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Statewide Opioid Prescriptions and the Prevalence of Adolescent Opioid Misuse in Ohio

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Abstract

Background—Little is known about the relationship between opioid prescribing practices and the prevalence of adolescent opioid misuse.

Objective—To examine relationships between both adolescent and adult opioid prescriptions filled and adolescents seeking treatment for opioid misuse in Ohio.

Methods—Analyses of large statewide databases from 2008–2012 including all 88 counties in Ohio. The Ohio Board of Pharmacy provided data regarding prescription opioids filled by adolescents (12–20 years, N=50,030,820 doses) and adults (>20 years, N=3,811,288,395 doses) by county of residence. The Ohio Department of Mental Health and Drug Addiction Services

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provided annual treatment admissions for adolescent opioid misuse by county of residence (N=6446).

Results—Adults filled prescriptions for nearly 100 oral opioid doses per capita annually while adolescents filled prescriptions for approximately 7 oral opioid doses per capita annually. In Bayesian Poisson modeling examining the effect of annual adult per capita dose on adolescent treatment admissions, adjusted for annual adolescent per capita dose and year, an increase of one in the annual adult per capita opioid dose resulted in an increase of 1.3% (RR = 1.013, 95% HPD CI = [1.008, 1.017]) in the rate of adolescent treatment admissions. This association corresponds to 99.99% chance that the adolescent treatment rate increases when the annual per capita adult dose is increased by one unit.

Conclusion—The amount of opioids filled by adults in Ohio, although relatively stable from 2008–2012, is approximately 13 times that filled by adolescents, and is significantly associated with adolescents seeking treatment for opioid misuse. Efforts to decrease adolescent opioid misuse should also focus on reducing adult opioid prescriptions.

Introduction

Adolescent opioid use is a major public health concern (1, 2). Prescribing rates for controlled medications at ambulatory visits for adolescents and young adults in the United States have increased dramatically over the past decade (3). The nonmedical use of prescription opioids by adolescents has now surpassed use of all other illicit drugs except marijuana with over 10% of high school seniors reporting any misuse of prescription opioids (1, 4). The peak risk for nonmedical use of prescription opioids among adolescents (age 12–21 years) occurs at age 16 (2). Of all adolescents who misuse substances, only a small portion will seek treatment (2).

Nationally, the United States consumes 80% of the world's opioid supply, yet represents only 4.6% of its population (5). The prevalence of medical and nonmedical use of controlled medications differs according to geographic region; therefore, it is important to evaluate the nonmedical use of prescription opioids at local, state, and national levels (4). In a 2014 Vital Signs Press Release, the Centers for Disease Control and Prevention (CDC) reported that opioid prescribing varies widely among states and that regional variation (e.g. Northeast, South, Midwest, and West Census Regions) in prescription use cannot be explained by the underlying health status of the population. The CDC therefore recommends that opioid prescribing data and programs be evaluated by each state individually (6).

In the United States, unintentional drug overdose is the leading cause of injury death, surpassing death from homicide, motor vehicle accidents, falls, drowning, etc. (7). Within the state of Ohio, drug poisoning rates (for all ages) exceeded the national average in 2004, and have continued to increase since that time (8). In Ohio, deaths from unintentional drug overdose far exceed deaths from motor vehicle accidents, with prescription opioids being involved in the majority of these deaths (9). For adolescents specifically, more than 1 in 5 (21%) Ohio high school students reported the misuse of a prescription drug in 2011, with approximately half of these medications being opioids (10).

Little is known about the relationship between opioid prescribing practices and the prevalence of adolescent opioid misuse. The primary objective of the current study was to examine relationships between both adolescent and adult opioid prescriptions filled and adolescents seeking treatment for opioid misuse in the state of Ohio from 2008–2012. Secondary objectives were to present the geographic distribution of filled opioid prescriptions in Ohio by county and to explore the change over time. We hypothesized that both adolescent and adult opioid prescriptions would be associated with adolescent treatment admissions at the county level.

Methods

De-identified datasets for this study were provided by the Ohio Board of Pharmacy and the Ohio Department of Mental Health and Drug Addiction Services. The study was deemed exempt by the Institutional Review Board due to the de-identified, aggregate nature of the data involved.

The Ohio Board of Pharmacy provided data on the total number of doses of oral opioids filled annually by adolescents (12–20 years of age, N=50,030,820 doses) and adults (>20 years, N=3,811,288,395 doses) from 2008–2012 by county of residence. The adolescent age range for this analysis was determined based on existing definitions of adolescence from the World Health Organization (11) and the American Academy of Pediatrics (12) and on the manner in which substance abuse treatment episode data is collected and represented in the state of Ohio (13).

