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Developmental course of non-medical use of prescription drugs from adolescence to adulthood in the United States: national longitudinal data

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ABSTRACT

Aims To identify the developmental course of non-medical use of four separate prescription drug classes (opioids, sedatives, stimulants and tranquilizers) by examining the general functional growth and related covariates during the transition from adolescence to adulthood in the United States. **Design** Nationally representative probability samples of high school seniors were followed longitudinally across five waves (waves 1, 2, 3, 4 and 5: modal ages 18, 19/20, 21/22, 23/24 and 25/26 years, respectively). **Setting** Data were collected via self-administered questionnaires to high school seniors and young adults in the United States. **Participants** The sample consisted of nearly 72 000 individuals in 30 cohorts (high school senior years of 1977–2006) who participated in at least one wave. **Measurements** Self-reports of annual non-medical use of prescription opioids, sedatives, stimulants, and tranquilizers. **Findings** The annual non-medical use of prescription opioids, sedatives, stimulants and tranquilizers was highest at wave 1 over the five waves. There was a consistent descending path (linear and quadratic slopes, $P < 0.001$) in annual non-medical use from baseline across all four prescription drug classes (e.g. opioids linear slope = -0.043 and opioids quadratic slope = 0.034, $P < 0.001$). While the annual non-medical use of stimulants declined over time (linear slope = 0.063, $P < 0.01$; quadratic slope = -0.133, $P < 0.001$), the same decrease was not observed for the annual non-medical use of prescription opioids, sedatives or tranquilizers when controlling for socio-demographic and substance use behaviors at baseline. The covariates associated with the general functional growth differed across the four prescription drug classes. **Conclusions** The non-medical use of prescription opioids, sedatives, stimulants and tranquilizers appears to peak during late adolescence, suggesting preventive intervention efforts should be initiated in early adolescence. The developmental course of non-medical use is not the same among all four classes of prescription drugs, suggesting that each drug class warrants individual research.

Keywords Adolescence, longitudinal, non-medical use, prescription drugs, prescription opioids, prescription sedatives, prescription stimulants, young adulthood.

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INTRODUCTION

The non-medical use of prescription opioids, sedatives, stimulants and tranquilizers among adolescents and young adults represents a world-wide public health concern [1–7]. The non-medical use of prescription drugs (NUPD) is most prevalent in the United States among young adults aged 18–25, and remains second only to marijuana as the most prevalent form of illicit drug use among adolescents and young adults [4,5,7]. Indeed, more than one-fourth (26.6%) of young adults reported NUPD in their life-time, while more than half (51.9%) reported marijuana use [7]. NUPD-related consequences such as emergency department visits and substance use disorders involving NUPD have increased significantly during the past two decades in the United States [8,9]. Despite this significant public health problem, a systematic review concluded that there remains a lack of

longitudinal research assessing the developmental course of NUPD among adolescents and a strong need for greater focus on NUPD involving prescription sedatives and tranquilizers [10]. With the exception of a few studies focusing on non-medical use of prescription opioids, no national longitudinal study has examined the developmental course of NUPD involving each of the following four prescription drug classes (i.e. opioids, sedatives, stimulants and tranquilizers).

While the developmental course of cigarette smoking, binge drinking and marijuana use during the transition from adolescence to young adulthood are well documented in the United States [11–16], relatively little is known about the developmental course associated with NUPD during this key developmental period [10,17]. To date, the majority of research on this topic has been cross-sectional and identified the age-related prevalence and robust correlates associated with NUPD including sex (male), race/ethnicity (white), low parental education, low academic performance, no plans for college attendance, truancy/delinquent behavior, more evenings away from home and other substance use, including binge drinking, cigarette smoking and marijuana use [4,5,7,10,17–19].

A few longitudinal studies have examined the non-medical use of prescription opioids during adolescence and young adulthood based on regional [17,20] and national samples [21,22]. Taken together, these studies found (1) the annual prevalence of non-medical use of prescription opioids peaked in the senior year of high school; (2) the majority of individuals who reported non-medical use of prescription opioids in secondary school did not engage in this behavior following high school; (3) the mean level of annual non-medical use of prescription opioids held relatively steady during adolescence; and (4) most non-medical use of prescription opioids is both initiated and stopped before the late 20s. Despite this valuable information, these studies were somewhat limited, because they either focused exclusively on the non-medical use of prescription opioids and/or combined multiple prescription drug classes together including some with minimal abuse potential (e.g. antidepressants). Regional and national cross-sectional studies indicate the peak ages of risk for initiating non-medical use of prescription anxiolytics, opioids, sedatives and stimulants were concentrated between 16 and 19 years of age and onset dropped off considerably following 19 years of age [23–25].

