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Predictors of Emergency Department Opioid Use Among Adolescents and Young Adults

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Objective: It is well established that adolescents and young adults are increasingly vulnerable to the effects of early opioid exposures, with the emergency department (ED) playing a critical role in such introduction. Our objective was to identify predictors of ED opioid administration (ED-RX) and prescribing at discharge (DC-RX) among adolescent and young adults using a machine learning approach.

Methods: We conducted a secondary analysis of ED visit data from the National Hospital Ambulatory Medical Care Survey from 2014 to 2018. Visits where patients were aged 10 to 24 years were included. Predictors of ED-RX and DC-RX were identified via machine learning methods. Separate weighted logistic regressions were performed to determine the association between each predictor, and ED-RX and DC-RX, respectively.

Results: There were 12,693 ED visits identified within the study time frame, with the majority being female (58.6%) and White (70.7%). Approximately 12.3% of all visits were administered an opioid during the ED visit, and 11.5% were prescribed one at discharge. For ED-RX, the strongest predictors were fracture injury (odds ratio [OR], 5.24; 95% confidence interval [CI], 3.73–7.35) and Southern geographic region (OR, 3.01; 95% CI, 2.14–4.22). The use of nonopioid analgesics significantly reduced the odds of ED-RX (OR, 0.46; 95% CI, 0.37–0.57). Fracture injury was also a strong predictor of DC-RX (OR, 5.91; 95% CI, 4.24–8.25), in addition to tooth pain (OR, 5.47; 95% CI, 3.84–7.69).

Conclusions: Machine learning methodologies were able to identify predictors of ED-RX and DC-RX, which can be used to inform ED prescribing guidelines and risk mitigation efforts among adolescents and young adults.

Key Words: opioids, opioid epidemic, machine learning

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The introduction of opioids during critical developmental periods, regardless of their legitimacy, has been frequently acknowledged as a risk factor for misuse in adulthood.[1–5] Adolescents and young adults are at increased vulnerability, primarily because of ongoing neurocognitive brain development, specifically in regard to impulsivity and risk taking.[6–8] Use and misuse of prescription opioids during such critical windows have been found to increase the risk of long-term use and dependence, in addition to premature mortality.[3,9–13] Opioid use in this population has also been associated with poorer overall physical and mental health, including increased risk of sexually transmitted diseases, injury, violence, and suicide.[14–16] Prevalence of prescription opioid use among adolescents and young adults has been estimated as high as 14.3% to 16.3%.[11,17,18] Studies have indicated that a majority of misused prescription opioids among this population are obtained from friends or family (55.7%–80%), which may be an unsettling reflection of the number of opioids currently in community circulation.[18,19] Equally as concerning, it has been reported that more than 25% of misused opioids are obtained directly from a health care system, highlighting the need for judicious prescribing practices among this age group.[18]

Opioid prescribing has become a complex balancing act between oligoanalgesia and risk for aberrant use, especially among providers for whom pain management is a primary focus. This is increasingly problematic within the emergency department (ED) setting, where providers not only predominantly assess and treat pain,[20,21] but also do so among patients across the entire age spectrum. Emergent medical care, including pain management, among pediatric and adult populations often involves clinically different approaches, which has necessitated the development of specialized pediatric EDs.[22] However, not all institutions are equipped with separate pediatric facilities, therefore making it unsurprising that an upward of 90% of pediatric patients are treated within the general ED setting.[22,23] This makes it difficult to capture the predictors of opioid prescribing specifically among adolescent and young adult patients, especially when using secondary data sources to evaluate such decision making.

Previous studies have been successful in evaluating opioid prescribing within the ED using nationally representative databases; however, analyses have been often restricted to the adult population or limited in their analytic methodologies or study time frames.[15,24–32] Among the studies conducted among younger cohorts using such databases, few have performed higher-level statistical analyses and evaluated multivariable models.[29–31] Furthermore, the predictive variable inclusion among these studies was primarily determined a priori from emergency medicine literature and/or via bivariate analyses. The predictive modeling capabilities of such analytic methodologies are limited, thereby reducing the number of potential predictors included within multivariable modeling. This concept has been previously discussed, and the application of a more comprehensive means of determining such predictors of opioid prescribing, specifically via machine learning, has been successful.[33] However, this technique has yet to be applied to nonadult ED, or even general, populations. Therefore, it is our aim to expand on previous research by using the advanced analytic technique of machine learning to identify predictors of both opioid administration and prescribing within the ED among adolescent and young adult (10–24 years) patients.

