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Article type : Original Research Article

**Shifting Age of Peak Binge Drinking Prevalence: Historical Changes in Normative Trajectories among Young Adults Aged 18 to 30**

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Development of this manuscript was supported by research grants from the National Institute on Alcohol Abuse and Alcoholism (R01AA023504 to M. Patrick and R01AA026861 to J. Jager & K. Keyes) and the National Institute on Drug Abuse (R01DA037902 to M. Patrick and R01DA039854 to S. Lanza). Data collection and manuscript preparation were also supported by the National Institute on Drug Abuse (through research grants R01DA001411 to R. Miech and L. Johnston and R01DA016575 to J. Schulenberg and L. Johnston). The study sponsors had no role in the study design, collection, analysis or interpretation of the data, writing of the manuscript, or

This is the author manuscript accepted for publication and has undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the [Version of Record](#). Please cite this article as [doi: 10.1111/acer.13933](https://doi.org/10.1111/acer.13933)

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27 the decision to submit the paper for publication. The content is solely the responsibility of the  
28 authors and does not necessarily represent the official views of the study sponsor.

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35 **Abstract**

36 **Background:** This study examined the extent to which the developmental pattern of prevalence  
37 of binge drinking in the past two weeks from ages 18 through 30 has changed across 29 cohorts  
38 of US young adults, and whether the changes differed by gender.

39 **Methods:** Analyses used national longitudinal data from 58,019 12<sup>th</sup> grade students (from  
40 graduating high school classes 1976-2004) participating in the Monitoring the Future study  
41 followed through modal age 30 (with age 29/30 data collected from 1987-2016). Weighted time-  
42 varying effect modeling was used to model cohort group differences in age-related patterns of  
43 binge drinking.

44 **Results:** The age of peak binge drinking prevalence increased across cohorts (from age 20 in  
45 1976-1985 to 22 in 1996-2004 for women, and from 21 in 1976-1985 to 23 in 1996-2004 for  
46 men). Historical change in the developmental pattern of binge drinking across all ages of young  
47 adulthood differed for men and women. Even after controlling for key covariates, women in the  
48 more recent cohort group reported significantly higher binge drinking prevalence than women in  
49 earlier cohorts from ages 21 through 30. Men in the more recent cohort group reported higher  
50 binge drinking prevalence at ages 25-26, but prevalence levels then converged to those seen in  
51 earlier cohort groups by age 30.

52 **Conclusions:** An older age of peak binge drinking and a decreased rate of decline in the  
53 prevalence of binge drinking in later young adulthood among more recent cohorts have resulted  
54 in an extension of individual and societal risks associated with binge drinking, particularly for  
55 women, across young adulthood. High-risk alcohol use prevention efforts are needed throughout  
56 at least the third decade of life.

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## Introduction

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The individual and societal risks associated with binge drinking are well recognized (e.g., Centers for Disease Control and Prevention, 2017; Naimi et al., 2003; World Health Organization, 2014). Binge drinking is often defined as 5+ drinks per occasion (e.g., Dawson et al., 2015; Miech et al., 2018; Schulenberg et al., 2018; Substance Abuse and Mental Health Services Administration, 2018). Young adults (and those around them) are at higher risk for negative consequences resulting from binge drinking compared to other age groups. The normative developmental pattern of binge drinking involves escalation from late adolescence into the early 20s, followed by some level of moderation or “maturing out” thereafter (Maggs and Schulenberg, 2004; Patrick et al., 2016; Substance Abuse and Mental Health Services Administration, 2017; Bachman et al., 2002; Bachman et al., 1997; Schulenberg et al., 2018). This normative developmental pattern is distinct from historical fluctuations in binge drinking prevalence. That is, regardless of whether historical trends in binge drinking during late adolescence have increased, decreased, or remained stable, binge drinking has been observed to increase from age 18 through the early 20s and then decrease through the late 20s. The extent to which these developmental patterns in the prevalence of binge drinking have changed historically has not been closely examined.

It is recognized that etiology, in terms of course of alcohol and other drug use, varies by history (Schulenberg et al., 2014), with important cohort-related changes in the normative developmental pattern of average frequency of binge drinking during the transition to adulthood (e.g., Jager et al., 2015; Jager et al., 2013). Specifically, using national U.S. longitudinal data from 28 high school class cohorts (1976 to 2003), latent growth curve models showed that binge drinking frequency accelerated more quickly across ages 18 to 22 (Jager et al., 2015; Jager et al., 2013) and decelerated more slowly across ages 22 to 26 (Jager et al., 2015) for recent cohorts compared to earlier cohorts. Therefore, more recent cohorts reported lower frequency binge drinking at age 18, but higher frequency binge drinking at age 26 relative to past cohorts. The focus of the current study, however, is on prevalence of binge drinking—that is, how many young adults report any binge drinking in the past two weeks. A focus on changing prevalence results in the ability to examine variation in the proportion of the population at risk for negative alcohol-related consequences at a given age. Change in the frequency of binge drinking, on the

89 other hand, does not allow for distinguishing between changes in the rate of binge drinking  
90 among drinkers from changes in the proportion of the population engaging in any binge drinking.  
91 That is, an increase in average binge drinking frequency may be the result of a subset of drinkers  
92 increasing how often they binge drink or of a greater proportion of the population engaging in  
93 any binge drinking.

94 Historical changes in the developmental pattern of binge drinking prevalence have  
95 meaningful implications for expected individual and societal costs associated with alcohol use,  
96 and thus important implications for research, prevention, and intervention efforts. More young  
97 adults initiating binge drinking in recent years would help explain why the average frequency of  
98 binge drinking from ages 18 to 22 increased in Jager et al. (2013); it would also mean that  
99 important reductions in harms and costs associated with past decreases in adolescent binge  
100 drinking have not necessarily extended to lower risk behavior in young adulthood. Delayed  
101 participation in binge drinking is beneficial in that adolescent binge drinking is associated with  
102 impairments in memory, decision making, reasoning, attention, and academic performance  
103 (Alfonso-Loeches and Guerri, 2011; Crego et al., 2009; Squeglia et al., 2012). However, brain  
104 development (particularly aspects related to cognition, decision making, and neural connectivity)  
105 continues at least through age 30 (Lebel and Beaulieu, 2011; Pujol et al., 1993; Sowell et al.,  
106 1999; Tamnes et al., 2010; Walhovd et al., 2005) suggesting that just delaying alcohol use onset  
107 and escalation until early adulthood does not fully avoid the potential negative impacts of alcohol  
108 on maturation. One key indicator of the ages at which young adult risk is most concentrated is  
109 the age of peak binge drinking prevalence. If this age has changed historically, we need to adjust  
110 our prevention and intervention efforts accordingly. In particular, if the age of peak binge  
111 drinking has increased, then the risks associated with an increasing population of binge drinkers  
112 would extend further into young adulthood. Conversely, if the age of peak binge drinking  
113 prevalence has decreased historically, then risk associated with binge drinking would remain  
114 even more highly concentrated in early young adulthood as the period of highest risk would not  
115 extend as far into the 20s.