County of residence was defined as the county in which the patient resided rather than the county where the prescription was written or filled. Oral opioids were defined as all medications containing an opioid provided in oral form including codeine, hydrocodone, hydromorphone, methadone, morphine, oxycodone, oxymorphone, meperidine, tramadol, and propoxyphene. All 88 counties in the state of Ohio were included in the dataset.

The Ohio Department of Mental Health and Drug Addiction Services provided annual adolescent admission data for treatment of opioid misuse, as defined by inclusive International Classification of Diseases 9th edition (ICD-9) and Diagnostic and Statistical Manual of Mental Health Disorders, fourth edition, text revision (DSM-IV-TR) diagnostic codes, by county of residence for 2008–2012 (N=6446 admissions). Admission data obtained from the Ohio Department of Mental Health and Drug Addiction Services included any adolescent receiving residential, intensive outpatient, or outpatient treatment for opioid misuse. De-identified admission data did not specify between admissions related to heroin versus prescription opioids or initial versus repeat admissions. Admissions data also did not include adolescents who presented to hospitals for opioid overdose, or those who presented to any medical establishment with medical problems related to their opioid misuse. County of residence was defined as the county in which the patient resided, not the county where treatment was provided. ICD-9 and DSM-IV-TR codes used to determine opioid misuse are presented in Table 1. Annual population by age per county from 2008–2012 was obtained from the United States Census Bureau. U.S. Census data were utilized to calculate annual oral opioid dose per capita estimates for adolescents and adults from 2008–2012 by county

of residence and overall. In addition, U.S. Census data were utilized to calculate annual adolescent opioid misuse treatment admissions per 1000 from 2008–2012 by county of residence and overall.

State maps for doses filled per capita by county of residence from 2008–2012 were generated for adolescents and adults (Figure 1). Similar maps were generated to represent adolescent opioid misuse treatment admissions per 1000 adolescents by county of residence (Figure 2). All maps were created using the ggplot2 package in R (14, 15).

To assess the association of adolescent treatment rates with adult and adolescent dose rates at the county level, we fit Bayesian Poisson generalized linear mixed models. Bayesian Poisson modeling is a standard approach for handling counts and rates while adjusting for exposure through an offset term. This modeling approach is widely used in spatial epidemiology (16). The model included fixed effects for year, the county adult per capita dose rate, and the county adolescent per capita dose rate. Year was included as a categorical variable and the dose rates were calculated for each county for each year. Two-way interactions were explored but not included in the final model based on model assessment using the deviance information criterion (DIC). The model also includes an offset of the natural log of the adolescent population for each county. We included two random effects in the model to account for spatial and temporal dependence. A spatial random effect was included that follows a conditionally autoregressive model (CAR) (17) where neighborhoods are defined by the adjacency matrix (18). A temporal random effect is included that follows an autoregressive of order 1 (AR1) model within each county. Weakly informative prior distributions were specified for all parameters in the model. The full model is specified in the supplemental materials. The INLA (19) R package was used to estimate the posterior distributions using integrated nested Laplace approximations.

We fit similar models to separately assess the change in adult and adolescent dose rates over time. The county level model for adult doses included a categorical term for year, an offset of the natural log of the adult population, and random effects as in the model described above. The county level model for adolescent doses was fit similarly with an offset of the adolescent population. Prior distributions and estimation approach were the same as above.

As the purpose of this study was to estimate the relationship of oral opioid doses filled to adolescent treatment rate, we summarize our models with posterior mean rate ratios and 95% highest posterior density (HPD) credible intervals. An HPD interval is the shortest interval given the data that contains 95% of the posterior probability for a parameter and can be interpreted such that the parameter is contained in the interval with 95% probability.

Results

In the state of Ohio, adolescents filled between 9 to 10 million opioid doses annually while adults filled approximately 740 to 780 million opioid doses annually from 2008–2012. Throughout the study period, adults filled prescriptions for nearly 100 oral opioid doses per capita annually (Table 2). Adolescents filled prescriptions for approximately 7 oral opioid doses per capita annually during this time. The annual mean statewide oral opioid dose per

capita for adults was approximately 13 times that of adolescents. The adolescent treatment admission rate ranged from 0.7 – 1.09 per 1000 from 2008 – 2012.

Annual per capita oral opioid doses by county from 2008–2012 are shown for adolescents and adults in Figure 1. The highest rates of oral opioid doses filled were observed in the southern portion of Ohio. Similarly, adolescent treatment admissions for opioid misuse appeared to be concentrated in the southern portion of the state (Figure 2).

