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Article

Associations between fentanyl usage and social media use among U.S. teens

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SUMMARY

The abuse of fentanyl needs attention as this substance contributes greatly to drug overdose fatalities in the U.S., especially among adolescents. Our study was conducted to help develop effective intervention strategies to decrease adolescent fentanyl abuse by looking into the effects of social media usage and other factors on fentanyl exposure among teens in the U.S. We hypothesized that social media usage would have a positive association with socioeconomic factors and fentanyl abuse in teens in the U.S. The data utilized in this study was from a cross-sectional survey, the Monitoring the Future (MTF) dataset, which focused on 8th and 10th grade American youth. This study observed variables of sex, race, academic disciplinary history, frequency of substance usage, amount of social media usage, and relationship with parents. Frequency tabulation, chi-square test, and logistic regression were conducted for the evaluation of a trend between teenage social media and fentanyl usage, considering potential confounding factors. The results showed that there is a higher frequency of fentanyl use when students have had suspension histories, use marijuana, or use alcohol. This information can be used to design interventions that focus specifically on students who have such histories. Although not statistically significant, the results of logistic regression combined with frequency graphs show a notable trend that the amount of time teenagers spend on social media in daily life is positively correlated with fentanyl usage frequency.

INTRODUCTION

Fentanyl, a potent synthetic opioid certified by the Federal Drug Administration (FDA) to manage severe pain associated with surgery or complex pain conditions, has greatly contributed to the surge in drug overdose fatalities in the U.S (1). The number of overdose fatalities involving synthetic opioids (excluding methadone) is growing, reaching 70,601 reported deaths in 2021 (2). Illegally manufactured fentanyl and other synthetic opioids have increasingly occupied the drug supply, leading to a substantial growth in overdose deaths, with fentanyl being identified as the major cause (77.14%) of adolescent overdose fatalities (3). The misuse of potent opioids like fentanyl has emerged as a critical public health issue among teens in the United States (U.S.). Substance abuse among adolescents is an important public health issue that needs to be addressed because of its severity, shown through the rapidly increasing fatality rate among teenagers, and long-term consequences of overdose deaths.

Social media such as Instagram, Facebook, TikTok, Snapchat, Twitter, and others are broadly used by most teens in the U.S. (4). Even though there are some positive effects of social media such as self-affirmation for marginalized populations and the opportunity to achieve self-expression, youth on social media are also exposed to many risks (4). The use of social media has become a negative influence on the lives of adolescents, including their behaviors and attitudes related to substance abuse (4).

Fentanyl is increasingly found in counterfeit pills that are widely accessible, often through social media and e-commerce platforms, posing a pronounced risk to unsuspecting individuals, including teens and young adults (5). Some known risk factors affecting substance abuse among adolescents include emotional distress, aggressiveness, engagement in alcohol or drug use at a young age, peer substance use, and the low-cost and high availability of substances in the community (6-7). These risk factors can increase the likelihood of youth substance use and abuse, leading to various consequences, such as mental health issues, violence, and high-risk behaviors (8).

Previous studies have examined the relationship between social media usage and substance abuse in different populations. When adolescents see their peers sharing content related to alcohol and marijuana on social platforms, they are more inclined to use these substances themselves (9). In addition, there is a significant association between high digital technology use and increased substance use, particularly in the case of alcohol and marijuana (10). While the relationship between digital forms of social networks and alcohol and/or marijuana use has been investigated, previous studies lack comprehensive understanding of data pertaining to new psychoactive substances, such as benzodiazepines, synthetic cannabinoids, or fentanyl analogues (11). Specifically, fentanyl has recently become a serious issue among youth in the U.S. The National Center for Drug Abuse Statistics revealed that fentanyl is a factor in more than half of drug overdose deaths in the U.S. (12). However, there has not been sufficient evidence that can elucidate the effect of social media on fentanyl usage among the youth in the U.S. This gap shows the need for our research to explore the relationship between social media usage and fentanyl abuse in this population.

We investigated the effect of social media usage and other factors on fentanyl abuse in teens in the U.S. The objectives of this research were to evaluate and compare fentanyl usage in various groups, to determine the environmental factors

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that are associated with fentanyl abuse, and to ascertain the association between social media usage and fentanyl abuse among American teenagers, especially 8th and 10th grade students. By answering these questions, this research could support a deeper comprehension of the current situation of fentanyl abuse among teenagers and cultivate an understanding of the effects of social media usage on youth substance abuse. Based on this, we can formulate more effective intervention strategies or support systems aimed at promoting the mental well-being of adolescents and reducing the number of teenage drug overdoses. We hypothesized that social media usage would have a positive association with potential socioeconomic factors (i.e. sex, race, parents' education level) and fentanyl abuse in teens in the U.S. This hypothesis was evaluated by comparing fentanyl usage in various demographic groups of age, race, sex, and parent's education level.