To our knowledge, this study will be the first national longitudinal study to describe the developmental course and covariates associated with the non-medical use of four classes of prescription drugs from adolescence to adulthood. The primary aims of this study were to: (1) estimate the developmental course of non-medical use of four separate prescription drug classes (i.e. opioids, sedatives, stimulants, tranquilizers) from ages 18–26; and (2) compare the similarities and differences in covariates associated with the developmental course of non-medical use of each prescription drug class.

METHODS

The present study used national panel data from the Monitoring the Future (MTF) study [4,5,11,12]. Based on a three-stage sampling procedure, MTF has surveyed nationally representative samples of approximately 17 000 US high school seniors each year since 1975, using questionnaires administered in classrooms. Stage 1 is the selection of geographic areas within the four regions of the country including the Northeast, South, Midwest and West. Stage 2 is the random selection of approximately 130 public and private high schools with replacement (schools that decline are replaced with schools that are similar on geographic location, size and urbanicity). Stage 3 is the selection of students within each school. Approximately 2400 high school seniors are selected for biennial follow-ups each year using mailed questionnaires. The biennial follow-up surveys begin 1 year after high school for one random half of each cohort and 2 years after high school for the other half. For the purposes of these analyses, the two halves were combined (combining modal ages 19/20, 21/22, 23/24 and 25/26). Corrective weighting was used to adjust for the unequal probabilities of selection and to approximate the given population most effectively. The project design and sampling methods are described in greater detail elsewhere [4,5,11,12].

SAMPLE

The sample for the present study consisted of respondents who were surveyed as high school seniors (wave 1) from 1977 to 2006 and who were surveyed in their first, second, third and/or fourth biennial follow-up surveys (waves 2, 3, 4 and 5, respectively). Given the aims of the present study, the 30 cohorts were combined and analyses were conducted with nearly 72 000 respondents (range was 71 918 for prescription opioids to 71 980 for prescription tranquilizers in the longitudinal sample across the four prescription drug classes) in the MTF longitudinal study who provided data at any of the five waves. The sample consisted of 52.3% females, 73.3% whites, 12.1% blacks, 7.7% Hispanics, 2.9% Asian and 4% other racial/ethnic groups or not specified (see Table 1). The student response rate ranged from 77 to 86% at wave 1 (with nearly all non-response due to respondent being absent rather than refusing to participate) and retention over all five waves was approximately 50% [4,5].

Table 1 Baseline descriptive statistics for the longitudinal sample at age 18.

Baseline characteristics at age 18	*% (95% CI)*	*% missing at age 18*
Sex		0.0
Female	52.3 (51.9–52.6)	–
Male	47.7 (47.3–48.1)	–
Race/ethnicity		1.5
White	73.3 (72.9–73.6)	–
Black	12.1 (11.8–12.3)	–
Hispanic	7.7 (7.5–7.9)	–
Other race	4.0 (3.8–4.2)	–
Asian	2.9 (2.7–3.0)	–
Parental education		2.9
At least one parent attended some college	64.1 (63.6–64.4)	–
Grades in the 12th grade		3.1
C+ or lower	23.2 (22.9–23.6)	–
College plans		5.5
Definitely will attend college	48.5 (48.1–48.8)	–
Truancy		2.6
Skipped school at least once during the past 4 weeks	35.4 (35.1–35.8)	–
Social evenings out		4.2
Went out three or more times	49.2 (48.7–49.5)	–
Substance use		–
Cigarette use (past 30 days)	29.6 (29.3–29.9)	1.4
Binge drinking (past 2 weeks)	32.2 (31.8–32.6)	5.0
Marijuana use (past year)	35.4 (35.1–35.8)	2.3
Opioid cohorts		0.0
1977–90	45.7 (45.3–46.1)	–
1991–96	21.7 (21.4–22.1)	–
1997–2001	17.1 (16.8–17.4)	–
2002–06	15.4 (15.1–15.7)	–
Sedative cohorts		0.0
1977–85	28.1 (27.7–28.4)	–
1986–94	32.3 (31.9–32.6)	–
1995–2006	39.5 (39.1–39.9)	–
Stimulant cohorts		0.0
1977–85	28.1 (27.7–28.4)	–
1986–89	13.9 (13.6–14.2)	–
1990–95	21.9 (21.6–22.2)	–
1996–2004	30.8 (30.1–31.2)	–
2005–06	5.1 (5.0–5.4)	–
Tranquilizer cohorts		0.0
1977–87	34.9 (34.5–35.3)	–
1988–2000	46.2 (45.8–46.6)	–
2001–06	18.8 (18.5–19.1)	–

The average amount of missing data across waves is about 30% for each of the four outcomes. CI = confidence interval.