We explored the change in the annual per capita adolescent and adult doses from 2008–2012 and present the posterior summaries in Table 3. In general, annual adolescent per capita doses decreased approximately 5% annually from 2009 to 2012. Doses in 2008 and 2009 were comparable. For the annual adult per capita dose, the rates were slightly increasing from 2009 to 2012 at roughly 1–2% annually. There was a slight decrease in 2009 compared to 2008 on the order of approximately 3%.

Posterior summaries were also calculated for the rate ratios comparing each pair of years in 2008–2012 on adolescent treatment admissions adjusted for annual per capita adult and adolescent doses (Table 4). In general, the average adolescent treatment rate increased approximately 20% annually from 2008 to 2011. However, in 2012, the average treatment rate regressed to approximately 2009 levels, which was a 25% decrease from the average treatment rate in 2011.

Associations of adolescent treatment rates with adult and adolescent dose rates at the county level were examined. For an increase of one in the annual adult per capita opioid dose, there was an increase of 1.3% (RR = 1.013, 95% HPD CI = [1.008, 1.017]) in the rate of adolescent treatment (Table 4). This association corresponds to 99.99% chance that the treatment rate increases when the annual per capita adult dose is increased by one unit. These results were adjusted for the annual adolescent per capita dose and year.

With an increase of one in the annual adolescent per capita dose, there was an increase of 3.4% (RR = 1.034, 95% HPD CI = [0.981, 1.089]) in the rate of adolescent treatment (Table 4). This association corresponds to 89.4% chance that the treatment rate increases when the annual per capita adolescent dose is increased by one unit. These results were adjusted for the annual adult per capita dose and year.

Discussion

This study explored the relationship between opioids filled by adolescents and adults and adolescent treatment admissions for opioid misuse on both the state and county level. This work represents an important step in fulfilling the CDC recommendation that states examine local opioid prescribing trends. Trends in overall oral opioid doses filled per capita in Ohio varied by age from 2008–2012. While there has been a significant decrease in adolescent opioid prescriptions filled, there has been no appreciable change in the number of prescriptions filled by adults. Over this 5-year time period, the annual mean opioid dose per capita for adults was approximately 13 times that of adolescents.

The sheer number of opioids filled by adults and its potential impact on adolescent opioid misuse warrants further consideration. We hypothesize that adult doses provide adolescents access to opioids through family members, friends, and household cabinets without a written prescription. Prior research has shown that opioids filled by adults contribute to the pool of opioid availability for adolescents (20, 21). Indeed, 8 out of 10 adolescents who misuse prescription drugs report that their access to these drugs comes from friends or relatives (22). This may potentially be reflected in the fact that the rate of admission for opioid misuse treatment in adolescents continued to increase until 2011 during the study period despite a decrease in the number of opioid prescriptions filled by adolescents. It is unclear why the adolescent treatment admission rate decreased approximately 25% from 2011 – 2012. Interestingly, the state of Ohio saw a decrease in the overall prescription opioid drug overdose rate from 2011 – 2012 (23). Key contributing factors to this decrease in prescription opioid overdose rates were conjectured to be closure of pill mills in southern Ohio and implementation of tamper resistant packaging.

Many legislative efforts to contain the opioid misuse epidemic in Ohio are currently in place. In 2011, Governor Kasich formed the Governor's Cabinet Opiate Action Team to combat prescription drug abuse, misuse and unintentional overdose (24). Various policies have been passed including House Bill 93 which placed limits on prescribers' ability to furnish controlled substances, strengthened licensing requirements and law enforcement surrounding pain-management clinics, and developed a statewide prescription-drug "take-back" program (25). In 2012, opioid prescribing guidelines for Ohio emergency departments and acute care facilities were established, and by 2013 new opioid prescribing guidelines for all prescribers were in place (24). Along with efforts targeting the prescribing of opioids, the introduction of further opioid treatment programs in southern Ohio is underway (26).

In an effort to focus specifically on adolescents' opioid misuse, Ohio Bill 314 was passed in September 2014. This bill requires that, in the absence of a medical emergency, all prescribers obtain signed informed consent from a guardian prior to issuing a prescription opioid to a minor and limits the amount of opioids that can be prescribed. The informed consent includes assessing the minor's mental health and substance abuse history as well as discussing the risks and dangers of taking a controlled medication with both the minor and the guardian; the signed consent form must be placed in the minor's medical record (27). House Bill 314 is an important step to help decrease adolescent opioid use. Efforts should also be taken to curtail adult prescriptions which constitute the majority of the state's overall opioid burden.