116 Vulnerability to negative consequences from alcohol use and binge drinking (such as  
117 alcohol-related health and psychosocial consequences) is higher for women than men (Dir et al.,  
118 2017). The normative developmental pattern of binge drinking has been understood to generally  
119 follow similar patterns for both men and women, but with higher prevalence levels for men

120 (Patrick et al., 2016; Schulenberg et al., 2018). Yet, the gap between men and women in overall  
121 alcohol use (including binge drinking) has decreased notably in recent decades (e.g., Dir et al.,  
122 2017; Erol and Karpyak, 2015; Schulenberg et al., 2018; Slade et al., 2016; White et al., 2015).  
123 There is some evidence that women may have a greater rate of increase in binge drinking  
124 frequency from ages 18 to 22 than men (Jager et al., 2013) and that the rate of decline in binge  
125 drinking prevalence across ages 35 to 85 is slower for women than for men (Karlman et al.,  
126 2006). These studies suggest that there may be differences in age-related patterns of binge  
127 drinking prevalence for men and women, including different ages of concentrated risk indexed  
128 by the age of peak binge drinking prevalence.

129 Historical change in binge drinking prevalence may be associated with fundamental shifts  
130 in the underlying behavior, with responses to changes in policy and social roles, or with shifting  
131 demographic characteristics. During the early- to mid-1970s, the majority of US states lowered  
132 their minimum legal drinking age (MLDA) to under 21 years of age (Wagenaar and Toomey,  
133 2002). However, public concern regarding increasing negative alcohol-related consequences  
134 (e.g., traffic crashes) led to calls to re-instate the MLDA of 21, and the federal government  
135 enacted the Uniform Drinking Age Act of 1984. By 1988, all US states had returned to a MLDA  
136 of 21 (Wagenaar and Toomey, 2002). Evaluations of adolescent and young adult alcohol use in  
137 these changing policy environments found that lower MLDA was associated with significantly  
138 higher alcohol consumption (O'Malley and Wagenaar, 1991; Wagenaar and Toomey, 2002).  
139 Thus, one would expect to see higher binge drinking prevalence during early young adulthood  
140 for cohorts from the 1970s through mid-1980s. For both genders, historical differences in age 18  
141 binge drinking from 1976 to 2004 were significantly linked to MLDA; for males only, historical  
142 differences in age 18 to 22 growth in binge drinking from 1976 to 2004 were also significantly  
143 linked to MLDA (Jager et al., 2015). MLDA will be included as a control in the current study.

144 Other possible contributors to historical variation in binge drinking prevalence include  
145 historical variation in social roles associated with alcohol use (e.g., parenthood, marriage, college  
146 attendance, employment status; Bachman et al., 2002), and the racial/ethnic composition of the  
147 US population. Specifically, there have been historical increases in the percentages of young  
148 adults in social roles associated with higher alcohol use, such as being a college student  
149 (National Center for Education Statistics, 2018), not married (US Census Bureau, 2017), not a  
150 parent (Khandwala et al., 2017; Mathews and Hamilton, 2016; Matthews and Hamilton, 2009),

151 and not employed full-time (Taylor et al., 2012) or at all (US Bureau of Labor Statistics, 2004-  
152 2017)). Delays in marriage and parenthood and decreasing employment among those of younger  
153 ages may be contributing to the extension of peak binge drinking age across cohorts. Adjustment  
154 for changes in such social roles explains some historical change in the binge drinking frequency  
155 growth rate during early adulthood, but not past the age of 22 (Jager et al., 2015). The  
156 racial/ethnic composition of the US also has changed dramatically. Since the mid-1970s, the  
157 proportion of the US population identifying as White has decreased from 81% to 62% (Pew  
158 Research Center, 2015), and alcohol consumption is generally higher among White than non-  
159 White individuals (Delker et al., 2016; Miech et al., 2018; Terry-McElrath and Patrick, 2018).  
160 We include these sociodemographic indicators as controls in order to evaluate the extent to  
161 which these changing factors account for observed historical changes.

162 Analytic methods used to model the developmental pattern of binge drinking have often  
163 employed growth curve modeling with longitudinal data (e.g., Conrod et al., 2008; Jager et al.,  
164 2013; Patrick and Schulenberg, 2011; Patrick et al., 2016; Wood et al., 2010) or age-period-  
165 cohort models with cross-sectional data (e.g., Kerr et al., 2009). These methods are very useful  
166 but impose parametric forms for all associations and typically assume that the observed  
167 associations are consistent over time (see also Patrick et al., 2017a). When seeking to determine  
168 if the strength of a particular association changes across time, time-varying effect modeling  
169 (TVEM) provides an alternative modeling approach (Lanza et al., 2016; Li et al., 2015; Tan et  
170 al., 2012). TVEM models (described in greater detail below) allow for not only the behavior of  
171 interest (i.e., binge drinking) to change across time (i.e., age), but also for the possible effects of  
172 covariates to change across time (e.g., gender over age), with no assumptions of parametric form  
173 for the observed changes.

#### 174 *The Current Study*

175 Previous studies that examined the average frequency of binge drinking through the mid-  
176 20s with latent growth curve models (Jager et al., 2015; Jager et al., 2013) provided important  
177 insights into historical change in alcohol use epidemiology. The current study extends such work  
178 by: (1) expanding the age range to 18-30, (2) testing for gender differences in historical changes  
179 and the extent to which controlling for key covariates explains observed gender differences, (3)  
180 focusing on prevalence rather than frequency of binge drinking, (4) using a nonparametric data  
181 analysis technique, and (5) focusing on peak age of binge drinking. The current study uses

182 TVEM to consider cohort by gender variation in developmental patterns of binge drinking  
183 prevalence from ages 18 through 30 using national panel data from 29 high school class cohorts.  
184 We give particular emphasis to cohort variation in the peak age of binge drinking prevalence  
185 following high school graduation.

