Published in final edited form as:

J Addict Dis. 2016 ; 35(4): 258–265. doi:10.1080/10550887.2016.1186413.

Longitudinal trajectories of non-medical use of prescription medication among middle and high school students

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Abstract

The non-medical use of prescription medications has been identified as a major public health problem among youth, although few longitudinal studies have examined non-medical use of prescription medications in the context of other drug use. Previous cross-sectional studies have shown gender and race differences in non-medical use of prescription medications. It was hypothesized that (1) non-medical use of prescription medications increases with age, and (2) these increases will be stronger in magnitude among female and Caucasian adolescents. Changes in non-medical use of prescription medications across 4 years were examined and compared with changes in other drug use (e.g., alcohol and marijuana). Middle and high school students enrolled in 5 schools in southeastern Michigan completed web-based surveys at 4 annual time points. The cumulative sample size was 5,217. The sample ranged from 12 to 18 years, 61% were Caucasian, 34% were African American, and 50% were female. Using a series of repeated measures latent class analyses, the trajectories of non-medical use of prescription medications were examined, demonstrating a 2-class solution: (1) the no/low non-medical use of prescription medications group had low probabilities of any non-medical use of prescription medications across all grades, and (2) the any non-medical use of prescription medications group showed a roughly linear increase in the probability of non-medical use of prescription medications over time. The probability of any non-medical use of prescription medications increased during the transition from middle school to high school. Results from this longitudinal study yielded several noteworthy findings: Participants who were classified in the any/high non-medical use of prescription medications group showed a discontinuous pattern of non-medical use of prescription medications over time, indicating that non-medical use of prescription medications is a relatively sporadic behavior that does not persist over time. However, among the “any/high non-medical use of prescription medications” group the pattern of change over time varied by race/ethnicity, with Caucasians showing a clear increase in the probability of non-medical use of prescription medications over time compared to non-Caucasians. This study fills gaps in knowledge by

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Drs. Cranford and Boyd had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

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examining non-medical use of prescription medications over time and provides important information about the course of non-medical use of prescription medications among adolescents.

Keywords

Adolescents; prescription drug abuse; substance abuse

Introduction

The non-medical use of prescription medications (NUPM) among adolescents has been identified as a major public health problem in the United States. The United States represents less than 5% of the world's population, yet U.S. consumers use about 80% of the global opioid supply.¹ It is opioid use that drives the NUPM epidemic in the United States and globally. Evidence shows that among adolescents NUPM is directly related to diversion of prescription medications,² psychological symptoms,³ and suicidal ideation,^{4,5} and inversely related to academic performance⁶ and health-related quality-of-life.⁷ NUPM is correlated to other forms of substance use and may be part of an externalizing spectrum.^{8,9} Relatively few studies have examined changes in adolescents' NUPM over time, and the lack of longitudinal studies of NUPM has been noted as an important gap in the literature.^{10,11} To our knowledge, no studies have examined the trajectories of NUPM longitudinally among middle and high school students.

The few extant longitudinal studies of NUPM have yielded mixed results. For example, Catalano et al.¹² assessed annual non-medical use of prescription opioids among adolescents from grade 10 to age 20 and found that NUPM prevalence peaked in grade 12. No linear trends in NUPM over time were observed and, while some continuity in NUPM from high school to young adulthood was evident, NUPM was less stable over time than marijuana and other drug use. McCabe et al.¹³ examined non-medical use of prescription opioids in a sample of 18- to 23-year-olds using four waves of data from the *Monitoring the Future* (MTF) study. Results showed that the majority of those who reported any NUPM used only at one wave.

The extent to which NUPM differs by gender^{14,15} and race/ethnicity^{11,16,17} also remains unclear. Several studies have found higher rates of NUPM among females,^{11,14} although others found higher prevalence rates among males,^{18–20} and two studies reported no gender differences in NUPM.²¹ With respect to race/ethnicity, previous research showed that NUPM is higher among Caucasians compared to some other race/ethnic groups.^{18,22} However, some studies found higher rates of some forms of NUPM among African Americans,¹⁶ while other studies found no race/ethnicity differences in NUPM.²¹

The present study was designed to fill these gaps in knowledge by examining changes in NUPM over time in a large sample of middle and high school students. Changes in NUPM across 4 years were examined and compared with changes in alcohol, tobacco, marijuana, and illicit drug use. The extent to which changes in NUPM varied by gender and race/ethnicity was also assessed. Based on the previously mentioned literature, it was

hypothesized that (1) NUPM will increase with age, and (2) these increases will be stronger in magnitude among female and Caucasian adolescents.