The logistic analysis reveal a positive association between social media usage and fentanyl usage among American teenagers. Although the odds ratio is not statistically significant, the results considered with the descriptive analysis of **Figures 1 and 2** hints for a trend between social media usage and fentanyl usage of teenagers in the U.S.

RESULTS

This research utilized data from the cross-sectional Monitoring the Future (MTF) survey, conducted in 2021 (13). This data contains answers to questionnaires given to 8th and 10th grade American students. Out of the different variables found in MTF survey, we focused on variables of sex, race,

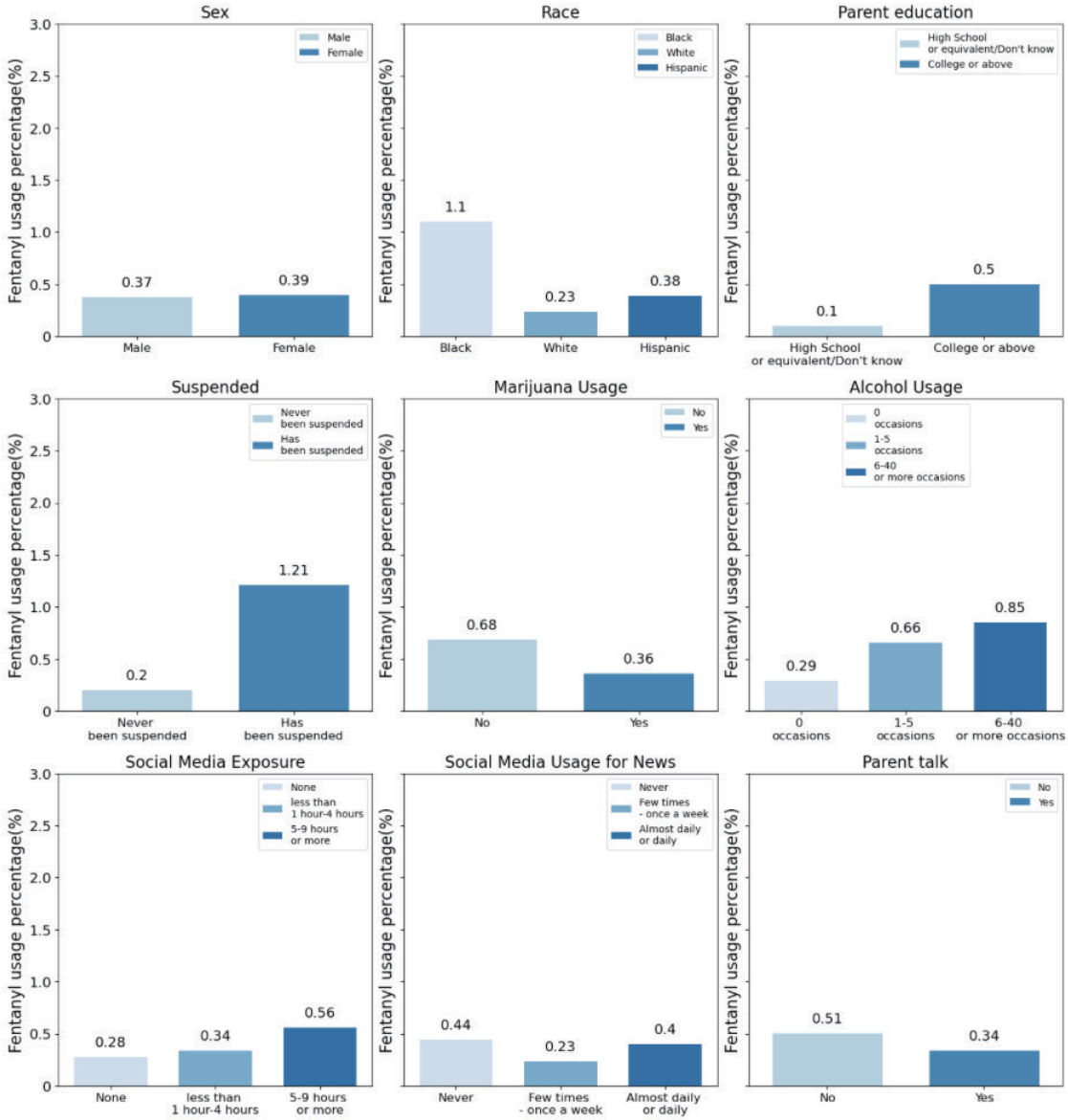

Figure 1: Comparison of fentanyl usage percentage in different groups categorized by different variables across the total sample. Bar graph showing the proportion of participants who have used fentanyl in percentage in different groups. (n = 3631). The participants were categorized by sex, race, parent education, academic discipline history, illicit substance use, social media use, and the relationship with parents.