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METHODS

Study Population

We conducted a secondary analysis of adolescent and young adult ED visits collected from the National Hospital Ambulatory Medical Care Survey (NHAMCS) from 2014 to 2018.[34–38] The NHAMCS is a US nationally representative sample of emergency and outpatient department utilization and care services data from noninstitutional general and short-stay hospitals.[39] The NHAMCS surveys patient visits based on a 4-stage probability design. First, area primary sampling units are selected and then hospitals within primary sampling units and then clinics within outpatient departments, and then patient visits within clinics/emergency service areas.[39] Although adolescence and young adulthood have varying definitions, for this study, adolescent and young adult visits will be considered as those where patients were aged 10 to 24 years, which is guided by the World Health Organization and current literature.[32,40–45] Visits were excluded if the patient died (n = 9), left before triage, after triage without being discharged, or left against medical advice (n = 426) because of the inability to determine ED opioid history. Those with missing pain scores (n = 5547) were also excluded because of known differential analgesic use across scores.

The use of NHAMCS data is approved by the National Center for Health Statistics research ethics review board, and therefore, institutional review was not necessary for this study.

Measures

Information regarding opioid administration (ED-RX) and prescribing (DC-RX) in the ED was extracted from the NHAMCS standardized data collection instruments. Medications were described in such instruments as either being "given in the ED" or "Rx at discharge" and were recorded for each visit, and up to 30 medications were listed. A propriety database, Lexicon Plus (Cerner Multum, Inc), was used to map medications onto therapeutic drug classifications. ED-RX was defined as any narcotic analgesic or narcotic analgesic combination medication that was documented as being given during an ED visit. DC-RX was defined as any of the aforementioned medications but was prescribed at visit discharge. Opioid prescriptions included in this study are described by the NHAMCS.[39]

Patient demographic and ED visit characteristics were also collected. Demographic information included patient age in years, sex, race, and ethnicity. Insurance was collected as expected primary payer and was categorized as private, Medicaid/CHIP/State-based programs, other (Medicare, self-pay, worker's compensation, and no charge), and blank/unknown. Clinical variables collected were pain-related reason for visit, immediacy for which to be seen (ie, triage level), vital signs, imaging ordered, provider seen, and diagnoses. Although the NHAMCS reports primary, secondary, and tertiary pain diagnoses, only the primary diagnoses were included in analyses. Pain-related reasons for visit were defined and guided by Marra et al,[25] who categorized painful conditions based on the "Primary Reason for Visit" provided in the NHAMCS database. Injury and pain-related diagnosis categories were defined using the NHAMCS documented physician diagnoses, in addition to *International Classification of Diseases* (ICD) codes and pain conditions classified by Mayhew et al.[46] Because of the differences in *ICD-9* versus *ICD-10* codes, we used the Barrell Matrix for years 2014–2015[47] and the Injury Mortality Diagnosis Matrix for years 2016–2018.[48]

Specific *ICD-10* codes defining comorbidities, pain related diagnoses, and reasons for visit were reviewed to ensure their appropriate application to the adolescent and young adult population (ie, excluding adult age-related comorbidities such as dementia). Variables reflective of time, including visit year, season, and day of week (weekend vs not), were also included. Nonopioid analgesic medication ordering was also collected, in addition to number of nonopioid medications given in the ED and prescribed at discharge. Because the NHAMCS does not delineate pediatric versus general EDs, a surrogate variable was created to account for this limitation, as has been done in previous studies.[29,30]

Statistical Analysis

All analyses were performed using the entire patient population (10–24 years of age). Patient and clinical variables were compared separately by each outcome, ED-RX and DC-RX. Weighted *t* tests were performed to assess differences across the 2 outcomes among continuous variables, and Rao-Scott χ^2 tests were performed among categorical variables. Only categorical variables had to have a count of at least 30 to be included in models.[39] All variables also needed to have a relative SE less than 30% to be included.[39] Variables exhibiting high collinearity, defined as having a variance inflation factor above 5, were also excluded.

Missing Data

Missing data were either excluded from exclusion criteria or imputed using the missRanger package. The exclusion criteria removed 29.9% visits with missing pain scores. The variables with missing data were emergency medicine residency program (5.1%), episode of care (4.0%), immediacy with which to be seen (17.2%), insurance type (9.0%), and seen in the last 72 hours (6.1%). The amount of missing values to be imputed was 33.3% (n = 4229). To impute data, random forests were iteratively fit to predict missing values in variables with missing values using the R package missranger.[49] Briefly, the missing values are predicted by averaging over many classification or regression trees, while also using predictive mean matching to keep the predicted values within bounds of the original data.