## 186 **Method**

### 187 *Participants*

188 Data from the national Monitoring the Future (MTF) study included nationally  
189 representative cohorts of US 12<sup>th</sup> grade students, a portion of whom were followed longitudinally  
190 (for detailed methodology, see Bachman et al., 2015; Miech et al., 2018; Schulenberg et al.,  
191 2018). Each year since 1975, nationally representative samples of approximately 15,000 12<sup>th</sup>  
192 graders (modal age 18) from about 130 schools in the contiguous US were surveyed using self-  
193 administered paper surveys, typically during a normal class period. From each annual cohort, a  
194 subsample of about 2,400 was selected for longitudinal follow-up; drug users were oversampled.  
195 Respondents were randomly assigned to begin biennial follow-up either one year later (at modal  
196 age 19) or two years later (at modal age 20) using mailed questionnaires. Therefore, young adult  
197 data were provided at a maximum of seven time points per person, at modal ages 18, 19/20,  
198 21/22, 23/24, 25/26, 27/28, and 29/30. A University of Michigan Institutional Review Board  
199 approved the study.

200 Analysis was limited to cohorts with the opportunity to complete all baseline and follow-  
201 up surveys through age 29/30. The analytic sample included respondents from the 29 12<sup>th</sup> grade  
202 cohorts of 1976-2004 (birth cohorts of approximately 1958-1986) who were eligible to respond  
203 at age 29/30 (age 29/30 data collected during 1987-2016). A total of 70,843 individuals were  
204 selected for follow-up participation from the relevant cohorts; 58,076 respondents (82.0%)  
205 participated in at least one of the six follow-up data collection efforts, and 58,019 (99.9% of  
206 those who participated in a follow-up) provided data on binge drinking on at least one occasion.  
207 The mean number of available measurements on binge drinking per respondent in the resulting  
208 analytic dataset was 5.3 (range of 1-7). The analytic sample was 53.7% female, and 78.5%  
209 White, 9.2% Black, 6.0% Hispanic, 2.4% Asian, and 3.9% Other race/ethnicity. Attrition  
210 adjustments are discussed below.

### 211 *Measures*

212 On each survey, respondents were asked to think back over the last two weeks when  
213 answering the question, “How many times have you had five or more drinks in a row?” with  
214 response options of none, once, twice, 3-5 times, 6-9 times, and 10 or more times. Binge  
215 drinking was coded as a dichotomous variable indicating any consumption of five or more drinks  
216 during the last two weeks (yes, no).

217 Covariates at 12<sup>th</sup> grade included self-reported gender (male, female) and race/ethnicity  
218 (coded for analysis as a dichotomy of non-White vs. White). Time-varying covariates self-  
219 reported at each follow-up from age 19 through 30 included college attendance (currently  
220 attending a four-year college vs. not); employment (having at least 1 full-time or part-time job  
221 vs. no paid work); marital status (married vs. not); and parental status (any children vs. no  
222 children). Age was based on the modal year of age per survey from 18 to 30. State MLDA was  
223 coded based on the state and year in which the respondent answered the 12<sup>th</sup> grade survey and  
224 was used as a continuous measure (range 18 through 21; policy data were obtained from  
225 Hedlund et al., 2001; Hoxie and Skinner, 1987).

226 Cohort (indicating year of 12<sup>th</sup> grade survey) was coded into three non-overlapping  
227 groups: 1976-1985, 1986-1995, and 1996-2004. The decision to define cohort groups in this way  
228 was based on two considerations. First, these groups reflect distinct changes in age 18 binge  
229 drinking prevalence (Miech et al., 2018): 1976-1985 were cohorts with higher prevalence, 1986-  
230 1995 were cohorts with decreasing 12<sup>th</sup> grade prevalence, and 1996-2004 were cohorts with  
231 more stable 12<sup>th</sup> grade prevalence. Second, prior research (Jager et al., 2015) indicated that the  
232 historical rate of change in binge drinking frequency from ages 18 to 26 differed meaningfully,  
233 with the reported differences generally following the three cohort groups defined here. Analyses  
234 for the current paper also showed that, averaged across age, binge drinking and covariate  
235 prevalence/means differed significantly across these three cohort groups (see Supplemental  
236 Table 1). Similar levels of within-cohort group variability were evidenced by similar standard  
237 errors for cohort-group specific binge drinking and covariate estimates other than race/ethnicity  
238 (which showed increasing variability over time) and MLDA (which showed decreasing  
239 variability over time).

#### 240 *Data Analysis*

241 All analyses were conducted using SAS 9.4. Time-varying effect modeling (TVEM) was  
242 used to statistically model regression coefficients (i.e., intercepts and slopes) as flexible, non-



243 parametric functions of age. In other words, prevalence levels and associations between one or  
 244 more covariates and an outcome were estimated across age in a smooth manner, making no  
 245 assumptions about the parametric forms of the coefficient functions (Lanza et al., 2014; Li et al.,  
 246 2015; Tan et al., 2012). In all models reported here, time was operationalized as modal age in  
 247 years. TVEM models were fit using the SAS macro %WeightedTVEM (v. 2.6.0) (Dziak et al.,  
 248 2014; Weighted TVEM SAS Macro, 2017). The coefficient functions (presented in figures) are  
 249 expressed as odds ratios (ORs) or adjusted odds ratios (AORs, for bivariate or multivariable  
 250 associations) with point-wise 99% confidence intervals (CIs) for each smoothed point along  
 251 continuous age (an alpha of 0.01 was used in order to yield more conservative significance  
 252 testing). Coefficients were significant at  $p < .01$  at points where CIs do not contain 1.0. The  
 253 optimal number of knots (corresponding to smoothness) for each coefficient function was  
 254 selected based on comparison of pseudolikelihood AIC and BIC values from unpenalized B-  
 255 spline regression models (Dziak et al., 2017).