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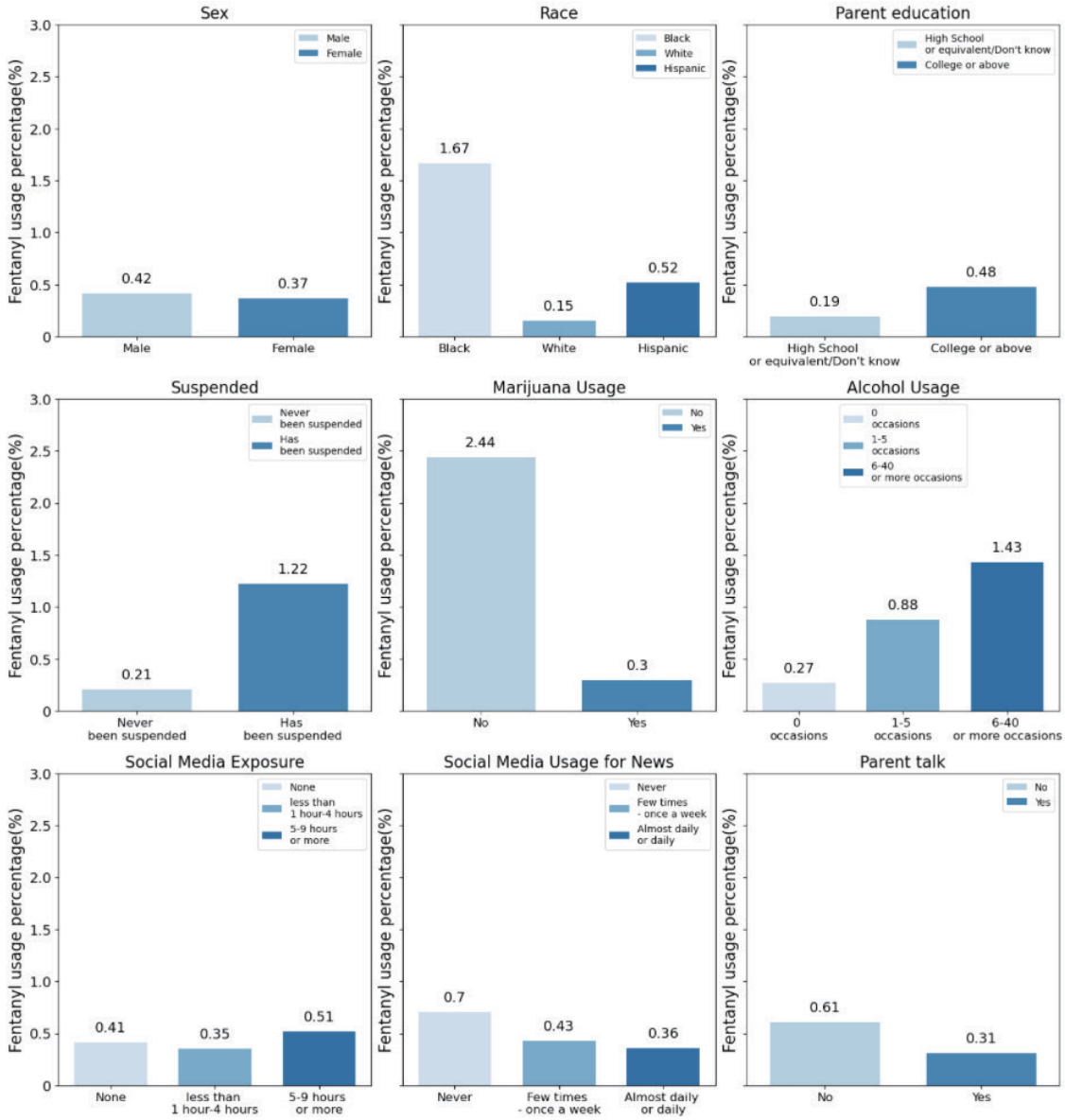

Figure 2: Comparison of fentanyl usage percentage in different groups categorized by different variables among 8th grade students. Bar graph showing the proportion of participants (n = 1772) who have used fentanyl, categorized by sex, race, parent education, academic discipline history (history of suspension), illicit substance use (marijuana, alcohol), social media use (daily life exposure, usage for news), and the relationship with parents.

academic disciplinary history (whether the participant has ever been suspended), frequency of substance usage (marijuana, alcohol, and fentanyl), the amount of social media usage (time spent on social media in daily life or for obtaining information/news), and relationship with parents (parent's education level and whether there is any problem with communication). Looking at these variables, we had the ultimate goal of helping create more effective intervention methods to protect teenagers from the growing rate of fentanyl abuse among teenagers.