MEASURES

Demographic and background characteristics were assessed at baseline (modal age 18) and consisted of student self-reports of the following: sex, race/ethnicity (white, black, Hispanic, Asian, other), parental education (some college versus high school or less), high school grade point average (B– or higher versus C+ or lower), college plans (any plans versus no plans), truancy (did not skip any days in the past 4 weeks versus 1 or more skipped days), social evenings out (less than three per week versus three or more per week), past-month cigarette smoking (any versus none), past 2-week binge drinking (any versus none) and past-year marijuana use (any versus none). The senior year cohort was split into distinct periods for each prescription drug class based on the high school class survey year, and these cohort periods were selected due to changes in the prevalence of non-medical use of each prescription drug class among high school seniors reported elsewhere [4,5]. The cohort breakdown was as follows:

prescription opioids (1977–90, 1991–96, 1997–2001, 2002–06), prescription sedatives (1977–85, 1986–94, 1995–2006), prescription stimulants (1977–85, 1986–89, 1990–95, 1996–2004, 2005–06) and prescription tranquilizers (1977–87, 1988–2000, 2001–06). Cut-points in the covariates were determined based on sensitivity analyses; categorical covariates were desirable, given our analytical and descriptive approaches.

Non-medical use of prescription drugs was assessed in the same manner at all five waves with items asking respondents on how many occasions (if any) they used each prescription drug class (i.e. opioids, sedatives, stimulants, tranquilizers) on their own, without a doctor's orders, during the past 12 months. Extensive lists of examples were provided for each prescription drug class including opioids (e.g. Vicodin®, OxyContin®, Percocet®, codeine), sedatives (e.g. Seconal®, Tuinal®), stimulants (e.g. Ritalin®, Dexedrine®) and tranquilizers (e.g. Librium®, Valium®, Xanax®). The response scale for each drug class ranged from (1) no occasions to (7) 40 or more occasions.

STATISTICAL ANALYSIS

The estimated prevalence rates and means of annual NUPD were examined separately for each prescription drug class (i.e. opioids, sedatives, stimulants and tranquilizers) over the five waves of the study. Next, growth trajectories of the mean frequency of NUPD were examined using latent growth curve models (LGCM) for each prescription drug class (Mplus version 7.3) [26]. Preliminary analyses examined both prevalence rates and means because previous research has examined both types of outcomes [10–22]. However, in analyses presented here, we focused upon trajectories of the mean frequency of NUPD (i.e. continuous outcomes) rather than prevalence of NUPD (i.e. dichotomous outcomes) because the continuous outcomes accounted for frequency of non-medical use associated with each prescription drug class, the continuous outcomes are consistent with earlier work examining trajectories of binge drinking and marijuana use [15,16], and the continuous outcomes had the best fit with the data (i.e. two dichotomous models did not converge). The time-invariant covariates included in the models were all drawn from wave 1, including gender, race/ethnicity, senior year cohort, high school grade point average, truancy, social evenings out, college plans, parental education, 30-day cigarette smoking, 2-week binge drinking and past-year marijuana use based on previous work [4,5,7,10,17–22]. Previous attrition analyses of the MTF study revealed that those retained in the MTF study differed at age 18 from those who dropped out of the study [22]. For instance, individuals retained were more likely to be female, white, report good grades, have higher parental education and have lower rates of truancy, evenings out, 2-week binge drinking, 30-day cigarette use, past-year marijuana use and past-year NUPD. To adjust for effects of attrition, full information maximum likelihood (FIML) was used on the outcomes, and missing data on the covariates were handled by including the covariates in the model via modeling variances [27]. Because MTF samples 12th graders via samples of school and uses a three-stage sampling design, it is necessary to adjust for the complex sample design when analyzing the cross-sectional 12th grade data. However, MTF has shown that it is not necessary to include adjustments for 12th grade design effects in panel analyses such as those conducted in this study [28]. Analyses were, however, weighted for follow-up sampling selection.

RESULTS

As shown in Fig. 1a and 1b, the estimated prevalence rates and means for the annual non-medical use of prescription opioids, sedatives, stimulants and tranquilizers indicate that the annual non-medical use of each prescription drug class were highest at wave 1 (modal age 18) over the five waves and there was a consistent decrease from wave 1 (modal age 18) to wave 2 (modal ages 19 and 20) across all four prescription drug classes. In general, annual NUPD had a descending path over time, but the rate of decline was not the same across all prescription drug classes. More specifically, the decline in mean levels and prevalence of annual non-medical use of prescription stimulants appeared larger from wave 1 (age 18) to wave 5 (ages 25 and 26) than the declines over this same time-period for the annual non-medical use of prescription opioids, sedatives and tranquilizers. As illustrated in Fig. 1a, the decline in the prevalence rate of annual non-medical use of prescription stimulants was 12.3% at wave 1 (modal age 18) to 4.8% at wave 5 (modal ages 25 and 26). Additional analysis of a small subset of the sample used in the present study indicated the modal age of onset among non-medical users was 9th grade for prescription sedatives, stimulants and tranquilizers and 10th grade for prescription opioids (data not shown).