Variable Selection

Various machine learning methods were used to determine the most important predictors for ED-RX and, separately, DC-RX: LASSO/Lasso regularization, elastic net regularization, conditional inference random forest, naive Bayes, and stochastic gradient boosting. Predictor selection was performed because of the large number of plausible candidate predictor variables available. It was based on machine learning approaches instead of traditional automatic selection procedures using *P* values, which inflates type 1 errors because of multiple testing. LASSO/Lasso and elastic net used a shrinkage penalty to regulate coefficient estimates to decrease variance, with greater variable importance based on greater absolute values of the coefficients. Through conditional inference random forest, bootstrapped samples were used to fit classification trees. Each node was split within every sample, based on a random sample of predictors, and predictions were subsequently averaged across all trees. Naive Bayes used the conditional probability that a visit had the outcome, based on its predictor values. In stochastic gradient boosting, each tree was successively fit on a modified version of the data set in accordance with the tree from before. The ranking of the importance of each variable in random forest and gradient boosted machine was calculated by the average of the amount of decrease in the error of all trees, based on the total decrease of each tree's splits. Each machine learning method produced a ranking of the most important variables for ED-RX and DC-RX on a scale from 0 to 100, and the lists were averaged to create an overall average variable importance ranking for the 2 individual outcomes (Supplemental Digital Tables 1, http://links.lww.com/

PEC/A985 and 2, http://links.lww.com/PEC/A986). After evaluation of their distributions, variables with a mean rank >10, indicating at least 10% importance, were selected for final models. There are no validated cutoffs in the literature, so our selection was decided based on recommendations to not overfit the data and to create consistency across outcomes. Additional criteria for variable selection, using 5% and 15% importance cutoffs, were also assessed to evaluate the sensitivity of using the 10% cutoff, and similar results were found (data not in tabular format). Separate weighted logistic regressions were performed to determine the association between each predictor and ED-RX and DC-RX using these selected variables. The weighted regressions were run in SAS 9.4 (SAS Institute Inc, Cary, NC) using *SURVEYLOGISTIC* procedures. Analyses used the strata, cluster, and weight design variables provided by the NHAMCS, as well as a domain variable to account for subsetting analyses to the adolescent study sample.[39] R version 3.6.1 was used for the machine learning, using the *caret* package.[50]

Sensitivity Analyses

To understand the differences in ED-RX and DC-RX explicitly among the adolescent (10–17 years) and young adult (18–24 years) populations, separate sensitivity analyses were performed for these samples. The same aforementioned machine learning methodologies were used to produce variable importance rankings for ED-RX and DC-RX among both populations. Again, separate weighted logistic regression models were performed using the variables with >10 average importance to examine the association between predictors and ED-RX and DC-RX.

RESULTS

There were 12,693 adolescent and young adults ED visits identified within the study time frame. Patients were predominantly female (58.6%), White (70.7%), and with an average age of 18.2 years (SE = 0.08; Table 1).

Opioids Administered in the ED (ED-RX)

Opioids were administered in approximately 12.3% of all ED visits (Table 1). Proportions of ED-RX did not significantly differ by sex, race, or ethnicity ($P > 0.05$). Visits where the primary payer was public (ie, Medicaid, CHIP, state based) had lower proportions of opioid being given in the ED (10.3%). Southern (13.5%) and Western (14.8%) regions had higher proportions of ED-RX, as well as visits that occurred in the earlier years of the study period. Visits where patients had preexisting asthma had lower proportions of ED-RX (10.2%). Proportions were higher among visits where imaging was ordered (15.9%–30.7%) and when a consulting physician was seen (20.0%). Mean pain scores were higher among visits with ED-RX compared with those without ED-RX (7.4; 95% confidence interval [CI], 7.2–7.6 vs 4.7 4.6–4.8; data not in tabular format). Proportions of ED-RX for additional clinical variables can be found in Supplemental Digital Table 3, http://links.lww.com/PEC/A987. Upper extremity (shoulder and arm) and tooth (35.9%) pain-related reasons for visit had the highest proportions of ED-RX (Fig. 1).

The strongest predictors of ED-RX among adolescents and young adults were fracture injury (odds ratio [OR], 5.24; 95% CI, 3.73–7.35) and Southern regions (OR, 3.01; 95% CI, 2.14–4.22; Table 2). Visits where nonopioid analgesics were given in the ED, compared with those where they were not, were associated with 54% lower odds of ED-RX (OR, 0.46; 95% CI, 0.37–0.57).