The variables that were considered as demographics were sex, race, and parent's education level for each 8th and 10th grade sample. Alcohol use was categorized based on the number of occasions of use in the last 12 months (0 occasions, 1-5 occasions, 6-40 occasions or more). Social media exposure was grouped based on the hours of usage per day (none, <1-4 h, 5-9 h or more), while social media usage for news and current events was categorized differently (never, a few times to once a week, almost daily or daily).

54% (n = 960) and 49% (n = 907) of respondents were male in 8th- and 10th grade, respectively (**Table 1**). The majority in both grades were white, at 76% (n=1340) and 66% (n = 1225) in 8th and 10th grades, respectively. Regarding the parent's education level, more than 50% of fathers or mothers of all respondents had obtained college or higher levels of education.

The chi-square test revealed there was a statistically significant difference across various demographic groups regarding fentanyl use history (**Table 2**). Black adolescents/ students showed the highest proportion of fentanyl use

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Demographic variable		8th Grade (n = 1772)	10th Grade (n = 1859)
Sex	Male	960 (54%)	907 (49%)
	Female	812 (46%)	952 (51%)
Race	White	1340 (76%)	1225 (66%)
	Black	240 (14%)	305 (16%)
	Hispanic	192 (11%)	329 (18%)
Father's education level	High School or Equivalent	525 (30%)	609 (33%)
	College or above	884 (50%)	980 (53%)
	Don't Know	363 (20%)	270 (15%)
Mother's education level	High School or Equivalent	356 (20%)	424 (23%)
	College or above	1136 (64%)	1258 (68%)
	Don't Know	280 (16%)	177 (10%)

Table 1: Demographics of the total sample, by grade level. The total sample (n = 3631) included 1772 8th-grader students and 1859 10th-grade students. The percentages were calculated by dividing the number of students in each category of each variable by the total number of students in the grade for that variable.

history at 1.7% and 1.1% for the 8th grade and total sample (p = 0.002 and 0.012), respectively. Participants who had been suspended showed higher proportions of fentanyl use history than those who have no experience of suspension (p = 0.008, 0.007, and < 0.001, for 8th, 10th, and both grade groups, respectively). Lastly, 8th graders who had used marijuana during the last 12 months showed a significantly higher proportion of fentanyl use history (29%) compared to those who had no experience of marijuana use (5%) during the same period (p = 0.003).

The comparative analysis of fentanyl use history percentages across diverse groups is stratified by variables delineated in the study, including sex, race, suspension history, marijuana use, alcohol use, social-media-related variables, and relationship with parents (**Figures 1, 2, and 3**). **Figure 1** provides a comparison of the total sample and **Figures 2 and 3** shows frequencies in the different strata, 8th and 10th grade, and the total sample.

Of the total sample, there was no significant difference in frequency of reported fentanyl usage between male (0.37%) and female (0.39%) students, while the other demographic variables, race and parents' education level, showed a somewhat significant difference (p = 0.012 for race, p = 0.084 for parent's education level) across the groups (**Figure 1**). Black students (1.1%) appeared to more frequently report fentanyl usage history compared to White (0.23%) and Hispanic (0.38%) students. In addition, students whose parents had a college education or above, appeared to have a higher frequency of fentanyl use history compared to those whose parental education level was high school or equivalent or unknown (0.50% vs. 0.10%, respectively).

There were notable differences in fentanyl use history across levels of student-focused variables such as academic disciplinary history, marijuana/alcohol usage history, social media exposure, and social media usage for news. Students who had been suspended were found to report a higher proportion of fentanyl use history compared to those without suspension history (1.21% vs.0.20%, respectively). Comparing fentanyl usage between the groups who had/hadn't used alcohol/marijuana in the last 12 months, a greater proportion of students who had used marijuana or alcohol during the last 12 months reported using fentanyl compared to the students who had not used those substances or had used it less (alcohol) for the same period (marijuana 0.68% vs. 0.36%; alcohol 0.85% vs. 0.66% vs. 0.29%). Similar to this gradual increase of fentanyl exposure depending on the severity of student's alcohol usage, a gradual increase in the frequency of fentanyl use was noted as the amount of social media usage increased: 0.56% of students with heavy exposure to social media (5 to 9 or more hours) reported fentanyl use history compared to 0.34% of students with mild exposure to social media (less than 1 to 4 hours) and 0.28% of students with no exposure to social media. However, with regards to social media use for obtaining information or news, there was no notable trend in fentanyl usage (**Table 2**).