Figure 2 illustrates the general latent growth curve model (LGCM) approach used for all four prescription drug classes. For each prescription drug class, model comparisons based on χ^2 difference tests indicated that the growth model specifying linear and quadratic slopes provided a better fit compared to the growth model specifying only a linear slope [models without covariates: opioids $\Delta\chi^2$ (d.f. = 4) = 134.52, $P < 0.001$; sedatives $\Delta\chi^2$ (d.f. = 4) = 74.43, $P < 0.001$; stimulants $\Delta\chi^2$ (d.f. = 4) = 526.96, $P < 0.001$; tranquilizers $\Delta\chi^2$ (d.f. = 4) = 115.15, $P < 0.001$: models with covariates: opioids $\Delta\chi^2$ (d.f. = 20) = 535.31, $P < 0.001$; sedatives $\Delta\chi^2$ (d.f. = 19) = 370.28, $P < 0.001$; stimulants $\Delta\chi^2$ (d.f. = 21) = 1569.98, $P < 0.001$; tranquilizers $\Delta\chi^2$ (d.

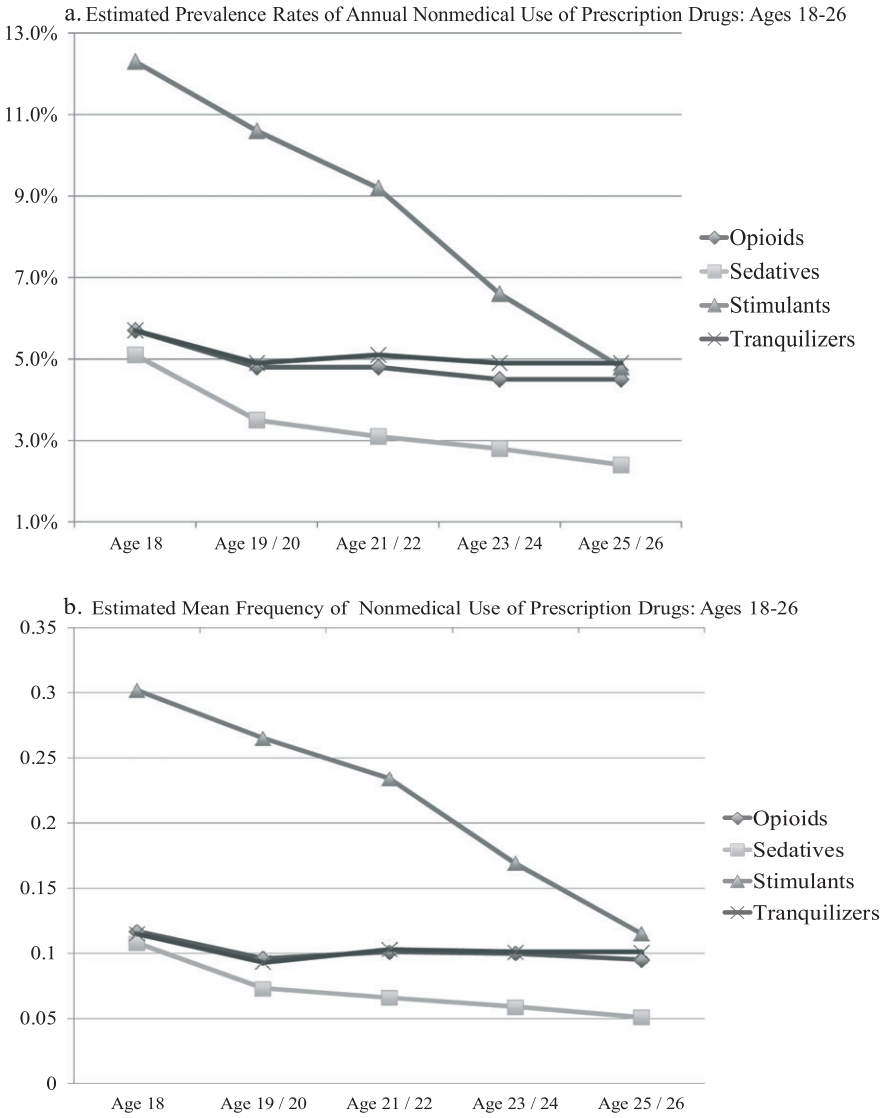

Figure 1 (a) Estimated prevalence and (b) estimated mean frequency of annual non-medical use of prescription drugs, ages 18-26. The response scale for mean frequency of nonmedical prescription drug use was rescaled so '0' represented 'no occasions'

f. = 19) = 436.14, $P < 0.001$]. For the growth models including linear and quadratic slopes, complete fit statistics are listed separately for models without and with covariates in Table 2.