256 Before examining the main research questions, an intercept-only TVEM was used to  
 257 show the overall developmental pattern of binge drinking prevalence from ages 18 to 30 for all  
 258 cohorts and genders combined to compare with previously-reported studies. Then, to address the  
 259 main research questions, binge drinking was regressed simultaneously on cohort, gender, and  
 260 gender by cohort interaction terms. Based on significant gender by cohort interactions, gender-  
 261 specific models then examined where there were significant cohort effects for men and women  
 262 separately. The TVEM including cohort group, gender, and gender by cohort interactions using  
 263 1976-1985 as the referent category can be written as:

$$\ln \left( \frac{P(BINGE_{it} = 1)}{1 - P(BINGE_{it} = 1)} \right) = \beta_0(t) + \beta_1(t)Cohorts86to95_i + \beta_2(t)Cohorts96to04_i + \beta_3(t)Male_i + \beta_4(t)Male_i * Cohorts86to95_i + \beta_5(t)Male_i * Cohorts96to04_i$$

264 where  $t$  indicates continuous age and  $i$  denotes data for individual  $i$ . Here,  $\beta_0$  is the intercept,  
 265 reflecting the log-odds of binge drinking across age for females in the earliest cohort group;  $\beta_1$   
 266 and  $\beta_2$  are the slope functions describing the age-varying association between cohort group  
 267 (referent = cohort group 1976-1985) and binge drinking among females;  $\beta_3$  is the slope function  
 268 describing the age-varying association between gender and binge drinking among young adults  
 269 in the earliest cohort group (referent = females); and  $\beta_4$  and  $\beta_5$  are the slope functions describing

270 the age-varying gender differences in cohort group differences in the log-odds of binge drinking.  
271 Finally, gender-specific multivariable models were run for ages 19-30 specifying time-varying  
272 associations for cohort group as well as time-varying effects of control variables including  
273 race/ethnicity, college attendance, employment, marital status, parental status, and MLDA.  
274 Multivariable models were limited to ages 19-30 because several measures (particularly college  
275 attendance, but also marital and parental statuses) gained meaningful variance only after  
276 completion of high school. A total of 56,316 individuals (97.1% of those included in  
277 gender/cohort group models) provided data on all covariates and were included in multivariable  
278 models.

279 All analyses accounted for clustering of repeated measures within individuals by  
280 providing robust standard errors using Taylor linearization (Dziak et al., 2017). Further, all  
281 analyses were weighted using follow-up specific attrition weights, calculated as the inverse of  
282 the probability of responding at each age based on covariates measured at age 18 (cohort, region  
283 of country, gender, race/ethnicity, parental education, number of parents in the home, religiosity,  
284 college plans, high school grades, alcohol use, cigarette use, marijuana use, and sampling weight  
285 correcting for over-sampling of age 18 substance users).

## 286 Results

### 287 *Descriptive Background: Age-Related Changes in Binge Drinking*

288 Figure 1 presents the estimated prevalence of binge drinking from ages 18 to 30 among  
289 all respondents (i.e., all high school cohorts 1976-2004) from an intercept-only TVEM. Binge  
290 drinking prevalence rose from 32.2% (99% CI 31.6, 32.7) at age 18 to a peak of 40.8% (40.2,  
291 41.4) at age 21, and then decreased gradually across the remainder of young adulthood, reaching  
292 28.3% (27.4, 29.2) by age 30. This overall developmental pattern has been reported previously  
293 (e.g., Patrick and Schulenberg, 2011; Schulenberg et al., 2018). The current study sought to  
294 identify gender and cohort variations in this pattern.

### 295 *Cohort by Gender Interactions in the Age-Related Pattern of Binge Drinking*

296 To examine the main research questions, models regressing binge drinking on cohort,  
297 gender, and gender by cohort interactions were examined. There was evidence of significant  
298 gender-by-cohort moderation in the developmental patterns of binge drinking. In the model using  
299 1976-1985 as the referent cohort group, the male\*1986-1995 interaction term was significant  
300 from ages 18 through 22, and the male\*1996-2004 interaction term was significant at all ages. In

301 the model using 1996-2004 as the referent group, the male\*1986-1995 interaction term was  
 302 significant at age 18 as well as ages 21 through 30. Therefore, to address our research questions  
 303 pertaining to gender-specific cohort differences in developmental patterns and to increase  
 304 interpretability of resulting figures, the analysis proceeded with gender-specific models  
 305 regressing binge drinking on cohort. Figure 2 presents modeled estimates of binge drinking  
 306 prevalence from ages 18 through 30 separately by cohort group for women and men. TVEM  
 307 results regressing binge drinking on cohort groups separately for women and men are presented  
 308 in Figures 3 and 4, respectively.

### 309 *Modeled Prevalence of Peak Age of Binge Drinking by Cohort and Gender*

310 As Figure 2 shows, the pattern of binge drinking across age for both men and women in  
 311 all cohort groups was best described as increasing from age 18 through varying ages in the early  
 312 20s when an inflection point was reached, followed by decreasing prevalence thereafter (through  
 313 age 30). For women, binge drinking prevalence for the 1976-1985 cohort group peaked at age 20  
 314 (specifically, age 19.70<sup>1</sup> at 32.36% [31.16, 33.59]), for the 1986-1995 group at age 21  
 315 (specifically, age 20.55 at 29.55% [28.39, 30.74]), and for the 1996-2004 group at age 22  
 316 (specifically, age 21.64 at 33.29% [32.02, 34.59]). For men, binge drinking prevalence for the  
 317 1976-1995 cohort group peaked at age 21 (specifically, age 20.67 at 54.14% [52.76, 55.51]), for  
 318 the 1986-1995 group at age 22 (specifically, age 21.76 at 50.41% [48.88, 51.93]), and for the  
 319 1996-2004 group at age 23 (specifically, age 22.97 at 51.40% [49.54, 53.26]).

### 320 *Modeled Cohort Differences in the Age-Related Pattern of Binge Drinking*

321 *Comparing the earliest high school cohorts (1976-1985) to more recent cohorts (1986-*  
 322 *1995 and 1996-2004).* The odds of binge drinking were significantly lower for individuals in the  
 323 1986-1995 cohort group (vs. the 1976-1985 group) at ages 18-21 for women (Figure 3) and ages  
 324 18-22 for men (Figure 4), and statistically similar thereafter (differences were significantly larger  
 325 for men than women). The odds of binge drinking for individuals in the 1996-2004 cohort group  
 326 (vs. the 1976-1985 group) were significantly lower at ages 18-19 for women and ages 18-21 for  
 327 men, and significantly higher at ages 22-30 for women and 25-28 for men (differences were

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<sup>1</sup> Readers are reminded that TVEM reports estimates using smoothed points along continuous age; the default of 100 points has been used in these analyses, and thus the specific peak age is non-integer. Rounding is used for most age reporting in the current paper, but for these analyses which focus on historical change in peak age across cohorts, we also provide specific values.

