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# Characterizing prescription stimulant nonmedical use (NMU) among adults recruited from Reddit

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ABSTRACT

*Objective:* Increased prescription stimulant nonmedical use (NMU) is part of a growing polysubstance use landscape. The purpose of the present study was to characterize prescription stimulant NMU among adults reporting past 5-year non-oral prescription stimulant NMU.

*Methods:* Adults who reported non-oral prescription stimulant NMU within the last 5 years were recruited by banner ads placed on the Reddit website between February and September 2019. Types of prescription stimulants used, routes of administration, preferred routes of administration, motivations for prescription stimulant NMU, concurrent substances used simultaneously during prescription stimulant NMU, illicit substances used and factors impacting prescription stimulant NMU were queried.

*Results:* Respondents ($n$ = 225) were male (86.2%), non-Hispanic (92.4%), white (78.2%), between 18 and 24 (48.0%) or 25–34 (43.1%) years with some amount of college education (81.3%). Most reported lifetime intranasal (93.8%) or oral use (85.2%). Prescription stimulants were diverted: 64.5% reported the prescription stimulants were given to them by a family or a friend and 10.5% reported that they had stolen these medications from a family or friend. Preferred route of administration was oral use (70.2%). Motivations to use were stratified by route of administration: intranasal (55.6%) or oral (63.0%) use was primarily endorsed as an attempt to enhance performance at work or at school; use by injection (57.1%) or smoking (62.5%) was primarily endorsed to get high. Most of the sample reported concurrent drug use (79.1%) including tobacco (57.3%), marijuana (52.0%), caffeine (47.6%) or alcohol (41.8%), among others. When excluding licit substances, 30.7% reported using 1 illicit substance concurrently with prescription stimulants and 25.3% reported using 2 or more illicit substances concurrently with prescription stimulants. Whether participants would undertake prescription stimulant NMU was determined by their work/school schedules or the location of the NMU (48.9%) whereas the route of administration employed was primarily influenced by the desired feeling or effect (56.9%).

*Conclusions:* Adults reporting lifetime non-oral prescription stimulant NMU engage in substantial risky behaviors that in addition to alternate routes of administration include polysubstance use, diversion and concurrent substance use.

## 1. Introduction

Attention-deficit/hyperactivity disorder (ADHD) is a prevalent childhood neurodevelopmental disorder that can persist into adulthood (Asherson et al., 2016; Bonvicini et al., 2016; Faraone and Biederman, 2016; Wilens et al., 2004, 2018; Subcommittee on Attention-Deficit/Hyperactivity et al., 2011; Wolraich et al., 2019; Barbaresi et al., 2013). An often-utilized treatment strategy includes prescription stimulants (Chai et al., 2012) which are most frequently amphetamine or methylphenidate products (U.S. Drug Enforcement Administration, 2012). Increased rates of prescribing stimulants to adults began in 1994 (Olfson et al., 2013). This was due, in part, to FDA approval of the use of these medications for the treatment of adult ADHD (Burcu et al., 2016; Castells et al., 2018) and, in part, to amphetamines being prescribed for

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reasons beyond ADHD, such as obesity, narcolepsy, depression, or shift work sleep disorder (Olfson et al., 2013; Burcu et al., 2016).

The nonmedical use (NMU) of prescription stimulants, defined here as use other than prescribed, has been studied in adolescents (Vosburg et al., 2020; Wilens et al., 2006; Zosel et al., 2013) and young adults, especially college students (Arria et al., 2008, 2011; Babcock and Byrne, 2000; Barrett et al., 2005; Benson et al., 2015; DeSantis et al., 2008; Garnier-Dykstra et al., 2012; McCabe et al., 2005; Rabiner et al., 2009a, 2009b; Teter et al., 2005, 2006; Weyandt et al., 2013). Studies with adult samples beyond the college environment are rare but do exist. For example, among adults responding to internet surveys, estimates of lifetime prescription stimulant NMU rates ranged from 7.1% to 8.1% (Cassidy et al., 2015b; Schepis & McCabe, 2016) and past-year NMU prevalence estimates ranged from 0.3% to 2.2% (Cassidy et al., 2015b; Schepis & McCabe, 2016; Novak et al., 2007; SAMSHA, 2018). Among adults seeking treatment for substance use disorder, rates of past 30-day NMU ranged from 1.29% to 2.11% (Burtner et al., 2018; Cassidy et al., 2015a). Recently, the National Survey on Drug Use and Health (NSDUH) estimated that prescription stimulant NMU was initiated in the past year by approximately 819,000 individuals aged 18 and older, and of those, 302,000 were 26 and older (SAMSHA, 2018).