As illustrated in Table 2 (where coefficients are provided for intercepts, linear slopes and quadratic slopes), the LGCMs that were estimated without covariates show two distinct growth trajectories that were similar to what was found in Fig. 1a and 1b. First, non-medical use of prescription stimulants was found to have a significant rate of change in terms of both linear and quadratic change that indicated a decrease in the mean frequency of use between the ages of 18 and 26 with an accelerated rate of decline over time. Secondly, non-medical use of prescription opioids, sedatives and tranquilizers was found to have a significant rate of change in terms of both linear and quadratic change that indicated an overall decrease in mean frequency of use and then a slower but continued rate of decline between ages 18 and 26. In addition, the LGCMs that were estimated with covariates found that the non-medical use of prescription stimulants had a significant rate of change in terms of both linear and quadratic change. The inclusion of covariates in the LGCMs for prescription opioids, sedatives and tranquilizers resulted in non-significant growth trajectories with respect to the combination of linear and quadratic change over time.

With respect to the covariates associated with the growth factors modeling the mean frequency of NUPD

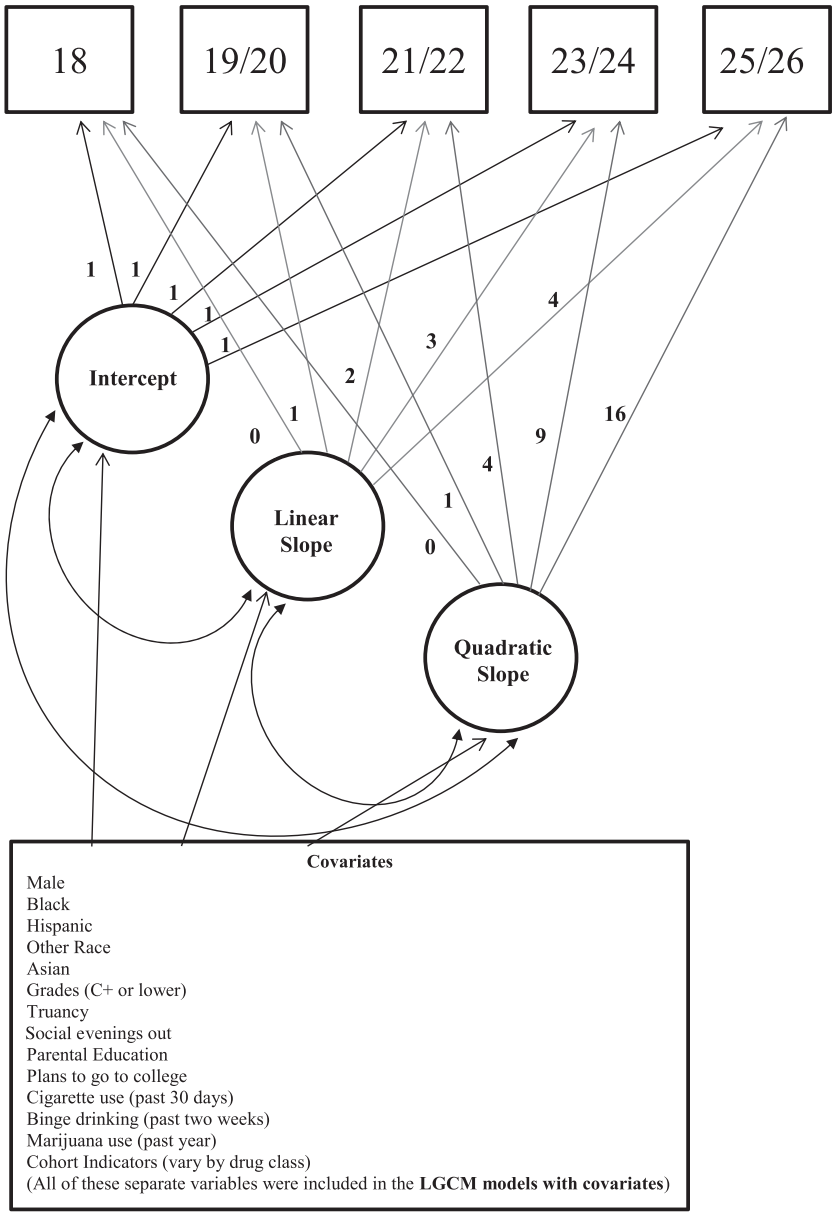

Figure 2 Latent growth curve model

across the five waves, the analyses found several differences across the four drug classes (Table 3). For instance, while males had a higher mean frequency of non-medical prescription opioid use at age 18 when compared to females, females had a higher mean frequency of non-medical use of sedatives, stimulants and tranquilizers at age 18 when compared to males. Moreover, males had faster rates of decline in the mean frequency of use across all of the drug classes when compared to females.

With respect to race, white respondents had a higher mean frequency of NUPD across the four prescription drug classes at age 18 and similar rates of decline across the five waves when compared to black and Hispanic respondents. Respondents who were classified as 'other race' had a higher mean frequency of non-medical use of sedatives and stimulants at age 18 and a slower rate of decline when compared to whites (white and 'other race' respondents had comparable growth trajectories with respect to opioids and tranquilizers). Moreover, Asian respondents had similar growth trajectories with respect to non-medical use of opioids and tranquilizers when compared to white respondents (except for mean frequency of use at age 18). However, while Asian respondents had similar mean frequencies of non-medical stimulant use at age 18 when compared to white respondents, Asian respondents had slower rates of decline in non-medical stimulant use when compared to whites.