Opioids Prescribed at ED Discharge (DC-RX)

The proportion of DC-RX among adolescents and young adults was 11.5% (Table 1). Opioid prescribing at ED discharge did not differ by sex. Visits where patients were White versus non-White (12.2% vs 9.8%, $P = 0.02$) and non-Hispanic or Latino (11.9% vs 9.4%, $P = 0.02$) had higher proportions of DC-RX. Similar to ED-RX, Southern (14.2%) and Western (12.3%) regions and earlier study years had higher proportions of DC-RX. Visits where patients had preexisting depression compared with those who did not had lower proportions of DC-RX (9.2% vs 11.8%). Opioid prescribing at ED discharge was higher among visits when computed tomography (CT) scans (18.7%) and x-rays (15.5%) were ordered. Proportions of DC-RX were higher among visits where nonnarcotic analgesics were given (13.0%) compared with those who did not receive them. Opioid prescribing at ED discharge differed significantly by each of the aforementioned variables. Additional DC-RX clinical variables proportions are displayed in Supplemental Digital Table 3, http://links.lww.com/PEC/A987. Tooth pain as a reason for visit had the highest proportion of DC-RX (56.3%) compared with all other reasons (Fig. 1).

Fracture injury diagnosis (OR, 5.91; 95% CI, 4.24–8.25) and tooth pain as the reason for ED visit (OR, 5.47; 95% CI, 3.84–7.79) were the strongest predictors of DC-RX (Table 3). Public insurance as the primary payer for ED visits was associated with lower odds of DC-RX compared with private insurance. Visits with abdominal pain discharge diagnoses had 4.11 times greater the odds of DC-RX compared with those that did not (OR, 4.11; 95% CI, 2.19–7.69).

Sensitivity Analyses

Proportions of ED-RX among adolescents and young adults were 8.1% and 15.3%, respectively (data not in tabular format). Proportions of DC-RX were 6.2% among adolescents and 15.2% among young adults (data not in tabular format).

Sensitivity analyses of predictors of ED-RX and DC-RX among adolescents and young adults are displayed in Supplemental Digital Tables 4, http://links.lww.com/PEC/A988 and 5, http://links.lww.com/PEC/A989. Similar to the main analysis, the strongest predictor of ED-RX for both adolescents and young adults was fracture injuries. The number of nonopioid medications given in the ED was also a strong predictor in both groups.

For DC-RX, the strongest predictors among adolescents and young adults were fracture injury diagnoses, abdominal pain diagnoses, and tooth pain for reason for visit, which is again consistent with the main analyses.

DISCUSSION

The application of machine learning enabled the comprehensive identification of separate sets of predictors by ED-RX and DC-RX and by adolescent/young adult age category. We found that the strongest predictors of administering opioids in the ED among adolescents and young adults were fracture injuries and Southern geographic region, which are consistent with previous findings. Past assessments of nationally representative samples have reported higher proportions of opioids being prescribed for higher acuity visits, such as those involving fractures, among both the adult and younger populations.[23–27,30,33] Geographic variation in prescribing has also been frequently discussed, with non-Northeastern regions disproportionally prescribing more opioids in the ED.[23,27–33] Although machine learning was useful in the fact that it further confirmed existing predictors of opioid use, it also had utility in identifying new ones, such as year of data collection and the number of nonopioid medications given in the ED. Using a machine learning approach, we were also able to

TABLE 1. Adolescent and Young Adult Visit Characteristics Compared by Opioid Administration (ED-RX) and Prescribing (DC-RX) in EDs; NHAMCS 2014–2018