Methods

An accelerated longitudinal design²³ was used to examine changes in any past 12-months NUPM over time among adolescents. This study is part of a larger mixed-method, longitudinal study aimed at testing a predictive model of NUPM by adolescents. Participants were middle and high school students enrolled in five schools within two school districts in Southeastern Michigan. These schools were selected because the authors wanted to create a diverse sample. They provide rural, upper-middle class, high poverty, and African American sub-samples. Two schools have 8% of the student body eligible for free or reduced price lunches; 90% of students are classified as Caucasian. Approximately 20% of the student body is considered rural. Three of the schools are approximately 50% African American or from other under-represented ethnic groups and are located nearer the Detroit border; however, two of these schools also service a predominantly Caucasian, upper-middle class community that comprise 15% of the student body in these schools.

In the United States, 7th graders are generally 12 or 13 years of age, and 12th graders are 17- to 18-years-old. At each wave, all students in grades 7–12 were eligible to complete the web-based, self-administered Secondary Student Life Survey (SSLS), that included questions about past 12-months NUPM. The SSLS was administered in the respondents' school settings during a class or lunch period, took approximately 40 minutes to complete, and was supervised by the research team and conducted in a manner that provided privacy. Data from the survey were transmitted to a private research firm using a hosted internet site running under secure socket layers (SSL) protocol to ensure safe transmission of data. To maintain confidentiality, students were provided with a unique identification number to enter the survey. Approval from the Institutional Review Board of the University of Michigan, a National Institutes of Health (NIH) Certificate of Confidentiality, active parental consent, and student assent were obtained prior to data collection. Other studies based on data from the SSLS have been published,^{3,24,25} but this is the first report utilizing all four waves of data. The overall response rate was 71% with all students in the schools eligible to take the survey. In this report, the final cumulative sample size was 5,217, and the prospective panel cohort was 1,442, with 75.2% ($N = 1,085$) of the panel cohort completing all four waves of data collection. It was found that the response rate was higher among those who reported any NUPM over the past year (82.9%) compared to those who reported no NUPM over the past year (74.1%), $\chi^2(1) = 7.2, p < 0.05$. The authors believe this is, in part, a reflection of the race/ethnicity differences in NUPM and lower response rates for African Americans. The sample ranged from 12- to 18-years-old; about 50% of the participants were female; 61% were Caucasian, and 34% were African American.

Measures

Demographics

Data on participants' gender, race/ethnicity, grade, and age were preloaded into the web survey based on data from each school's registrar office.

Any NUPM in the past 12 months

At each wave, participants were asked, “On how many occasions in the past 12 months have you used the following types of medicines not prescribed to you?” The questions focused on four controlled drug classes and provided respondents with examples that included trade names as well as generic terms. Participants were asked about non-medical use of (1) sleeping medication (e.g., Ambien®, Lunesta®, Restoril®, temazepam, triazolam); (2) anti-anxiety medication (e.g., Ativan®, Xanax®, Valium®, Klonopin®, diazepam, lorazepam); (3) stimulant medication (e.g., Ritalin®, Dexedrine®, Adderall®, Concerta®, methylphenidate); and (4) pain medication (e.g., opioids such as Vicodin®, OxyContin®, Tylenol 3® with codeine, Percocet®, Darvocet®, morphine, hydrocodone, oxycodone). Response options were: 0 occasions; 1–2 occasions; 3–5 occasions; 6–9 occasions; 10–19 occasions; 20–39 occasions; and 40 or more occasions. Because several items had low frequencies, all variables were collapsed into binary “yes/no” indicators and a single binary variable was created indicating if the participant reported non-medical use of at least one of the four medications on at least one occasion in the past 12 months.

