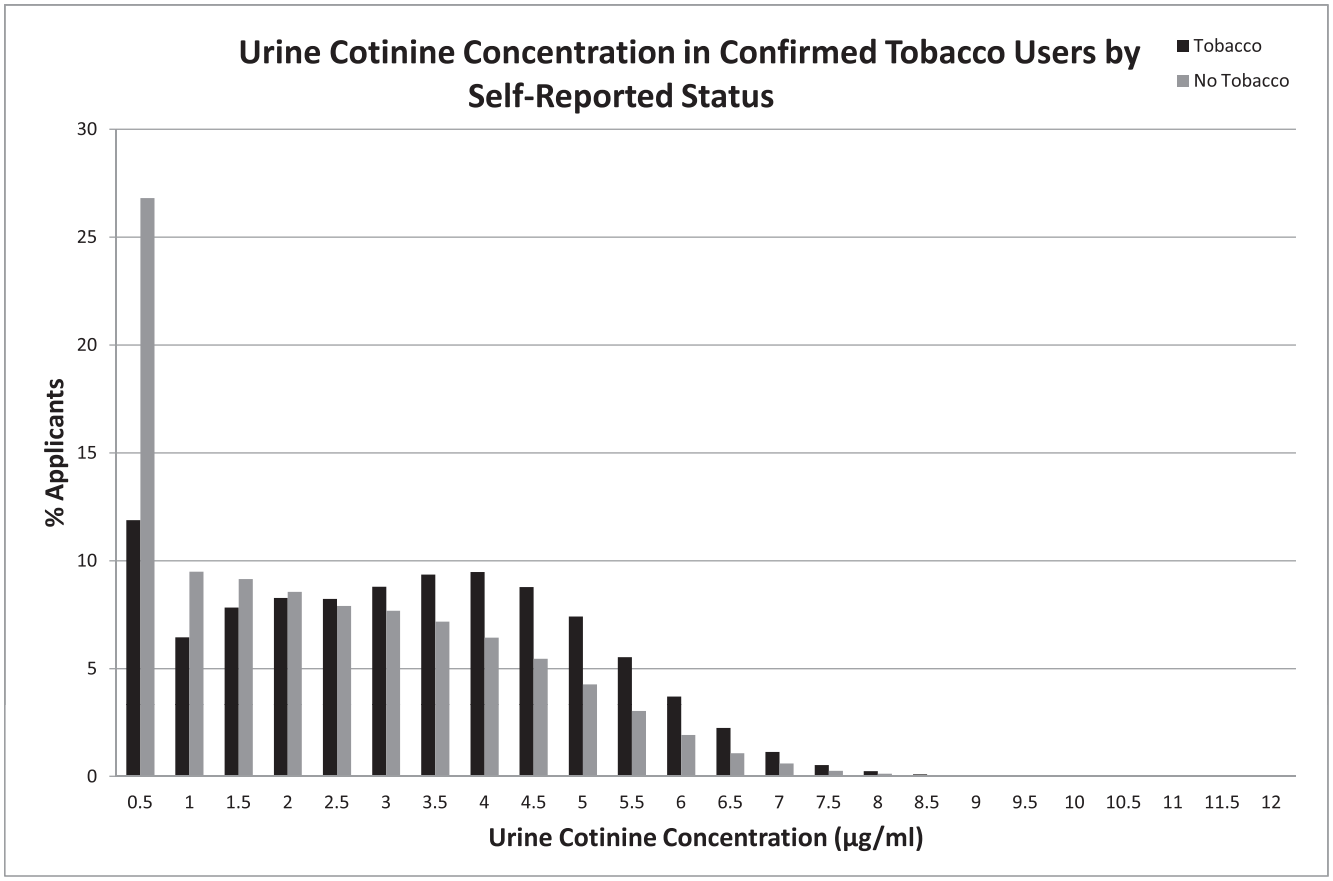

Figure 5. *Mean urine cotinine concentrations are low among self-reported non-tobacco users, with the range immediately above the cutoff level (0.5–1.0 µg/ml) particularly over-represented.*

life insurance products if accepted as truthful by underwriters. Policy face value is one among several variables which are moderately predictive of FNSR; peer group effects (broadly defined by age, gender and geography) may also be relevant.

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