	Unweighted No. Visits	Weighted Visits, % (95% CI)	Weighted Visits for ED-RX, % (95% CI)*	P†	Weighted Visits for DC-RX, % (95% CI)*	P†
Total	12,693	12.2 (11.4–13.0)	12.3 (11.3–13.3)		11.5 (10.5–12.5)	
Demographics						
Age, mean (95% CI)	18.2 (SE = 0.08)		19.6 (19.3–19.9)	<0.001	20.1 (19.9–20.4)	<0.001
Sex				0.10		0.10
Female	7430	58.6 (57.2–59.9)	11.8 (10.5–13.0)		11.0 (9.9–12.0)	
Male	5263	41.4 (40.1–42.8)	13.0 (11.7–14.3)		12.1 (10.7–13.6)	
Race				0.08		0.02
White	8794	70.7 (67.5–73.9)	12.8 (11.7–14.0)		12.2 (10.9–13.4)	
Other	3899	29.3 (26.1–32.5)	11.0 (9.3–12.7)		9.8 (8.3–11.3)	
Ethnicity				0.09		0.02
Hispanic or Latino	2356	17.4 (15.0–19.7)	10.6 (8.5–12.7)		9.4 (7.6–11.2)	
Not Hispanic or Latino	10,337	82.6 (80.3–85.0)	12.6 (11.6–13.7)		11.9 (10.8–13.0)	
Primary payer				0.001		<0.001
Blank/Unknown	1120	9.0 (6.8–11.3)	11.8 (8.0–15.6)		7.8 (5.7–9.9)	
Private insurance	4040	31.0 (29.2–32.9)	13.4 (11.7–15.1)		13.0 (11.1–14.9)	
Medicare/Medicaid/State-Based	5727	44.0 (41.4–46.6)	10.3 (9.0–11.6)		9.1 (8.0–10.1)	
Other	1806	15.9 (14.1–17.7)	15.9 (13.2–18.6)		17.2 (14.9–19.5)	
Geographic region				<0.001		<0.001
Northeast	2393	15.2 (12.5–17.9)	6.5 (5.1–7.9)		4.7 (3.6–5.8)	
Midwest	3283	27.3 (22.3–32.3)	12.1 (10.2–14.0)		10.8 (8.5–13.1)	
South	4416	38.8 (33.8–43.8)	13.5 (11.8–15.3)		14.2 (12.7–15.8)	
West	2604	18.8 (15.8–21.7)	14.8 (12.4–17.1)		12.3 (10.7–13.8)	
Year				<0.001		<0.001
2014	3066	20.7 (17.7–23.8)	14.5 (12.4–16.6)		16.1 (13.5–18.8)	
2015	2875	21.3 (18.5–24.0)	14.9 (12.5–17.2)		14.0 (11.6–16.3)	
2016	2429	21.1 (18.3–23.9)	11.4 (9.5–13.3)		11.3 (9.5–13.1)	
2017	2049	20.2 (17.1–23.4)	10.9 (8.8–13.1)		9.0 (7.1–10.8)	
2018	2274	16.7 (14.0–19.3)	9.0 (7.0–11.1)		5.7 (4.1–7.3)	
Visit characteristics						
Hospital type				0.10		0.10
Pediatric ED	186	1.0 (0.1–1.9)	8.3 (4.0–12.7)		4.0 (0.0–9.6)	
General ED	12,507	99.0 (98.1–99.9)	12.3 (11.3–13.4)		11.5 (10.5–12.5)	
Immediacy with which to be seen				<0.001		0.9
Unknown/Blank/No triage	2270	17.2 (13.1–21.2)	12.7 (10.1–15.3)		11.3 (8.2–14.3)	
Urgent/Emergent/Immediate	5017	40.3 (37.6–43.0)	8.3 (7.2–9.5)		11.4 (9.8–13.0)	
Semiurgent/Nonurgent	5406	42.6 (39.5–45.7)	15.9 (14.5–17.3)		11.6 (10.3–12.8)	
Patient preexisting conditions						
Asthma				0.04		0.07
No	11,134	88.1 (87.1–89.1)	12.6 (11.4–13.7)		11.8 (10.7–12.9)	
Yes	1559	11.9 (10.9–12.9)	10.2 (8.3–12.1)		9.2 (6.9–11.5)	
Depression				0.40		0.003
No	11,730	97.0 (96.3–97.7)	12.4 (11.3–13.4)		11.8 (10.8–12.8)	
Yes	963	3.0 (2.3–3.7)	11.1 (8.3–13.9)		7.3 (4.8–9.8)	
Obesity				0.09		0.20
No	12,387	97.0 (96.3–97.7)	12.2 (11.2–13.2)		11.4 (10.4–12.4)	
Yes	306	3.0 (2.3–3.7)	16.7 (10.9–22.4)		14.7 (8.7–20.7)	
Providers seen						
ED attending physician				<0.001		0.70
No	1813	17.4 (14.3–20.4)	8.0 (6.4–9.7)		11.9 (8.8–15.0)	
Yes	10,880	82.6 (79.6–85.7)	13.2 (12.1–14.3)		11.4 (10.4–12.4)	
Consulting physician				<0.001		0.80