It should also be noted that cigarette use, binge drinking and marijuana use at age 18 were all associated with

Table 2 Fit statistics estimating growth curve models for mean frequency of annual non-medical use of prescription drugs.

LGCM models with no covariates	*Prescription opioids*	*Prescription sedatives*	*Prescription stimulants*	*Prescription tranquilizers*
Means				
Intercept	2.87 (0.075)***	3.08 (0.083)***	1.74 (0.022)***	2.81 (0.066)***
Linear	−0.043 (0.008)***	−0.124 (0.011)***	−0.058 (0.007)***	−0.049 (0.008)***
Quadratic	0.034 (0.009)***	0.084 (0.013)***	−0.042 (0.007)***	0.047 (0.009)***
Variances				
Intercept	0.150 (0.008)***	0.129 (0.007)***	0.560 (0.015)***	0.157 (0.008)***
Linear	0.079 (0.007)***	0.052 (0.006)***	0.253 (0.013)***	0.071 (0.007)***
Quadratic	0.004 (0.001)***	0.002 (0.001)***	0.011 (0.001)***	0.003 (0.001)***
χ^2	66.251***	34.922***	133.637***	53.513***
d.f.	6	6	6	6
CFI	0.984	0.986	0.982	0.989
TLI	0.973	0.976	0.971	0.982
RMSEA	0.012	0.008	0.017	0.010
n	71 918	71 946	71 958	71 980
LGCM models with covariates	*Prescription opioids*	*Prescription sedatives*	*Prescription stimulants*	*Prescription tranquilizers*
Means				
Intercept	2.30 (0.063)***	2.65 (0.074)***	1.54 (0.024)***	2.42 (0.060)***
Linear	0.040 (0.122)	0.061 (0.027)*	0.063 (0.024)**	−0.025 (0.026)
Quadratic	−0.016 (0.029)	−0.057 (0.033)	−0.133 (0.027)***	0.021 (0.030)
Variances				
Intercept	0.128 (0.008)***	0.113 (0.007)***	0.415 (0.014)***	0.139 (0.007)***
Linear	0.077 (0.007)***	0.051 (0.006)***	0.243 (0.013)***	0.071 (0.006)***
Quadratic	0.004 (0.001)***	0.002 (0.001)***	0.011 (0.001)***	0.003 (0.001)***
χ^2	4557.834***	4763.620***	6732.432***	4823.374***
d.f.	77	62	92	62
CFI	0.807	0.650	0.830	0.807
TLI	0.775	0.520	0.824	0.735
RMSEA	0.028	0.032	0.032	0.033
n	71 918	71 946	71 958	71 980

The CFIs for the models with covariates were relatively low (< 0.90) compared to typical standards. Moreover, unstandardized variance estimates are presented to compare models with and without covariates. LGCM = latent growth curve models; d.f. = degrees of freedom; CFI = comparative fit index; TLI = Tucker–Lewis index; RMSEA = root mean squared error of approximation ***$P < 0.001$; **$P < 0.01$; *$P < 0.05$; standard errors are in parentheses.

a higher mean frequency of non-medical opioid, sedative, stimulant and tranquilizer use at age 18. However, only binge drinking at age 18 was found consistently across all four prescription drug classes to be associated with slower rates of decline across the transition to adulthood. In fact, cigarette use at age 18 was associated with slower rates of decline in the mean frequency of non-medical use of opioids, sedatives and tranquilizers, while marijuana use at 18 was associated with slower rates of decline in only sedatives and tranquilizers. Finally, the estimates for the different cohorts presented in Table 4 indicate that mean frequency of non-medical use of prescription opioids, sedatives and tranquilizers at age 18 was higher among later cohorts, while mean frequency of non-medical use of prescription stimulants at age 18 was lower among later cohorts. Although there were few differences across cohorts with respect to linear and quadratic change for non-medical use of prescription opioids, sedatives and tranquilizers, later cohorts have slower rates of decline with respect to non-medical use of prescription stimulants between the ages of 18 and 26.

DISCUSSION

The findings of this longitudinal study extend previous knowledge regarding the developmental course of the non-medical use of four classes of prescription drugs among adolescents as they move into adulthood in several important ways. The annual non-medical use of prescription opioids, sedatives, stimulants and tranquilizers all reached the highest levels in the senior year of high school just prior to the start of the transition into adulthood. Other research that includes cross-sections of MTF 8th, 10th, and 12th graders indicates that use is highest at 12th grade [5], highlighting that, together with our findings, 12th grade is the probable peak prevalence. This developmental trend of reaching peak levels of non-medical use for each prescription drug class is also similar to previous regional

Table 3 Growth curve model with covariates: estimates for mean frequency of annual non-medical use for each prescription drug class.