Alcohol, tobacco, marijuana, and illicit drug use were measured with items from the *MTF* study.²⁶ Use of these substances was determined by the following three questions: (1) “On how many occasions in the past 12 months have you used marijuana?” (2) “How frequently have you used cigarettes in the past 12 months?” and (3) “On how many occasions (if any) in the past have you had alcohol to drink (more than just a few sips) during the past 12 months?” Response options ranged from “no occasions” to “40+ occasions” (and “rather not say”). For each substance all variables were collapsed into binary “yes/no” indicators and a single binary variable was created indicating if the participant reported use of that particular substance on at least one occasion in the past 12 months.

Drug-use related problems were assessed with the Drug Abuse Screening Test (DAST-10),²⁷ a brief screening instrument used to assess possible abuse of drugs other than alcohol in the past 12 months. Respondents were instructed that the DAST questions are about drugs other than alcohol and to answer “yes” or “no” to each item. The authors summed the 10 DAST items to create a total score reflecting the number of substance use-related problems experiences in the past 12 months. Previous work showed that the DAST had good reliability (Cronbach’s alpha = 0.86) and temporal stability (test–retest intra-class correlation coefficient = 0.71) and identified individuals who needed more intensive assessment for substance abuse problems.²⁷ In the current sample, Cronbach’s alpha for the DAST-10 at wave 1 was 0.68.

Analytic approach

In a previous work,²⁵ latent class analysis (LCA) was used to identify sub-groups based on NUPM using cross-sectional data. Variable- and person-centered analytic approaches to developmental change over time have been distinguished²⁸ and group-based trajectory modeling (GBTM)^{29,30} is a person-centered analytic approach that focuses on developmental trajectories, defined as “the course of a behavior or outcome over age or time.”³¹

Previous research suggests that change in NUPM over time might be episodic (e.g., they use 1 year, and then stop), and thus discontinuous, therefore, two analytic approaches were used: GBTM and repeated-measures latent class analysis (RMLCA). Like variable-centered approaches (e.g., multi-level modeling and latent growth curve analysis), GBTM is based on the assumption that the phenomenon of interest develops as a polynomial function of age or time.^{31,32} However, in many scenarios “it is possible that development cannot be characterized as a simple function of time.”³³ Lanza and Collins^{34,35} described RMLCA and noted that, unlike multi-level modeling and generalized growth mixture modeling, RMLCA “enables identification of common patterns of discontinuous development in a categorical manifest or latent variable.” In other words, RMLCA takes into account that the NUPM does not have a usual distribution, and that NUPM may be episodic. They applied RMLCA to the study of heavy drinking in the National Longitudinal Survey of Youth. A binary variable for “any heavy drinking in the last month” was measured across six waves of data (ages 18, 19, 20, 24, 25, and 30), and results from RMLCA showed that eight latent classes were sufficient to describe patterns of change over time (e.g., a “lifetime heavy drinking” class had high probabilities of heavy drinking at all time points; a “college age only” class had high probabilities of heavy drinking at ages 19 and 20, but low probabilities at all other ages). Because previous research suggested that change in NUPM over time might be discontinuous, both GBTM and RMLCA were used as analytic approaches.

The authors conducted exploratory GBTM to examine longitudinal changes in the past 12-months NUPM using the SAS PROC TRAJ. Maximum likelihood estimation yields parameter estimates that define (1) trajectory shape and (2) trajectory group membership probabilities. The two-stage model selection process described by Nagin²⁹ was used to define the optimal number of trajectory groups and the order of the polynomial needed to model the shape of each trajectory. Based on the shape of the average observed trajectory, a pre-set rule that all trajectories are linear was used to structure the first-stage search, and a binary model³³ was specified for the occurrence of any NUPM in the past 12 months from grades 7 to 12 (ages 13 to 18). Based on suggestions in Nagin²⁹ and Muthen and Muthen,²⁸ the optimal number of latent trajectory classes was determined by: (1) using the Bayes factor approximation to compare the difference in the Bayesian information criterion (BIC) scores between competing models; (2) calculating the average posterior probabilities for each class; and (3) the utility of the latent classes in practice, including the similarity of trajectories between classes and the number of cases within each trajectory class. Finally, multiple logistic regression analysis was used to examine predictors of class membership.