328 significantly larger for men during early young adulthood, but significantly larger for women  
329 during later young adulthood).

330 *Comparing the most recent high school cohorts (1996-2004) vs. the earlier cohorts*  
331 *(1976-1985 and 1986-1995).* The odds of binge drinking were significantly higher for  
332 individuals in the 1986-1995 cohort group (vs. the 1996-2004 group) at age 18 for men, and  
333 significantly lower at ages 20-30 for women and 24-28 for men (again, men had significantly  
334 larger cohort differences at early ages, while women had significantly larger cohort differences at  
335 later ages). Among women, the magnitude of difference between the 1996-2004 cohort group  
336 versus other cohort groups grew consistently from ages 20 through 24, and then generally  
337 stabilized (at ages 24-30, 1976-1985 cohort group OR ranged 0.68-0.69; 1986-1995 cohort group  
338 OR ranged 0.72-0.74). Binge drinking prevalence in the 1996-2004 cohort group was statistically  
339 higher than in all other cohort groups at ages 21-30 for women. In contrast, binge drinking  
340 prevalence in the 1996-2004 cohort group was statistically higher than in all other cohort groups  
341 only at ages 25-28 for men. Among men, the magnitude of difference between the 1996-2004  
342 cohort group versus other cohort groups gradually increased at ages 24-27 (reaching a maximum  
343 OR of 0.86 [0.77, 0.95] for the 1976-1995 cohort group, and 0.85 [0.77, 0.95] for the 1986-1995  
344 cohort group), and then gradually decreased during ages 27-28.

345 *Stability of cohort associations within gender from ages 19-30 after controlling for*  
346 *covariates.* After controlling for covariates (race/ethnicity, college attendance, employment,  
347 marital status, parental status, and MLDA), within-gender cohort group differences showed some  
348 degree of attenuation, but the overall findings remained—particularly for later young adulthood  
349 (see Supplemental Figures 1 and 2). With the earliest high school cohorts (1976-1985) as  
350 referent, the adjusted odds of binge drinking remained significantly lower for the 1986-1995  
351 cohort group, but only at age 19 for women and ages 19-20 for men. The adjusted odds of binge  
352 drinking were no longer significantly lower for women in the 1996-2004 versus 1976-1985  
353 cohort groups at ages 18-19, but were significantly higher for ages 21-30. Among men, the  
354 adjusted odds of binge drinking for the 1996-2004 versus 1976-1985 cohort groups retained  
355 significance but at smaller age ranges: lower at ages 19-21, and higher at ages 25-27.

356 When using 1996-2004 as referent, the adjusted odds of binge drinking for those in the  
357 1986-1995 cohort group remained significantly lower at ages 20-30 for women and 24-26 for  
358 men. The magnitude of difference between women in the 1996-2004 cohort group versus other

359 cohort groups continued to show consistent growth through age 24, and then generally stabilized.  
360 Among women, the adjusted odds of binge drinking remained higher in the 1996-2004 cohort  
361 group than in all other groups from ages 21-30; these differences were found only at ages 25-26  
362 for men.

363 *Sensitivity analyses.* Sensitivity analyses were conducted to examine if different findings  
364 emerged when examining the prevalence of multiple binge occasions within the past two weeks;  
365 resulting conclusions were substantively unchanged from those using any binge drinking.

### 366 Discussion

367 The current study is the first to examine historical shifts in the peak age of binge drinking  
368 during young adulthood. Using multi-cohort national samples of US young adults across three  
369 decades (12<sup>th</sup> grade cohorts of 1976-2004, which equate approximately with birth cohorts of  
370 1958-1986), we observed that the actual age of peak binge drinking prevalence has increased  
371 significantly across cohorts for both men and women. Within the 1976-1985 cohort group, binge  
372 drinking prevalence peaked at age 20 for women and 21 for men. Thereafter, peak age for  
373 women moved to 21 for the 1986-1995 cohorts, and then to 22 for the 1996-2004 cohorts.  
374 Among men, the peak age moved to age 22 and then age 23 for cohort groups 1986-1995 and  
375 1996-2004, respectively. Furthermore, historical changes in the course of binge drinking  
376 prevalence throughout young adulthood did not reflect a simple shift up the age spectrum.  
377 Rather, the age-related pattern of the increase, peak, and decrease in the prevalence of binge  
378 drinking changed and significantly varied by gender; such changes were not fully explained by  
379 controlling for policy, social role, and racial/ethnic covariates. These TVEM-based results for the  
380 prevalence of binge drinking from ages 18 to 30 extend prior research on the average frequency  
381 of binge drinking from ages 18 to 26 using latent growth curve modeling that showed cohort  
382 changes in age-related increases and decreases (Jager et al., 2015; Jager et al., 2013).

383 Controlling for covariates somewhat attenuated the observed cohort group differences for  
384 ages 19-20, particularly for women (leaving significant differences between women in the 1976-  
385 1985 and 1986-1995 cohort groups only at age 19, and no significant differences between  
386 women in the 1976-1985 and 1996-2004 cohort groups at ages 19-20). However, even after  
387 controlling for covariates, the adjusted odds of binge drinking among women remained higher in  
388 the 1996-2004 cohort group than all other groups for ages 21-30, and among men for ages 25-26.  
389 These findings support those from prior research (Jager et al., 2015), which found that growth

390 rates for binge drinking frequency were somewhat explained by MLDA and social roles only  
391 during early young adulthood. Thus, it appears that a fundamental shift in binge drinking  
392 behavior is occurring—particularly among women—during the mid- to late 20s. As new cohorts  
393 of high school graduates move through young adulthood, the course of binge drinking appears  
394 poised to reflect an even longer duration of increasing prevalence across late adolescence and  
395 early young adulthood than that observed in earlier cohorts, with a further delayed peak age. To  
396 the extent to which levels of binge drinking remain elevated into later ages, the elevated risks  
397 associated with binge drinking also extend further into young adulthood.