	Prescription opioids coeff.	*Prescription sedatives coeff.*	*Prescription stimulants coeff.*	*Prescription tranquilizers coeff.*
Intercept	2.30***	2.65***	1.54***	2.42***
Male	0.010*	−0.012**	−0.068***	−0.016***
Black	−0.037***	−0.040***	−0.072***	−0.041***
Hispanic	−0.036***	−0.019***	−0.028***	−0.023***
Other race	0.003	0.012**	0.010*	0.007
Asian	−0.007*	0.001	0.001	−0.005
Grades (C+ or lower)	0.014**	0.027***	0.028***	0.009
Truancy	0.050***	0.048***	0.055***	0.042***
Social evenings out	0.067***	0.060***	0.058***	0.061***
Parental education	0.012**	−0.010*	−0.002	0.000
Plans to go to college	−0.021***	−0.036***	−0.049***	−0.025***
Cigarette use (past 30 days)	0.106***	0.108***	0.114***	0.106***
Binge drinking (past 2 weeks)	0.091***	0.097***	0.140***	0.087***
Marijuana use (past year)	0.205***	0.178***	0.260***	0.176***
Linear	0.040	0.061*	0.063**	−0.025
Male	0.023**	0.024**	0.069***	0.029***
Black	0.002	0.014*	0.024***	0.008
Hispanic	0.010	0.002	0.008	−0.005
Other race	−0.008	−0.020*	−0.021**	−0.018*
Asian	−0.008	−0.001	−0.012*	−0.005
Grades (C+ or lower)	−0.017	−0.009	−0.021**	−0.013
Truancy	−0.010	−0.037***	−0.012	−0.014
Social evenings out	−0.027***	−0.042***	−0.012	−0.022**
Parental education	0.009	0.015	0.006	0.015*
Plans to go to college	0.034***	0.032***	0.044***	0.038***
Cigarette use (past 30 days)	−0.039***	−0.065***	−0.041***	−0.034***
Binge drinking (past 2 weeks	−0.054***	−0.055***	−0.071***	−0.042***
Marijuana use (past year)	−0.043***	−0.086***	−0.068***	−0.036***
Quadratic	−0.016	−0.057	−0.133***	0.021
Male	−0.021*	−0.021*	−0.054***	−0.026**
Black	−0.002	−0.005	−0.006	−0.007
Hispanic	−0.006	0.007	0.000	0.011
Other race	0.004	0.022*	0.024**	0.015
Asian	0.005	−0.004	0.014*	0.000
Grades (C+ or lower)	0.020*	0.005	0.021*	0.009
Truancy	0.006	0.032**	0.000	0.012
Social evenings out	0.018*	0.037***	−0.001	0.019*
Parental education	−0.014	−0.016	−0.012	−0.019*
Plans to go to college	−0.036***	−0.023*	−0.038***	−0.032***
Cigarette use (past 30 days)	0.034**	0.055***	0.017	0.033**
Binge drinking (past 2 weeks)	0.037***	0.032*	0.037***	0.026*
Marijuana use (past year)	0.021	0.052***	−0.006	0.026*

All models control for cohort periods for each specific drug class (estimates presented in Table 4). ***$P < 0.001$; **$P < 0.01$; *$P < 0.05$.

and national longitudinal studies examining the general patterns of binge drinking, marijuana use, non-medical use of prescription opioids and other illicit drug use during the transition from secondary school to young adulthood [13–17,20,22]. Furthermore, the modal age of onset among non-medical users of prescription sedatives, stimulants and tranquilizers (9th grade) and opioids (10th grade) in the present study was consistent with prior research [23–25]. Taken together, these findings reinforce the importance of implementing preventive intervention efforts in early adolescence before NUPD is initiated and reaches peak levels.

We found the mean levels of annual non-medical use of prescription opioids, sedatives and tranquilizers decreased relatively modestly during adolescence and young adulthood. These national findings extend results from an earlier regional study examining changes in the non-medical use of prescription opioids [17]. Catalano and colleagues [17] used longitudinal data from a regional sample of 912 adolescents and observed no significant linear trend

Table 4 Growth curve model with covariates—estimates for mean frequency of annual non-medical use for each prescription drug class across cohorts.