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TABLE 1. *(Continued)*

	Unweighted No. Visits	Weighted Visits, % (95% CI)	Weighted Visits for ED-RX, % (95% CI)*	*P*†	Weighted Visits for DC-RX, % (95% CI)*	*P*†
No	11,829	93.8 (92.9–94.8)	11.8 (10.8–12.8)		11.5 (10.5–12.5)	
Yes	864	6.2 (5.2–7.1)	20.0 (16.3–23.7)		11.1 (7.3–14.9)	
Imaging Ordered						
CT scan (any)				<0.001		<0.001
No	11,367	88.7 (87.7–89.8)	10.0 (9.1–10.8)		10.5 (9.5–11.6)	
Yes	1326	11.3 (10.2–12.3)	30.7 (27.2–34.1)		18.7 (16.0–21.4)	
X-ray				<0.001		<0.001
No	9108	70.0 (68.8–71.3)	10.8 (9.7–11.9)		9.7 (8.8–10.7)	
Yes	3585	30.0 (28.7–31.2)	15.9 (14.1–17.6)		15.5 (13.5–17.5)	
Ultrasound				<0.001		0.60
No	11,915	93.8 (92.9–94.6)	11.5 (10.5–12.5)		11.4 (10.4–12.4)	
Yes	778	6.2 (5.4–7.1)	24.0 (19.2–28.7)		12.2 (9.5–14.9)	
Nonopioid analgesics ordered				0.20		0.01
No	8049	62.4 (60.9–63.9)	11.8 (10.5–13.1)		10.6 (9.4–11.7)	
Yes	4644	37.6 (36.1–39.1)	13.1 (11.5–14.6)		13.0 (11.3–14.6)	
Pain score, mean (95% CI)		5.0 (4.9–5.1)	7.4 (7.2–7.6)	<0.001	7.0 (6.8–7.3)	<0.001

*Reflects row percentages.

†*P* values correspond to weighted *t* tests and Rao-Scott χ^2 tests, where appropriate.

observe differences in predictors across outcomes, with DC-RX having more potential predictors included within the final multivariable model. This highlights that the decision to prescribe an opioid at discharge is influenced by a variety of factors, separate from those involved in administration. This becomes increasingly important among the younger cohorts who are more vulnerable to take home prescriptions.[18,19]

In addition, we found that the administration of nonopioid analgesics while in the ED significantly predicted whether or not a patient also received an opioid medication, with nonanalgesic administration being associated with a 54% reduction in the odds of ED-RX. The concept of nonopioid analgesics for the management of pain in the ED has been a topic of recent discussion, particularly in light of the opioid epidemic and risk of misuse among this population. Nonopioid analgesics have been noted to be more commonly used among younger patients and particularly within pediatric EDs.[29] Several clinical trials have indicated that analgesia can be reached using nonopioid medications among both adult and

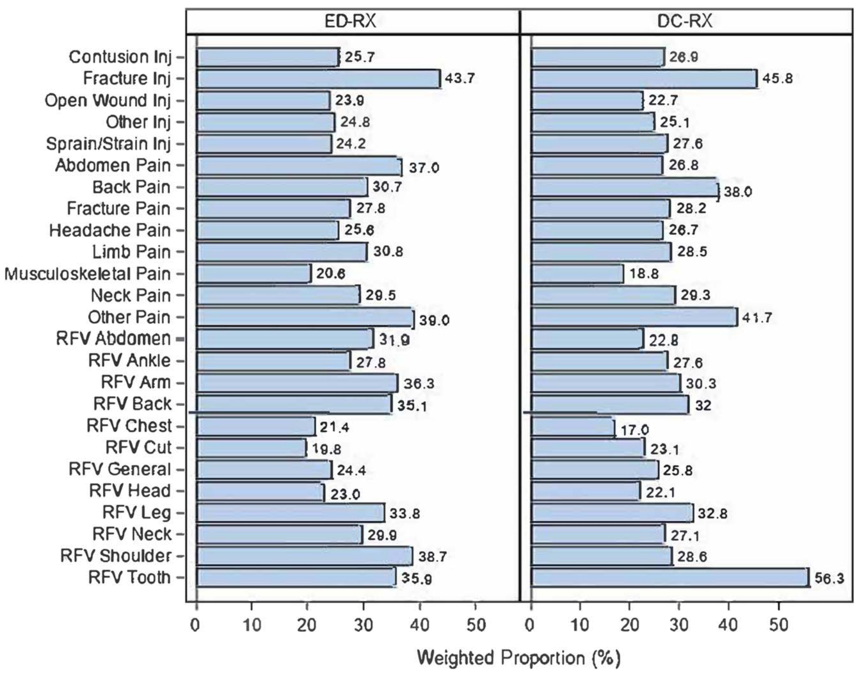

FIGURE 1. Weighted proportions (row %) of ED-RX and DC-RX among visits by (A) injury diagnoses, (B) pain-related diagnoses, or (C) pain reasons for visit (RFV).