The higher rates of oral opioid doses filled in the southern portion of the state warrant further research to investigate prescribing practices within these counties. Additionally, interstate relations between Ohio, West Virginia, and Kentucky, which border the southern part of Ohio, must be considered in future studies as the dataset in the current analysis only accounts for Ohio counties and excludes bordering states. The CDC highlights West Virginia and Kentucky as two of the top five states with the most prescription painkillers per person (6) and it is plausible that residents of southern Ohio counties receive prescriptions written in these states and bring them back to their county of residence in Ohio. Therefore, comprehensive evaluations of state opioid prescribing practices should include relationships

between neighboring states as possible drivers of opioid supply and misuse. Collaborative legislation (e.g. expansion of Prescription Drug Monitoring Programs as well as data sharing and interoperability between states) will be necessary to address the opioid epidemic on a broad scale (28).

Interpretation of the current study findings must be done within the context of the study limitations. The nature of the data, although allowing examination of county-level associations, precludes a true assessment of causality and patient-level associations. Use of de-identified data prevents knowledge of underlying health status and diagnoses associated with prescriptions filled and did not allow us to control for repeat admissions for opioid misuse treatment. The nature of the substance abuse admission data reported also did not allow us to specify between admissions related to heroin versus prescription opioids, however Ohio Youth Risk Behavior Surveillance Survey (YRBSS) data from 2011 indicates that the percentage of adolescents misusing prescription medication (21%) is higher than those ever using heroin (3%) (10). The admission data obtained allowed us to evaluate treatment seeking for opioid misuse in each county based on treatment admissions by county of residence of the adolescent and not merely treatment beds available in that county, as some counties may not have the substance abuse treatment resources needed. However, this dataset is likely still a conservative estimate of adolescent opioid misuse as it only included those who were seeking treatment and did not provide information on those who were seen for opioid overdose or medical problems related to opioid misuse. National data highlight that for every 1 death from opioid overdose there are 10 treatment admissions for abuse, 32 emergency room department visits for misuse or abuse, 130 people who abuse or are dependent, and 825 nonmedical users (29). While these national data include opioid misuse from all ages, they contribute to our hypothesis that there are many more adolescents misusing opioids in the state of Ohio than are captured by this current study. Because of this, true adolescent opioid misuse in each county is most likely underrepresented by treatment admissions data and there is potentially a larger increase in adolescent opioid misuse over the study time frame that we are unable to appreciate. Of note, evaluation of the impact of state policy efforts on adolescent opioid misuse is beyond the scope of the current analysis as policies were enacted at varying times during (and outside) of the study period, encompassed varying age ranges, and did not specifically target treatment admissions.

This study highlights the importance of examining opioid prescribing practices to both adults and adolescents when addressing availability of opioids to adolescents. While the number of opioid doses filled by adolescents is decreasing in Ohio, national data show that legitimate opioid prescriptions to adolescents are associated with future opioid misuse (30). Therefore, continued efforts targeting opioid prescriptions to adolescents should remain a priority. Given that this study found a significant association between opioids filled by adults and adolescents seeking treatment for opioid misuse, efforts focusing on reducing adult opioid prescriptions are also important. Future research should continue to monitor the impact that policy changes have on the opioid misuse epidemic.

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Figure 1. Oral Opioid Doses Filled Per Capita By County of Residence in Ohio
Dose rates are per person in the specified age range.

Figure 2.
Adolescent Opioid Misuse Treatment Admissions Per 1000 by County of Residence in Ohio

Table 1

Diagnostic codes used to define opioid misuse.

ICD-9 Diagnostic Codes
304.00 Opiate Type Dependence, Unspecified Use
304.01 Opioid Type Dependence, Continuous Use
304.02 Opioid Type Dependence, Episodic Use
304.03 Opioid Type Dependence, in Remission
304.70 Combinations of Opioid Type Drug with Any Other, Unspecified Use
304.71 Combinations of Opioid Type Drug with Any Other, Continuous Use
304.72 Combinations of Opioid Type Drug with Any Other, Episodic Use
304.73 Combinations of Opioid Type Drug with Any Other, in Remission
305.50 Opioid Abuse, Unspecified Use
305.51 Opioid Abuse, Continuous Use
305.52 Opioid Abuse, Episodic Use
305.53 Opioid Abuse, in Remission
DSM-IV-TR Diagnostic Codes
292.0 Opioid Withdrawal
292.11 Opioid-Induced Psychotic Disorder, With Delusions
292.12 Opioid-Induced Psychotic Disorder, With Hallucinations
292.81 Opioid Intoxication Delirium
292.84 Opioid-Induced Mood Disorder
292.89 Opioid Intoxication
292.89 Opioid-Induced Sexual Dysfunction
292.89 Opioid-Induced Sleep Disorder
292.9 Opioid-Related Disorder, NOS
304.00 Opioid Dependence
305.50 Opioid Abuse

Table 2
Summary statistics by year for adolescent and adult dose rates and adolescent treatment admissions.