A higher proportion of male 8th graders than female 8th graders (0.42% vs. 0.37%) reported fentanyl use history, unlike 10th graders and the total sample, among which females reported fentanyl use history more frequently than males (**Figure 2 and 3**). Black students showed the highest proportion in both grades (1.7% of 8th grade, 0.66% of 10th grade) as depicted in the total sample analysis, while White and Hispanic students showed different trends across grades as 0.15% of white and 0.52% of Hispanic 8th graders, and 0.33% of white and 0.30% of Hispanic 10th graders reported fentanyl usage.

Fentanyl usage across student-focused variables such as the history of suspension, marijuana use, alcohol use, and communication problems with parents showed the same trend in both grades as that in the total sample. The result from analyses of social-media-related variables revealed a mixed trend, since the subgroup with 'light usage' (1-9 hours of daily use of social media; at least once a week to few times a week usage of social media for news) of social media showed highest proportion of 'yes' to fentanyl exposure, rather than subgroups with 'no use' or 'moderate usage' (more than 9 hours of daily use of social media; almost daily or daily usage of social media for news).

Looking at the results of the chi-square test, various groups showed notable differences regarding fentanyl usage experience (**Table 2**). For the strata divided based on race, academic disciplinary history, and marijuana use history, the p-values were all less than 0.05, exhibiting statistical significance. Observing this, it was concluded that race, academic disciplinary history, and marijuana usage were potential confounders that could affect logistic regression analyses in the sample. This signifies that there could be potential autocorrelations between the race, disciplinary history, and marijuana use variable such as students with disciplinary history being more likely to have used marijuana.

Seeing this result, logistic regression analysis was performed both with (Model 2) and without (Model 1) controlling for confounders to check if there was a relationship between students' social media usage and fentanyl usage. Comparison of the results of logistic regression with and without controlling for confounders showing great differences in the results show the importance of controlling potential confounders (**Tables 3 and 4**). Social media usage was positively associated with fentanyl use history, as shown

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	8th Grade (n =1772)		10th Grade (n=1859)		Total Sample (n=3631)	
Fentanyl use	Never	Yes	Never	Yes	Never	Yes
Sex						
Male	956 (54%)	4 (57%)	904 (49%)	3 (43%)	1860 (51%)	7 (50%)
Chi-square(X^2, *p*-value)	0.0249, 0.875		0.0990, 0.753		0.0113, 0.915	
Race						
White	1338 (76%)	2 (29%)	1221 (66%)	4 (57%)	2559 (71%)	6 (43%)
Black	236 (13%)	4 (57%)	303 (16%)	2 (29%)	539 (15%)	6 (43%)
Hispanic	191 (11%)	1 (14%)	328 (18%)	1 (14%)	519 (14%)	2 (14%)
Chi-square	11.9977, 0.002**		0.7617, 0.683		8.7971, 0.012**	
Even been suspended						
Yes	323 (18%)	4 (57%)	331 (18%)	4 (57%)	654 (18%)	8 (57%)
Chi-square	6.9905, 0.008**		7.2798, 0.007**		14.2736, 0.000**	
Marijuana during last 12 months						
Yes	80 (5%)	2 (29%)	210 (11%)	0 (0%)	290 (8%)	2 (14%)
Chi-square	9.1292, 0.003**		0.8948, 0.344		0.7409, 0.389	
Alcohol (number of occasions)						
0	1470 (83%)	4 (57%)	1311 (71%)	4 (57%)	2781 (77%)	8 (57%)
1-5	226 (13%)	2 (29%)	377 (20%)	2 (29%)	603 (17%)	4 (29%)
6-40 or more	69 (4%)	1 (14%)	164 (9%)	1 (14%)	233 (6%)	2 (14%)
Chi-square	3.8203, 0.148		0.6461, 0.724		3.2150, 0.200	
Social media usage						
None	241 (14%)	1 (14%)	121 (7%)	0 (0%)	362 (10%)	1 (7%)
<1-4 h.	1137 (64%)	4 (57%)	1233 (67%)	4 (57%)	2370 (66%)	8 (57%)
5-9 h or more	387 (22%)	2 (29%)	498 (27%)	3 (43%)	885 (24%)	5 (36%)
Chi-square	0.1996, 0.905		1.2103, 0.546		0.9838, 0.611	
Using social media for news						
Never	141 (8%)	1 (14%)	83 (4%)	0 (0%)	224 (6%)	1 (7%)
Once or few times/wk	232 (13%)	1 (14%)	193 (10%)	0 (0%)	425 (12%)	1 (7%)
Almost daily-daily	1392 (79%)	5 (71%)	1576 (85%)	7 (100%)	2968 (82%)	12 (86%)
Chi-square	0.4008, 0.818		1.2251, 0.542		0.2954, 0.863	
Talk problem with parent						
Yes	1276 (72%)	4 (57%)	1356 (73%)	5 (71%)	2632 (73%)	9 (64%)
Chi-square	0.7981, 0.372		0.0114, 0.915		0.5059, 0.477	
Parent's highest education level						
High School or	517 (29%)	1 (14%)	490 (26%)	0 (0%)	1007 (28%)	1 (7%)
College or above	1248 (71%)	6 (86%)	1362 (74%)	7 (100%)	2610 (72%)	13 (93%)
Chi-square	0.7589, 0.384		2.5149, 0.113		2.9792, 0.084	