TABLE 2. Weighted Multivariable Logistic Regression for Opioids Administered in the ED (ED-RX)

Variable	OR	95% CI		*P*
Age, y	1.08	1.05	1.10	<0.0001
Geographic region				
Midwest vs Northeast	2.33	1.61	3.38	<0.0001
South vs Northeast	3.01	2.14	4.22	<0.0001
West vs Northeast	2.84	2.05	3.934	<0.0001
Year				
2014 vs 2018	2.40	1.71	3.36	<0.0001
2015 vs 2018	2.25	1.60	3.14	<0.0001
2016 vs 2018	1.68	1.15	2.46	0.008
2017 vs 2018	1.48	1.04	2.09	0.03
Pain scale	1.34	1.29	1.38	<0.0001
No. nonopioid medications given in the ED	2.05	1.92	2.19	<0.0001
Nonnarcotic analgesics given, yes vs no	0.46	0.37	0.57	<0.0001
Imaging ordered				
CT scan, yes vs no	2.12	1.68	2.68	<0.0001
X-ray, yes vs no	1.63	1.30	2.06	<0.0001
Injury discharge diagnoses				
Fracture, yes vs no	5.24	3.73	7.35	<0.0001

pediatric populations.[51–53] In light of this, our findings may be a reflection of such clinical shifts in pain management and overall aim of judicious prescribing. Although many national guidelines are not inclusive to younger cohorts, the application of multimodal pharmacological approaches, where opioids are given as a last line of therapy, has been recommended and implemented among EDs to appropriately and successfully reach analgesia in lieu of opioids.[54–57] This is increasingly important among adolescent and young adult opioid-naive patients who can thereby avoid unnecessary exposures to opioids.

Proportions of opioids prescribed at ED discharge for dental pain have hardly reduced from previous reports. Hudgins et al[23] reported that 59.7% of adolescent and 57.9% of young adult NHAMCS ED visits from 2006 to 2015 received an opioid prescription at discharge. Comparatively, among both adolescent and young adult patients, 56.3% of dental pain visits received DC-RX in the current study. Furthermore, dental pain also had the highest proportion of ED-RX across all other pain-related reasons for visit categories (35.9%). Tooth pain as a reason for ED visit was also associated with 6.65 times greater odds of being prescribed an opioid at ED discharge. These estimates of DC-RX are also comparative to that of the adult population,[33] further highlighting that this issue is not solely problematic among younger populations. Opioids are currently not advised for use to treat routine dental pain in the ED,[58] which raises the question as to why they are still being administered and prescribed in such high proportions. One study has attempted to answer this and found that the implementation of a prescribing guideline to identify legitimate need reduced the amount of ED opioid prescriptions by 17%.[59] Given that this study[59] included individuals 16 years and older, continuing this research and implementing similar guidelines among the adolescent and young adult populations and across institutions are warranted.

Our sensitivity analyses have indicated considerable differences in the overall proportions of ED-RX and DC-RX among adolescents and young adults. Adolescents were administered opioids while in the ED far less than their older counterparts, despite having similar average pain scores (adolescents vs young adults, 7.2 vs 7.5; data not in tabular format). They also were prescribed opioids upon ED discharge in proportions less than half that of young adults (6.2% vs 15.2%). Furthermore, among DC-RX for fracture injuries, 52.2% of young adult visits received an opioid prescription, whereas only 26.0% of adolescents received one for the same injury. The differences in opioid prescriptions between the 2 populations have been previously reported,[23,29,32] with older age being significantly associated with opioid prescribing. However, clinically speaking, our results question as to why, for the same injury and pain scores, are those younger than 18 years receiving less opioids? The risk of future misuse and abuse among adolescents is a plausible explanation; however, young adults have been indicated to experience similar elevated risks.[3,11,12,18] Opioid prescribing among young adults is more aligned with the adult population per a previous analysis,[33] which may indicate that providers

TABLE 3. Weighted Multivariable Logistic Regression for Opioids Prescribed at ED Discharge (DC-RX)