Prescription stimulant NMU is a public health concern that has been associated with physical and psychiatric complications as well as mortality (Barkus & Murray, 2010; Cooper et al., 2018; Hennissen et al., 2017; Westover & Nakonezny et al., 2010; Westover et al., 2008; Westover et al., 2018). Motives for prescription stimulant NMU are poorly understood and are likely different for various populations. For instance, young adult individuals report prescription stimulant NMU for cognitive enhancement (Schepis et al., 2020; Compton et al., 2018).

Although a preponderance of prescription stimulant NMU is oral (Cassidy et al., 2015a, 2015b; Burtner et al., 2018), some individuals transition from oral NMU to non-oral NMU. Non-oral prescription stimulant NMU is use that involves alternate routes of administration, or, taking medications via routes other than the medically intended route, for instance, chewing them before swallowing them, or using them intranasally or intravenously. Non-oral NMU is of particular interest because it is associated with substance use severity (Surratt et al., 2011; Strang et al., 1999; Strang, 1992a, 1992b, 1997), and more severe medical outcomes (Faraone, Hess, & Wilens, 2019). Non-oral prescription stimulant NMU has also been associated with tissue damage and toxicity (Bruggisser et al., 2011; Imbert et al., 2013; Marti et al., 2013; Massello & Carpenter, 1999; Parran & Jasinski, 1991) and adverse mental health (Barkus & Murray, 2010; Liu et al., 2020).

How the transition from oral to non-oral prescription stimulant NMU occurs is unknown. The specific event is difficult to capture because non-oral NMU is an example of a stigmatized, hidden behavior (MacDonnell et al., 2019; Ibarra et al., 2018). As such, online surveys can be an advantageous forum because participants can share sensitive information and experiences anonymously (Barratt et al., 2017).

The present study sought to examine characteristics associated with prescription stimulant non-oral NMU by identifying a knowledgeable and experienced demographic. Namely, adults who self-identified as having used prescription stimulants non-orally within the past 5 years. This timeframe was selected to ensure as many participants as possible would be included in the sample because it was not clear at the outset whether enough individuals could be recruited based on this particular criterion. A secondary object was to collect data that may be employed for future hypothesis generation related to prescription stimulant non-oral NMU.

## 2. Methods

NMU included ANY of the following: (1) use for any reason, even once, without one's own prescription, (2) use in ways other than prescribed (such as taking more than prescribed, more often than prescribed, or for any other reason or way than prescribed) or (3) use for the feeling or experience the medication caused (such as a feeling of being high, enhancement of other substances, prevention or treatment of withdrawal symptoms, or other feelings).

A convenience sample was recruited using the Reddit platform (https://www.redditinc.com/) with advertisement banners placed on Reddit from February through September 2019 (Shatz et al., 2017). Reddit is the 5th most visited website in the US (on Alexa, a search engine optimization and competitive analysis software: www.alexa.com), has over 52 million daily active users, over 100,000 active communities and 50 billion average screen views per month (https://www.redditinc.com/press). Reddit allows targeted identification of terms of interest and allows users to select terms or categories of interest to follow and interact with.

These specific communities, called subreddits, are increasingly being identified and used for research in general (Jamnik & Lane, 2017) and substance abuse research in particular (D'Agostino et al., 2017; Sowles et al., 2017). Reddit only allows targeting the top 5,000 subreddits for research activities as the others do not generate enough traffic to be considered for data collection (as of July 23, 2020, there were 2,259,769 subreddits). Reddit does not share the list of the top 5,000 subreddits but rather has a search engine to find them. Because study advertisement banners did not target any specific subreddits, banners were widespread across the entire website.