Table 2: Cross tabulation of students' personal-experience-related, media-exposure-related, and parent-related characteristics with fentanyl use history in 8th grade (n = 1772), 10th grade (n = 1859), and the total sample (n = 3631). All categorical variables were compared using chi-square test between fentanyl use groups. *p*-values below 0.05 are indicated by asterisks.

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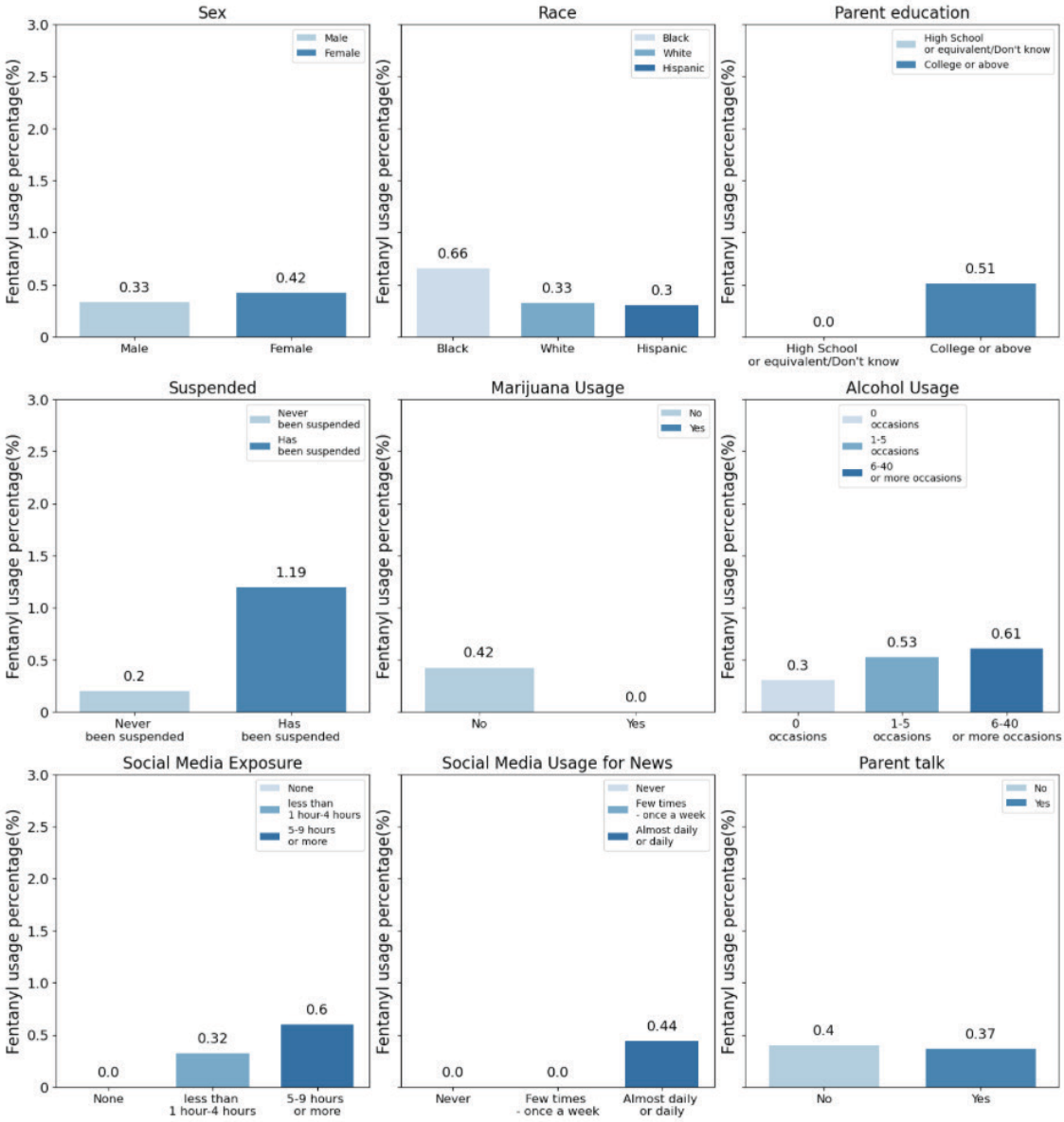