Variable	OR	95% CI		*P*
Age, y	1.14	1.11	1.17	<0.0001
Race, White vs other	1.32	1.05	1.67	0.02
Geographic region				
Midwest vs Northeast	2.58	1.81	3.67	<0.0001
South vs Northeast	3.93	2.85	5.43	<0.0001
West vs Northeast	3.27	2.38	4.49	<0.0001
Year				
2014 vs 2018	3.12	2.13	4.57	<0.0001
2015 vs 2018	2.53	1.75	3.64	<0.0001
2016 vs 2018	1.99	1.41	2.82	0.0001
2017 vs 2018	1.41	0.98	2.03	0.07
Expected source of payment				
Medicaid/CHIP/State-based vs private	0.73	0.60	0.91	0.004
Other vs private	0.95	0.74	1.22	0.7
Pain scale	1.22	1.18	1.25	<0.0001
Systolic blood pressure	1.01	1.00	1.01	0.02
Diastolic blood pressure	1.01	1.00	1.01	0.2
No. nonopioid medications prescribed at discharge	1.26	1.17	1.35	<0.0001
No. nonopioid medications given in the ED	1.10	1.05	1.16	0.0001
Nonopioid analgesics ordered, yes vs no	0.76	0.62	0.92	0.006
Injury discharge diagnoses				
Fracture, yes vs no	5.91	4.24	8.25	<0.0001
Contusion, yes vs no	1.38	1.09	1.74	0.007
Sports injury, yes vs no	1.51	1.04	2.19	0.0
Pain related discharge diagnoses				
Abdominal, yes vs no	4.11	2.19	7.69	<0.0001
Pain-related reason for visit				
Tooth, yes vs no	5.47	3.84	7.79	<0.0001
Chest, yes vs no	0.37	0.23	0.59	<0.0001
Imaging ordered				
CT Scan, yes vs no	1.33	1.02	1.73	0.04
X-ray, yes vs no	1.57	1.29	1.90	<0.0001
Emergency residency program				
No vs yes	0.84	0.63	1.13	0.2

are approaching these patients as they would adults, rather than those who are still developing. However, the risk of misuse among someone who is 16 or 17 versus 18 years old is likely similar, and yet those 18 years and older are consistently associated with higher odds of opioid dispensing. Menchine et al[29] allude to this idea with differing predictive probabilities of opioid prescribing at different ages; however, this concept warrants further investigation, particularly in light of prescribing reform.

Limitations

We are limited by the nature of the NHAMCS data set itself, beginning firstly with our inability to make inferences at the individual level. The NHAMCS databases are collected at the visit level, thereby making it impossible to decipher if patients are included at multiple time points, which could have misrepresented the variability in the study sample. Moreover, we were also unable to discern opioid dosing and/or amount administered or prescribed during each visit. Second, we are presenting conclusions based on the latest years of available data, which may not be representative of current regulatory or clinical practice. Furthermore, any prescribing guidelines and policies that may have been instituted at the institutions included in the NHAMCS data set during our study time fame were also unaccounted for. We were also unable to obtain information regarding ED provider specialty training, particularly in pediatrics, which could have provided additional context on opioid prescribing. Pediatric as an emergency medicine specialty has been noted to be more restrictive in terms of opioids,[29] and understanding how this may have impacted the presented ED-RX and DC-RX remains unknown. We did attempt to control for this by including a surrogate variable for ED type (pediatric vs general); however, more than 99% of all visits during our study time frame occurred in general EDs. Lastly, because this was a retrospective assessment of previously collected electronic medical record data, there is the possibility of misclassification and data errors that are inherent to such types of data sources. Specifically, we excluded approximately 30% of the eligible sample because of missing pain scores, which may have introduced selection bias. We conducted sensitivity analyses and found that, although demographic characteristics did not vary by documented pain score status, some clinical variables did, including our outcomes (Supplemental Digital Table 6, http://links.lww.com/PEC/A990). However, despite this, we believe that our results maintain generalizability. We found that 55.4% of visits with missing pain scores also had an unknown/missing or no triage assigned. Visits without or missing triage status likely occurred when patients left before being seen. Therefore, by excluding those with missing pain statuses, we also most likely excluded a proportion of visits where patients would not have even been seen by a provider, thus removing the opportunity for any prescribing, opioid or otherwise.

CONCLUSIONS

This is the first study to comprehensively identify predictors of ED-RX and DC-RX among adolescents and young adults by using machine learning methodologies. Nonopioid analgesic use significantly reduced the odds of ED-RX, which is encouraging in light of changes in both national and institutional prescribing guidelines. Dental pain is still a predominant predictor of DC-RX among this population, and more studies that aim at reducing such prescribing are justified, particularly among this high-risk cohort. Improving surveillance of continued opioid use after an ED visit will also enable risk mitigation and intervention efforts.

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