Results

The authors conducted attrition analysis comparing stayers ($n = 1,084$) and leavers ($n = 356$). Results showed that there was no difference in completion rate by gender (females = 74.4%, males = 76.1%, $\chi^2(1) = 0.5$, ns). However, there was a statistically significant association between race/ethnicity and completion rate, $\chi^2(1) = 77.6$, $p < 0.05$, with Caucasians showing a higher completion (82.2%) rate than non-Caucasians (60.8%). In addition, district B showed a higher completion rate than district A (81.7% versus 64.8%), $\chi^2(1) = 51.5$, $p < 0.05$. Completion rates were also statistically significantly higher among students who were in 7th and 8th grades at W1 (78.0 and 78.8%, respectively) compared to

those who were in 9th grade at wave 1 (69.0%), $\chi^2(2) = 15.3, p < 0.05$. As seen in Table 1, the overall prevalence of any past 12-months NUPM across all four waves was 11.8%. NUPM was significantly higher among females than males. American Indian/Alaskan Natives had the highest prevalence of NUPM, and Asian Americans had the lowest prevalence. There was no significant difference in prevalence of NUPM between school districts A and B. Combining across all cohorts, prevalence of NUPM showed a generally linear increase with age. Figure 1 presents the prevalence rates of any past 12-months alcohol, tobacco, marijuana, NUPM, and illicit drug use by age. Among 7th and 8th graders, the prevalence of NUPM was exceeded only by alcohol use.

Results from a series of GBMs indicated that a 2-class solution had the smallest BIC score, the most favorable Bayes factor approximation score, and yielded interpretable classes. However, one of the diagnostic measures suggested by Nagin (the odds of correct classification) suggested that classification quality was suboptimal.²⁹ Descriptive results indicated that patterns of change in NUPM over time appeared to be discontinuous. Among those who reported at least one incident of NUPM for at least one wave ($n = 614$), the vast majority ($n = 508, 82.7\%$) reported NUPM at one wave only, and 17.3% ($n = 106$) reported NUPM at two or more waves. Accordingly, RMLCA was conducted using the SAS PROC LCA procedure to examine longitudinal changes in past 12-months NUPM from grades 7 to 12.

As seen in Table 2, results from a series of RMLCAs also indicated that a 2-class solution best fit the data. Item-response probabilities presented in Table 3 indicate that: (1) the no/low NUPM group had very low probabilities of any NUPM across all grades, and (2) the any/high NUPM group showed a roughly linear increase in the probability of any NUPM over time. Multiple groups RMLCA showed that the 2-class solution was invariant across gender and race/ethnicity. However, differences in item response probabilities were observed. Caucasian females were more likely to be in the any/high NUPM class (20.4%), followed by non-Caucasian females (16.9%), Caucasian males (9.4%), and non-Caucasian males (9.3%). As seen in Figures 2 and 3, for Caucasian females and males, the probability of any NUPM increased with age, with a sharp rise during the transition from middle to high school.

Results from multiple logistic regression analysis of membership in the any NUPM group are presented in Table 4. Membership in the any NUPM group was significantly associated with being female, number of drug abuse problems, and past 12-month alcohol and illicit drug use.

Discussion

The present study represents the first 4-year prospective longitudinal study to examine trajectories of NUPM during the transition from middle school into high school. Results from this longitudinal study yielded several noteworthy findings about patterns of NUPM over time among adolescents. First, the overall prevalence of any past 12-months NUPM across all 4 years was approximately 12%. Compared to other substances, NUPM had an overall lower prevalence compared to alcohol (35.2%), marijuana (19.4%), and tobacco (16.7%). However, the order of prevalence rates varied by age/grade. Indeed, among 7th and

8th graders, NUPM was the second-most prevalent substance, behind only alcohol. The probability of any NUPM, however, increased at a slower rate compared to other substances and indicated considerable variability across substances.