Prescription opioids	*coeff.*	*Prescription sedatives*	*coeff.*	*Prescription stimulants*	*coeff.*	*Prescription tranquilizers*	*coeff.*
Intercept	2.30***	**Intercept**	2.65***	**Intercept**	1.54***	**Intercept**	2.42***
1977–90	ref.	1977–85	ref.	1977–85	ref.	1977–87	ref.
1991–96	0.007	1986–94	–0.040***	1986–89	–0.092***	1988–2000	–0.039***
1997–2001	0.043***	1995–2006	0.044***	1990–15	–0.125***	2001–06	0.041***
2002–06	0.122***	–	–	1996–2004	–0.123***	–	–
				2005–06	–0.056***	–	–
Linear	0.040	**Linear**	0.061*	**Linear**	0.063**	**Linear**	–0.025
1977–90	ref.	1977–85	ref.	1977–85	ref.	1977–87	ref.
1991–96	0.013***	1986–94	0.032***	1986–89	–0.064***	1988–2000	0.042***
1997–2001	0.050***	1995–2006	0.021	1990–95	–0.039***	2001–2006	0.031**
2002–06	0.046***	–	–	1996–2004	–0.037***	–	–
				2005–06	–0.001	–	–
Quadratic	–0.016	**Quadratic**	–0.057	**Quadratic**	–0.133***	**Quadratic**	0.021
1977–90	ref.	1977–85	ref.	1977–85	ref.	1977–87	ref.
1991–96	0.010	1986–94	0.014	1986–89	0.103***	1988–2000	–0.013
1997–2001	–0.009	1995–2006	0.021	1990–95	0.092***	2001–06	–0.018
2002–06	–0.038**	–	–	1996–2004	0.095***	–	–
				2005–06	0.029**	–	–

***$P < 0.001$; **$P < 0.01$; *$P < 0.05$; ref. = reference group.

over time in frequency of non-medical use of prescription opioids from 10th grade to 20 years of age. Although the present study did not find increases in NUPD over time, this should not be taken to ease concerns about such drug use during the transition to adulthood. There are well-documented adverse consequences associated with NUPD [8–10,20,21,29]. For example, the number of US emergency department visits involving non-medical use of prescription opioids, sedatives, stimulants and tranquilizers more than doubled between 2004 and 2011 for each prescription drug class [9]. The findings of the present study, along with the results of these prior studies, indicate the potential development of serious adverse consequences related to NUPD during the transition from adolescence to adulthood despite declines or minimal changes in mean levels and prevalence rates of NUPD during this developmental period at the population-level.

The majority of previous studies regarding NUPD among adolescents have been cross-sectional, and many studies have been limited because they have combined multiple prescription drug classes. The results of the present study indicate that there are distinct patterns and covariates associated with the rate of changes across prescription drug classes, suggesting the need for prescription opioids, sedatives, stimulants and tranquilizers to be examined separately instead of combined in future practice and research. For instance, white respondents had lower mean frequency of non-medical use of stimulants and sedatives at age 18 and faster rates of decline during the study period when compared to respondents who indicated 'other race'; however, this pattern was not found with respect to non-medical use of opioids and tranquilizers.

This study has several notable strengths that build upon previous research examining NUPD. First, this longitudinal national study focuses upon the developmental period (young adulthood) associated with the highest prevalence of NUPD [4,5,7]. Secondly, multiple cohorts were followed longitudinally across five waves to examine the historical course of NUPD within the same individuals over time. Thirdly, this study includes four distinct prescription drug classes and nationally representative samples of US high school seniors.

There were also some limitations of large-scale longitudinal survey research using self-administered surveys that should be noted when considering the implications of the study results. There are particular challenges to monitoring NUPD over time due to the emergence of new medications and the need to update prescription drug categories. For instance, the MTF study experienced such updates for prescription opioids (e.g. Talwin®, laudanum and paregoric were replaced with Vicodin®, OxyContin® and Percocet®) and prescription tranquilizers (e.g. Miltown® was replaced with Xanax®) categories in 2002. Notably, similar changes were made to prescription drug questions in other national studies conducted in the United States (e.g. NSDUH) and, on balance, updating questions that include 'current' prescription drugs is more important than maintaining items with obsolete wording [7]. In addition, more research is

needed to decompose NUPD into its constituent parts because the measure to assess NUPD (i.e. on their own, without a doctor's orders) encompasses a wide range of behaviors, such as someone using higher doses than prescribed or using leftover medication from a previous prescription [30].

Next, we acknowledge that the CFIs for the models with covariates were relatively low (< 0.90) compared to typical standards. There were also some important high-risk subgroups of the adolescent population missing from the MTF data, such as those absent from class at the time of data collection and those who have dropped out of school are not included in the sample [4,5,31], suggesting that our findings may underestimate NUPD. Based on the high rates of coingestion among adolescents who report NUPD, future longitudinal research should consider the temporal associations of NUPD and polydrug use, including whether the course of NUPD influences illicit drug use [2,32–34]. Future longitudinal research is needed to examine developmental trajectories associated with non-medical use of each prescription drug class, such as previous work examining binge drinking, marijuana use and illicit drug use [14–16,35,36], including assessment at an earlier age and a longer time-frame to adequately capture age of onset and the full developmental course of NUPD.

In summary, the findings of the present study indicate the annual non-medical use of each of the four prescription drug classes peaked in late adolescence and supports initiating preventive intervention efforts in early adolescence. We also found distinct patterns between individual prescription drug classes and the covariates associated with changes in each prescription drug class, thus providing strong evidence for considering each prescription drug class separately in future practice and research.

Declaration of interests

None.

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