Figure 3: Comparison of fentanyl usage percentage in different groups categorized by different variables among 10th grade students. Bar graph showing the proportion of participants who have used fentanyl in percentage in different groups (n = 1859). The participants were categorized by sex, race, parent education, academic discipline history, illicit substance use, social media use, and the relationship with parents.

by the higher odds ratios for heavy use compared to mild use (Model 1: OR = 2.0 and 1.2, respectively; Model 2: OR = 1.3 and 1.1, respectively), albeit the odds ratios were not statistically significant (Model 1 and 2). Any use of social media for obtaining information/news was associated with lower odds of fentanyl use history. Higher odds ratios with heavy use compared to mild use (Model 1: OR=0.91 and 0.53, respectively; Model 2: OR=0.67 and 0.45, respectively) were reported; however, these odds ratios were also not statistically significant.

DISCUSSION

We found that fentanyl use was more common among students who had any history of suspension, marijuana use, or alcohol use. Noting this, there could be future interventions made to stop the increasing trend of fentanyl usage by focusing on this correlation and giving careful attention to students with a history of suspension or other drug use.

The results of the logistic regression analysis reveal a positive association between social media usage and fentanyl abuse among American teenagers. Though the odds ratio is not statistically significant, the results, especially combined with the descriptive analyses presented in **Figures 1 and 2**, reveal a notable trend that could provide a pivotal hint for an approach to the fentanyl crisis among the youth in the U.S. The amount of time teenagers spend on social media in daily life has a positive association with the frequency of fentanyl use history (**Figures 1 and 2**). In fact, other studies have come to similar conclusions, stating that "[d]igital technology use that required interaction with others was associated

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Independent Variable	Odds ratio	95% CI	*p*-value
Social media usage (reference: no use)			
Social media usage (light use)	1.221	0.152-9.799	0.850
Social media usage (moderate use)	2.045	0.238-17.567	0.514
Using social media for news (reference: no use)			
Using social media for news (light use)	0.527	0.033-8.466	0.651
Using social media for news (moderate use)	0.906	0.117-6.997	0.924

Table 3: Logistic Regression without controlling for confounders (Model 1). (n = 1772 8th grade, 1859 10th grade, 3631 total sample). *p*-values below 0.05 are indicated by asterisks in the table. The results of logistic regression conducted on the total sample with independent variables of amount of social media usage in daily life (variable "social media usage") and for obtaining information/news (variable "social media news") and the dependent variable of fentanyl use history. The results report the odds ratios of fentanyl use history with the confidence interval (CI) and p-values from the logistic regression analysis. The table shows model 1, the regression analysis without controlling potential confounders.

with increased risk of past 30-day drinking, cannabis use, and vaping" (13). Another study also found that there is a relationship between cyberbullying involvement and later substance use among adolescents (14).

An intriguing difference in the frequency of fentanyl exposure was observed between analyses using social media usage for different purposes (in daily life vs. for obtaining information/news) as predictors. There was a clear increasing trend observed for the variable of Social Media Usage while there was no clear trend observed for the variable of Social Media Usage for News. This highlights that social media is a potential contributor to youth fentanyl use. However, a more comprehensive understanding will necessitate consideration of additional behavioral factors that contribute to the mechanism of its influence to fentanyl usage among youth. The intricate relationship, between social-media-related variables and fentanyl use history underlines the significance of not only the amount of time spent on social media but also the manner and intention behind social media use. Further studies will be needed to explore additional potential confounders, such as adverse childhood events or psychiatric disorder comorbidity, which could have affected the significance level of analyses.