Second, although some studies have found no relationship between age and NUPM, there were increases observed in the probability of NUPM with age. It was found that participants who were classified in the any/high NUPM group showed a discontinuous pattern of NUPM over time. For example, the largest subset of NUPM users reported using in 12th grade only; the next largest subset reported NUPM in 11th grade only; etc. Indeed, only about 17% of those who reported any NUPM did so at more than one time point. Results suggest that, in this sample of middle and high school students, NUPM is a relatively sporadic, perhaps opportunistic, behavior that does not persist over time. Results are similar to other longitudinal studies showing that NUPM over time may be discontinuous.

It is important to note that the finding of sporadic, discontinuous change in NUPM over time does not lessen the risk or severity of this behavior. For example, evidence shows that those who engage in any NUPM may experience severe negative consequences even after cessation of the behavior.⁴ Other longitudinal evidence showed that NUPM is associated with other substance use and subsequent incidence of mood and anxiety disorders. In turn, some mood and anxiety disorders predicted subsequent incidence of NUPM.^{18,36} In addition, the current results showed that membership in the any NUPM group was associated with alcohol and illicit drug use, as well as the number of drug abuse problems. In short, discontinuity in developmental patterns of NUPM is not necessarily informative about the potential negative consequences of this behavior.

Third, the multiple groups RMLCA showed that the 2-class solution did not vary by gender or race/ethnicity (i.e., across all demographic sub-groups, there was a class characterized by very low probability of any NUPM, and a second class that had non-zero probability of engaging in any NUPM over time). However, among the “any/high NUPM” group the pattern of change over time varied considerably by gender and race/ethnicity, with Caucasians showing a clear increase in the probability of NUPM over time compared to non-Caucasians, particularly during the transition from middle to high school. The current findings also pointed to one possible explanation for the inconsistent findings with respect to gender and race/ethnicity differences in NUPM. The risk of engaging in NUPM appears to ebb and flow in complex ways over time as a function of gender and race/ethnicity. Accordingly, prevalence rates based on cross-sectional data are likely to differ based on the age at assessment.

To the extent that NUPM is a target for prevention, the current results highlight the importance of middle school as a potentially critical time, particularly for non-Caucasian students. Evidence shows that universal prevention programs initiated in middle school can have long-term effects of reductions in NUPM. The present results suggest that the discontinuous pattern of NUPM over time and its associations with alcohol and illicit drug use make this behavior particularly amenable to universal prevention efforts and suggests school districts are encouraged to collect data to learn more about drug use behaviors because national results may not hold true in their respective schools.

Limitations to this study include the collection of data from only two school districts in the United States and thus, generalizability is constrained and findings may be less relevant to countries with lower prevalence of NUPM. For instance, the United Nations Office of Drug and Crime (see www.unodc.org) reports that adolescents' abuse of stimulant medication in countries other than North and South America is very low, while opioid analgesic abuse has stabilized at relatively high levels in the United States as well as Western and Central Europe. Further, the authors relied on self-reports of NUPM and other substance use, and the collection of data in school during school hours. Also, the authors used binary indicator of NUPM, and some evidence indicates that frequency and type of NUPM is also important.²⁰ In addition, while the previous work showed that most adolescents have unsupervised access to controlled medications, the effects of parental influence on patterns of NUPM were not evaluated. Despite these limitations, the current study provides important information about the course of NUPM among middle and high school students. Further replication and extension of these patterns for each medication class will inform targeted prevention that can reduce diversion and abuse by adolescents.

Acknowledgments

Funding

This research was supported by the National Institute on Drug Abuse, National Institutes of Health (research grant nos. R01DA024678, R01DA031160, and R01DA036541).

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Figure 1.
Any past 12-months substance use by grade in the SSLS (cumulative $N=5,217$).

Figure 2. Probability of past 12-Months NUPM by grade, gender, and race/ethnicity: Caucasians in the any NUPM group.

Figure 3. Probability of any past 12-Months NUPM by grade, gender, and race/ethnicity: Non-Caucasians in the any NUPM group.

Table 1

Prevalence and correlates of any past 12-Months NUPM in the Secondary Student Life Survey (cumulative $N = 5,217$).