398 Meaningful gender differences were observed in the ways that the developmental patterns  
399 of binge drinking prevalence have changed across recent decades. In the current study,  
400 significant gender by cohort differences were found across all ages 18 through 30 for the most  
401 recent cohorts compared to earlier cohorts, including during the late 20s which is a period of  
402 normative decline in binge drinking (Patrick and Schulenberg, 2011). In particular, from ages 21  
403 through 30, women in the more recent cohort group (high school graduating classes of 1996-  
404 2004) had significantly higher binge drinking prevalence than women in earlier cohorts (1976-  
405 1985 and 1986-1995). However, the magnitude of difference between binge drinking prevalence  
406 among women in the 1996-2004 cohort group and prior cohort groups stabilized at age 24,  
407 remaining generally consistent thereafter. Men in the more recent cohort group had higher binge  
408 drinking prevalence at ages 25-26 than men in earlier cohorts, but the prevalence of binge  
409 drinking converged to levels similar to those of earlier cohort groups by age 27 for men. Thus,  
410 while both men and women experienced a more rapid rate of acceleration in binge drinking  
411 prevalence from ages 18 through the mid-20s in the more recent cohort group versus earlier  
412 cohort groups (which supports prior research with binge drinking frequency through age 26  
413 (Jager et al., 2015; Jager et al., 2013)), higher binge drinking prevalence continued for women in  
414 the more recent cohort group (vs. earlier cohorts) through age 30. In contrast, for men, cohort  
415 differences in binge drinking prevalence disappeared between ages 27 and 30, such that by age  
416 30 binge drinking prevalence did not differ between the 1996-2004 cohorts and the prior cohorts.

417 Alcohol use during later young adulthood has received less research attention than the  
418 years of early- to mid-young adulthood. However, a gradual but generally steady historical  
419 increase in binge drinking prevalence among US young adults at age 30 has been observed  
420 (Patrick et al., 2017b; Schulenberg et al., 2018). Future studies that can examine cohort

421 differences in binge drinking into the 30s and beyond may find that, among women, binge  
422 drinking prevalence converges across cohort groups at a later age. However, extrapolating from  
423 the generally stable magnitude of difference in binge drinking prevalence for ages 24-30 between  
424 women in the more recent cohort group versus earlier cohort groups, binge drinking prevalence  
425 (and associated risks) may remain elevated among women in the more recent cohorts past age  
426 30.

427 The consistently higher likelihood of binge drinking for women—but not men—in the  
428 most recent cohort group compared with earlier cohorts from ages 21 through 30 is consistent  
429 with the narrowing gender gap in alcohol use that has largely been driven by increases among  
430 women (Slade et al., 2016). Further, the current study's findings support projections of decreases  
431 in alcohol use from middle age onward to be weaker for women than men (Karlman et al.,  
432 2006). As mentioned above, social role changes appear to have some level of explanatory role  
433 (e.g., delayed childbearing has been shown to be associated with significantly increased  
434 generational odds of heavy alcohol consumption in longitudinal studies of mother-daughter  
435 dyads (Alati et al., 2014). Key historical differences in alcohol industry product development and  
436 marketing also may have played a meaningful role, with concerted efforts by the alcohol industry  
437 to develop products and campaigns specifically targeting women (Alcohol Beverage Retail,  
438 2018; European Centre for Monitoring Alcohol Marketing, 2008; Parsons, 2010). Marketing for  
439 a range of alcohol products to women has increased notably, and—for women in the more recent  
440 cohort groups—may be leading to increased binge drinking (Kindy and Keating, 2016) through  
441 age 30 and possibly beyond.

#### 442 *Limitations and Strengths*

443 The findings of the current study should be considered within their limitations. The  
444 current analysis relied on repeated nationally representative samples of 12<sup>th</sup> grade students, thus  
445 excluding those who dropped out of school prior to 12<sup>th</sup> grade (school dropout is associated with  
446 increased binge drinking; Tice et al., 2017). Further, all data were self-report, used a general  
447 measure of 5+ drinks for both men and women (rather than gender-specific levels of 4+ for  
448 women and 5+ drinks for men per occasion (e.g., Centers for Disease Control and Prevention,  
449 2015; Kann et al., 2018)), and focused on binge drinking within a relatively short time frame  
450 (i.e., past two weeks). However, in 2013, the MTF prevalence estimate for past two week binge  
451 was 35.1% for individuals aged 19-28 in MTF (Schulenberg et al., 2018), which is comparable to

452 37.9% for past month binge prevalence among individuals aged 18-25 in the National Survey on  
453 Drug Use and Health (Center for Behavioral Health Statistics and Quality, 2015); and 25.8% for  
454 past month binge prevalence among those 18 and older in the National Epidemiologic Survey on  
455 Alcohol and Related Conditions III (Dawson et al., 2015). Finally, attrition across young  
456 adulthood is a limitation, somewhat mitigated by adjustments via weighting. However, the  
457 current analysis has a number of important strengths, particularly utilization of national  
458 longitudinal data with cohorts that have been assessed with consistent measurement across three  
459 decades. The use of TVEM has allowed models to focus on complex associations between both  
460 cohort and gender across age without the assumption of parametric associations or the *a priori*  
461 need to specify inflection points. The study is the first to show that the peak age of binge  
462 drinking prevalence is increasing during young adulthood.

#### 463 *Implications and Conclusions*

464 The results of the current study highlight that the developmental course of alcohol use has  
465 varied in important ways across adjacent cohorts, and underscores the fact that historical change  
466 in etiology can occur relatively rapidly. With such changes in course, other components of  
467 etiology—including risk factors and consequences of alcohol use—are also shifting, and these  
468 are important directions for future research (Schulenberg et al., 2014). The observed delays in  
469 the peak age of binge drinking frequency and elevated prevalence levels of such drinking into the  
470 late 20s for men and women have important theoretical and practical implications. While it  
471 remains the case that binge drinking prevalence tends to escalate after high school, peak during  
472 the early 20s, and then decline, there are also fundamental shifts in the shape of these  
473 developmental patterns. The peak age has shifted upward by 2 years over the past 3 decades  
474 (from age 20 to 22 for women, and from age 21 to 23 for men). In addition, women in the more  
475 recent cohort groups more commonly report binge drinking through age 30, while men in these  
476 same cohorts are returning to prevalence levels similar to those from earlier cohorts by age 30.  
477 Both of these fundamental shifts result in an extension of individual and societal risks associated  
478 with binge drinking into and throughout the 20s. The extent to which historical variation in the  
479 peak age of binge drinking prevalence found here generalizes to other binge drinking indicators,  
480 including binge drinking frequency and high-intensity (or extreme binge) drinking (Patrick et al.,  
481 2016; Patrick et al., 2017b), is not clear. Consequently, future research should examine the extent  
482 to which peak age varies historically for these other indicators. The majority of alcohol



483 prevention and intervention efforts have focused on adolescents and early college student  
 484 populations, but the current findings underscore the need to extend intervention efforts to young  
 485 adults more broadly and increasingly to women. There is a need to ensure that high-risk alcohol  
 486 intervention efforts are developed and implemented to reach individuals throughout the third  
 487 decade of life, and to alert clinicians to the importance of screening for alcohol-related problems  
 488 throughout this key developmental period.