Independent Variable	Odds ratio	95% CI	*p*-value
Social media usage (reference: no use)			
Social media usage (light use)	1.125	0.139-9.077	0.911
Social media usage (moderate use)	1.331	0.151-11.704	0.796
Using social media for news (reference: no use)			
Using social media for news (light use)	0.453	0.028-7.198	0.575
Using social media for news (moderate use)	0.666	0.085-5.221	0.699

Table 4: Logistic Regression controlling for confounders (Model 2). (n = 1772 8th grade,1859 10th grade, 3631 total sample). *p*-values below 0.05 are indicated by asterisks in the table. This table 4 shows model 2, controlling the potential confounders (race, history of suspension, and marijuana usage), which were found through the precedent chi-square test.

Some notable findings, seen in **Table 1**, helped this study achieve a more comprehensive understanding of the data. For the race variable, more than 70% of all respondents were white, and more than 50% of the parents of all respondents obtained college or higher levels of education. Even though these were not the main variables of interest in the current study, further research can be done to evaluate interactions among various social or economic factors to see if it plays crucial roles in the distinctive demographic profile. It also important to note how the MTF survey may have been influenced by survey bias. Therefore, further research in a different population may help provide stronger support for our hypothesis.

MATERIALS AND METHODS

Data Collection

The data utilized in this study was the Monitoring the Future (MTF) dataset, which is publicly accessible and funded by the United States Department of Health and Human Services, the National Institutes of Health, and the National Institute on Drug Abuse (15). The data was obtained from a cross-sectional survey of 8th- and 10th-grade students who were randomly assigned to one of 4 questionnaires on demographics and drug use of contemporary American youth. A total of 11,446 8th graders and 11,792 10th graders were surveyed in 2021. Across the questionnaires, there are a total of 696 variables, 181 of which are common across all 4 questionnaires. Our study focused on variables of sex, race, academic disciplinary history (whether the participant has ever been suspended), frequency of substance usage (marijuana, alcohol, and fentanyl), the amount of social media usage (time spent on social media in daily life or for obtaining information/news), and relationship with parents (parent's education level and whether there is any problem with communication).

Data Cleaning and Variables

To clean the data, variables with values of "prefer not to answer" and missing values were dropped. In addition, variables with values of 3 were dropped for the sex variable as it refers to the response "I don't know". The categorical variables of fentanyl usage history within the past 12 months and communication problems with parents were re-coded into dichotomous values (0=no, 1=yes). The categorical variables of alcohol usage and social-media-related variables were recategorized into three categories (0=no use, 1=mild use, 2=heavy use). There were two social-media-related variables, the amount of social media usage in daily life ("about how many hours on an average day a participant spends on social networking sites like Facebook, Twitter, Instagram, etc.") and the amount of social media usage for obtaining information/news ("how often a participant uses social media to get information about news and current events"). The parent's highest education level variable was recategorized into two categories (0=high school and high school equivalent level or don't know and 1=college level or above) (15). Data with 'unknown' academic level of parents were included to minimize potential bias that exclusion may raise and to maximize the total number of samples for data analysis.

Statistical Analysis

The statistical methods used in this analysis were

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frequency tabulation, chi-square test, and logistic regression using Python, version 3.11.4. We also used several libraries, including the sklearn library (version 4.7.1), statsmodels.api library (version 0.14.0), matplotlib.pyplot library, gdown library (version 4.7.1), pandas library (version 1.5.3), numpy library (version 1.24.3), seaborn library (version 0.12.2), and stats library from scipy. First, demographic information including sex, race, and parent's education levels was tabulated to outline and better understand the social status of the participants (**Table 1**). Second, a frequency table was created with categorical variables of sex, race, academic disciplinary history, substance usage, social media usage, and parent-related variables based on whether the student had used fentanyl before. These values were reported for each 8th- and 10th-grader and the total sample (**Table 2**). Additionally, chi-square tests were conducted to determine if there was any statistically significant difference in fentanyl usage among different groups. Lastly, logistic regression analyses of the total sample were conducted, with social-media-related variables ('social media usage' and 'social media news') as independent variables and with fentanyl usage as the dependent variable. Logistic regression was conducted with two different models, with or without controlling for potential confounders found through the chi-square test. Model 1 did not include the control for the potential confounders. For model 2, the analysis was controlled with three potential confounders: race, academic disciplinary history, and marijuana usage. As a result of the logistic regression analyses, the odds ratios of fentanyl usage were retrieved.

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APPENDIX

https://github.com/ell477/research-paper.git