	%	χ^2
Any past 12-months NUPM across waves	11.8	
Grade^I		
7th grade ($n = 1,590$)	4.4	29.5 *
8th grade ($n = 1,730$)	5.1	
9th grade ($n = 2,091$)	6.0	
10th grade ($n = 2,102$)	7.1	
11th grade ($n = 1,969$)	7.7	
12th grade ($n = 1,858$)	7.9	
Gender		
Female ($n = 2,588$)	15.3	63.3 *
Male ($n = 2,629$)	8.2	
Race/Ethnicity		
African American ($n = 1,756$)	10.9	8.2
American Indian/Alaskan Native ($n = 21$)	23.8	
Asian American ($n = 174$)	8.0	
Hispanic ($n = 96$)	14.6	
Caucasian ($n = 3,170$)	12.3	
District		
District A ($n = 2,346$)	12.7	3.3
District B ($n = 2,871$)	11.0	

^I Ns do not add up to 5,217 because participants in longitudinal cohorts could contribute more than one observation (total number of observations = 11,340).

* $p < 0.05$.

Table 2

Fit indices for repeated-measures latent class models of NUPM over time.

Number of classes	Likelihood ratio G^2	Degrees of freedom	AIC	cAIC	BIC	aBIC	Entropy
Baseline	235.52	57	247.52	292.71	286.71	267.64	1.00
2	28.04	50	54.04	151.95	138.95	97.64	0.56
3	14.86	43	54.86	205.49	185.49	121.94	0.64
4	9.36	36	63.36	266.72	239.72	153.92	*
5	*	*	*	*	*	*	*

Note: AIC: Akaike's Information Criterion (AIC; Akaike, 1974); cAIC: "consistent AIC" (Bozdogan, 1987; see Lin & Dayton 1997); BIC: Bayesian Information Criterion (Schwarz, 1978); aBIC: adjusted BIC using Rissanen's sample size adjustment (see Sclove, 1987).

DF: The degrees of freedom of the fitted model. In models with no covariates, this is the number of cells in the contingency table, minus the number of parameters that are freely estimated, minus 1.

* The 4-class model did not converge.

* The 5-class model did not converge.

Table 3

Item response probabilities for “yes” response to any past 12-months NUPM conditional on latent class.

	Latent class 1 No NUPM	Latent class 2 Any NUPM
Class proportion	0.84	0.16
Grade		
7th grade	0.02	0.21
8th grade	0.01	0.24
9th grade	0.02	0.32
10th grade	0.01	0.38
11th grade	0.02	0.40
12th grade	0.02	0.38

Table 4

Predictors of latent class membership for past 12-months any nonmedical use of prescription medications (NUPM) class.

	Any NUPM Class (16%)	
	OR (95% CI)	AOR (95% CI)
Gender		
Female	2.0 [*] (1.6–2.3)	2.2 [*] (1.8–2.7)
Male	—	—
Race/Ethnicity		
Caucasian	0.9 (0.7–1.1)	0.9 (0.7–1.2)
Non-Caucasian	—	—
School District		
District A	0.9 (0.7–1.02)	0.7 (0.6–0.9) [*]
District B	—	—
DAST-10 Score	2.0 [*] (1.8–2.2)	1.6 [*] (1.4–1.8)
Any past 12-months alcohol use	3.7 [*] (3.0–4.4)	1.8 [*] (1.4–2.3)
Any past 12-months tobacco use	3.8 [*] (3.2–4.6)	1.3 (0.9–1.7)
Any past 12-months marijuana use	4.0 [*] (3.4–4.9)	1.0 (0.7–1.3)
Any past 12-months illicit drug use	8.9 [*] (6.8–11.6)	2.8 [*] (2.0–4.0)

Note: OR: odds ratio from bivariate logistic regression analysis; AOR: adjusted odds ratio from multiple logistic regression analyses.

The AOR is the multiplicative effect of a predictor variable on the odds of being in the “any NUPM” class when all other variables in Table 4 were statistically controlled.

CI: confidence interval; DAST: Drug Abuse Screening Test.

— = reference group.

^{*} $p < 0.05$.