Outcome Variable	Year	Statewide Rate	County Level Summary		
			1 st Quartile	Median	3 rd Quartile
Adolescent Dose Rate (per adolescent)	2008	7.21	6.52	7.26	9.6
	2009	7.34	6.6	7.51	9.11
	2010	6.93	6.34	7.43	8.53
	2011	6.68	6.12	6.96	7.87
	2012	6.41	5.8	6.49	7.58
Adult Dose Rate (per adult)	2008	91.93	74.05	94.7	117.1
	2009	89.7	72.41	93.11	112.3
	2010	92	75.37	95.62	112.2
	2011	91.89	76.65	93.37	111.2
	2012	92.55	78.18	93.96	114.2
Adolescent Treatment Rate (per 1000)	2008	0.7	0.37	0.62	1.05
	2009	0.85	0.41	0.69	1.27
	2010	0.99	0.57	0.89	1.89
	2011	1.09	0.61	1.14	2.08
	2012	0.83	0.53	0.9	1.4

Table 3

Posterior means, standard deviations, and 95% highest posterior density (HPD) credible intervals for rate ratios associated with pairwise comparisons of each year for annual adolescent and adult per capita doses.[/]

<u>Effect</u>	<u>Posterior Mean Rate Ratio</u>	<u>Posterior SD</u>	<u>95% HPD CI</u>
Adolescent Per Capita Doses			
2009–2008	0.996	0.0097	(0.973, 1.019)
2010–2008	0.944	0.0126	(0.914, 0.974)
2011–2008	0.892	0.0141	(0.859, 0.926)
2012–2008	0.845	0.0148	(0.809, 0.880)
2010–2009	0.948	0.0093	(0.926, 0.970)
2011–2009	0.896	0.0119	(0.867, 0.924)
2012–2009	0.848	0.0134	(0.817, 0.880)
2011–2010	0.945	0.0093	(0.923, 0.968)
2012–2010	0.895	0.0119	(0.867, 0.924)
2012–2011	0.947	0.0093	(0.925, 0.969)
Adult Per Capita Doses			
2009–2008	0.971	0.004	(0.961, 0.981)
2010–2008	0.984	0.006	(0.971, 0.998)
2011–2008	0.987	0.007	(0.970, 1.004)
2012–2008	1.007	0.008	(0.987, 1.026)
2010–2009	1.014	0.004	(1.004, 1.024)
2011–2009	1.017	0.006	(1.003, 1.031)
2012–2009	1.037	0.007	(1.019, 1.055)
2011–2010	1.003	0.004	(0.993, 1.013)
2012–2010	1.023	0.006	(1.008, 1.037)
2012–2011	1.020	0.004	(1.010, 1.030)

[/] Posterior distributions were estimated from Bayesian Poisson regression models for each dose rate that included an offset for the appropriate population in each county, fixed effect of year, and random effects that account for spatial and temporal dependence.

Table 4

Posterior means, standard deviation, and 95% highest posterior density (HPD) credible intervals for adolescent treatment admission rate ratios associated with either a one dose increase in adolescent or adult per capita dose or pairwise comparisons of each year.¹

Effect	Posterior Mean Rate Ratio	Posterior SD	95% HPD CI
Adolescent Dose	1.034	0.0226	(0.981, 1.089)
Adult Dose	1.013	0.0019	(1.008, 1.017)
Years			
2009–2008	1.290	0.0568	(1.158, 1.429)
2010–2008	1.570	0.0778	(1.390, 1.762)
2011–2008	1.831	0.1013	(1.598, 2.083)
2012–2008	1.375	0.0874	(1.175, 1.593)
2010–2009	1.217	0.0526	(1.095, 1.346)
2011–2009	1.419	0.0721	(1.253, 1.598)
2012–2009	1.066	0.0646	(0.918, 1.226)
2011–2010	1.166	0.0466	(1.058, 1.280)
2012–2010	0.876	0.0437	(0.775, 0.983)
2012–2011	0.751	0.0314	(0.678, 0.828)

¹Posterior distributions were estimated from Bayesian Poisson regression models for adolescent treatment rates that included an offset for the adolescent population in each county, fixed effects of year, adolescent annual per capita dose, and adult annual per capita dose, and random effects that account for spatial and temporal dependence.