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 682 [1.pdf](http://www.who.int/substance_abuse/publications/global_alcohol_report/msb_gsr_2014_1.pdf)

683

684 **Figure Legends**

685

686 **Figure 1.** Modeled prevalence of binge drinking among US young adults aged 18 through 30  
 687 (from 12<sup>th</sup> grade cohorts 1976-2004 combined)

688

689 *Notes:* N(unwtd.) = 306,814 time points from 58,019 individuals. Estimates obtained from time-varying effect  
 690 models. Dashed lines indicate 99% confidence intervals. Binge drinking defined as having 5+ drinks in a row at  
 691 least once during the past two weeks.

692

693

694 **Figure 2.** Modeled prevalence of binge drinking by gender among US young adults aged 18  
695 through 30 by cohort groups

696

697 *Notes:* N(unwtd.) = 181,140 time points from 31,156 women; 135,674 time points from 26,863 men. Estimates  
698 obtained from time-varying effect models. Dashed lines indicate 99% confidence intervals. Binge drinking defined  
699 as having 5+ drinks in a row at least once during the past two weeks.

700

701 **Figure 3.** Odds ratios and corresponding 99% confidence intervals to test for age-varying  
702 associations between cohort groups and the odds of binge drinking among US young adult  
703 women aged 18 through 30

704

705 *Notes:* N(unwtd.) = 181,140 time points from 31,156 women. Estimates obtained from time-varying effect models.  
706 Dashed lines indicate 99% confidence intervals. Binge drinking defined as having 5+ drinks in a row at least once  
707 during the past two weeks.

708

709 **Figure 4.** Odds ratios and corresponding 99% confidence intervals to test for age-varying  
710 associations between cohort groups and the odds of binge drinking among US young adult men  
711 aged 18 through 30

712

713 *Notes:* N(unwtd.) = 135,674 time points from 26,863 men. Estimates obtained from time-varying effect models.  
714 Dashed lines indicate 99% confidence intervals. Binge drinking defined as having 5+ drinks in a row at least once  
715 during the past two weeks.



Figure 1.

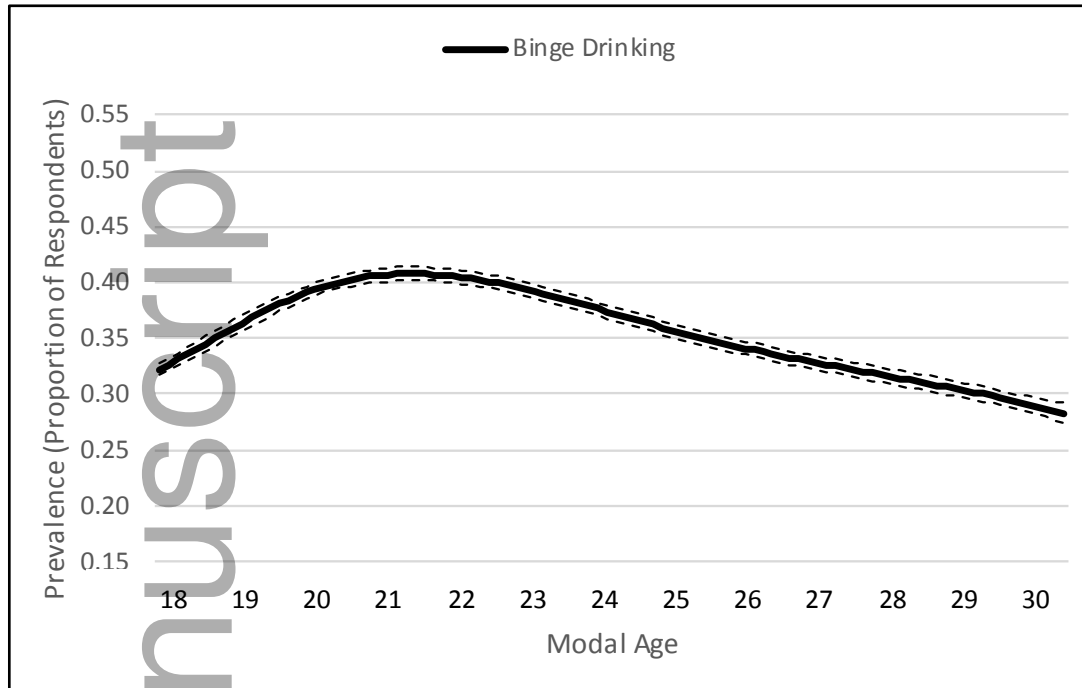


Figure 2.

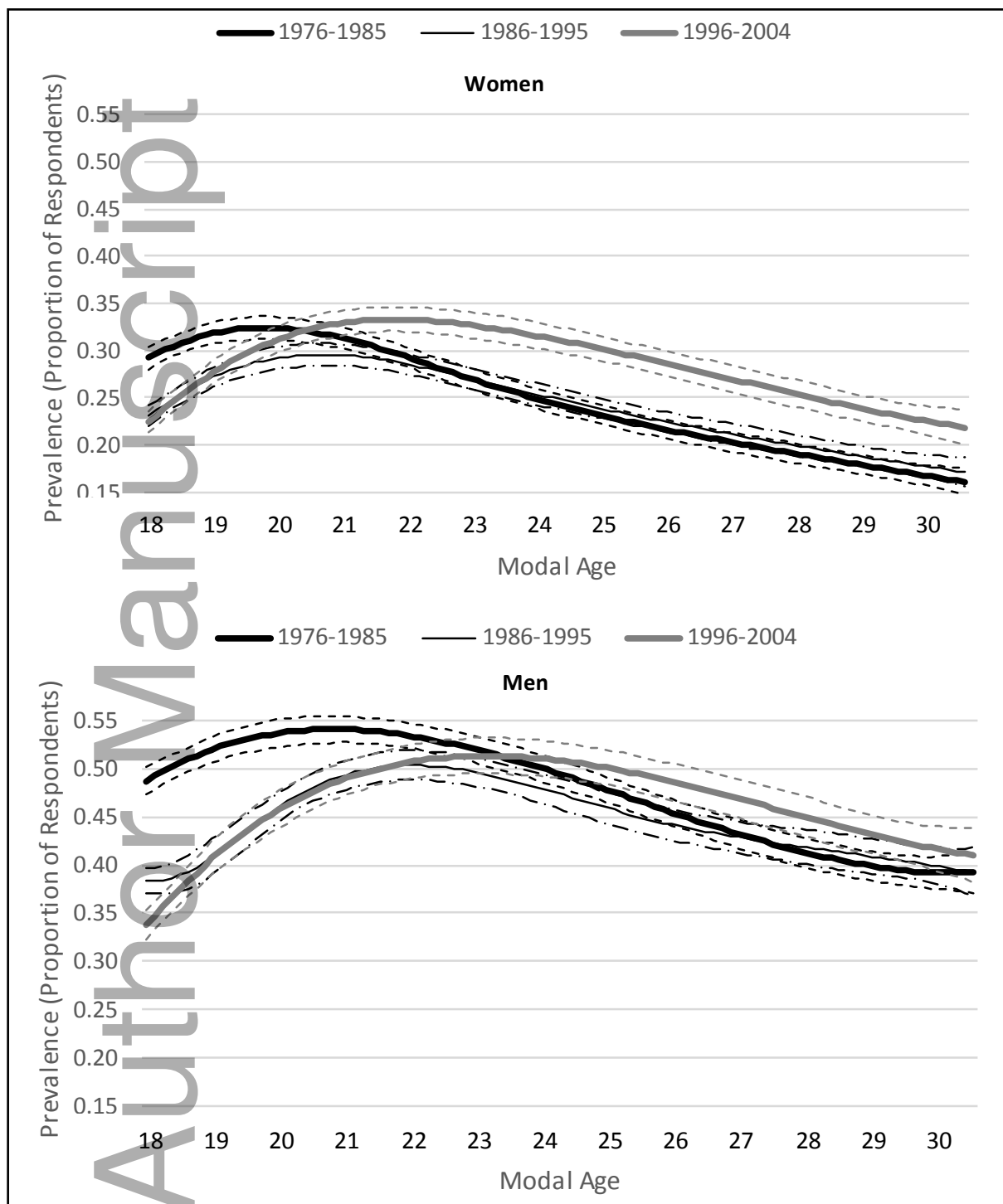


Figure 3.

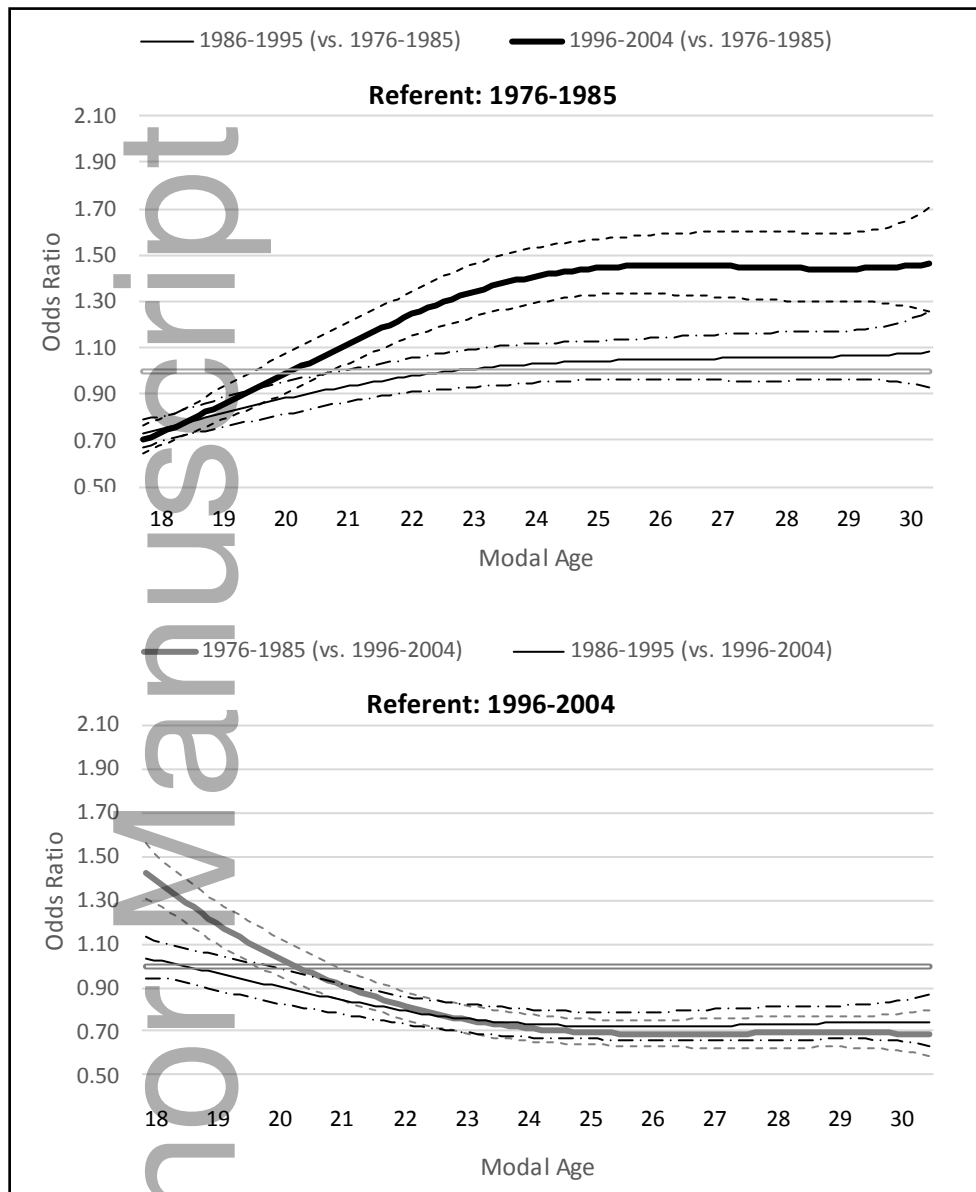


Figure 4.