Study recruitment banners indicated that individuals who were 18 or older, had personal experience with non-oral prescription stimulant NMU within the last 5 years and were interested in taking an online survey could click on an embedded survey link to participate. The link took them to the survey, which was hosted by YouGov. After providing informed consent, participants completed an online digital survey of the following topics: demographics, medical history, history of prescription medication NMU (including products, age of first use, routes of administration, motivations and substance procurement source) and history of illicit substance use (including substances, age of first use, routes of administration and motivations).

Images of prescription medications were employed so that participants could correctly identify substances that they had used. The survey took approximately 10–15 min to complete. Respondents could stop study participation at any time. Those who completed the entire online survey were compensated with a $20 e-gift card upon completion. Compensation was managed by the survey hosting site to reduce privacy concerns.

One methodological error was discovered whereby non-oral use criteria had not been programmed properly and individuals were allowed to progress beyond the screening questions to the survey without meeting the criteria. Once this problem was discovered it was promptly fixed. The result is a discrepancy between the number of respondents who completed the survey (n = 403) versus the number included in this report (n = 225), a difference of 178.

Participants must have been at least 18 years of age (based on self-report), English-speaking citizens of the United States, willing to complete the survey, have a history of prescription stimulant NMU within the last 5 years and have a lifetime history of prescription stimulant NMU via at least one non-oral route of administration.

### 2.1. Data handling and analyses

Survey data were downloaded from the hosting site and stored on a password-protected server that was only accessible by authorized study personnel. After data cleaning, each survey question was analyzed with descriptive frequencies to ensure completion and proper data values. All analyses were carried out using SAS Enterprise Guide Version 7.1 (Cary, NC). This study was approved by the New England Institutional Review Board.

## 3. Results

### 3.1. Sample characteristics

Between February and September 2019, 403 individuals completed the online survey. Of these, 225 met the inclusion criteria of non-oral NMU within the past 5 years and were included in the study sample. Table 1 presents demographic characteristics. Respondents were primarily male, not of Spanish, Latino or Hispanic origin or descent, white, approximately 25+ years of age, with some amount of college education. Most (60.4%) were single and working. The majority (55.1%) reported at least one psychiatric diagnosis in their lifetime.

Participants were, on average, 18.7 (±3.7) years of age when they first initiated prescription stimulant NMU. Lifetime prescription stimulant NMU included amphetamine (n = 209, 92.9%) or methylphenidate (n = 103, 45.8%). Participants also reported past-year (n = 171, 76.0%) and/or past month (n = 81, 36.0%) prescription stimulant NMU.

### 3.2. Lifetime prescription stimulant NMU

Fig. 1 summarizes the lifetime and preferred routes of administration employed by the recruited sample of adults with past 5-year prescription stimulant non-oral NMU. Fig. 1 (top) depicts that 85.3% used via "Any Oral" route, including, "Swallowed Whole," "Broke Into Smaller Pieces," "Chewed then Swallowed," or "Dissolved Then Swallowed." Per study inclusion criteria, all participants reported "Any Non-Oral" prescription stimulant NMU, 95.2% reporting non-oral amphetamine NMU and 58.3% reporting non-oral methylphenidate NMU. Of these, 99.1% reported snorting, 6.2% reported injecting and 3.6% reported smoking prescription simulants.

Fig. 1 (bottom) depicts that 70.2% of the sample preferred prescription stimulant NMU via "Any Oral" route of administration. Other preferred routes included snorting (59.1%), injecting (4.0%) or smoking (1.3%). Some participants reported more than one preferred route of administration for prescription stimulant NMU.

Across both prescription amphetamine and prescription methylphenidate, higher doses in milligrams were used for oral use than for non-oral use. Most individuals ($n$ = 195, 86.7%) indicated they did not escalate doses over time to achieve the desired effect (data not shown).

### 3.3. Source of procurement for NMU

Most (86.7%, n = 195) obtained prescriptions from a source other than their physician. Slightly more than three-quarters (76.4%, $n$ = 172) reported that prescription stimulants were given by, stolen from or bought from friends or family: 72.1% ($n$ = 124) bought the prescription stimulants from a family member or friend, 64.5% ($n$ = 111) reported the prescription stimulants were given to them by a family member or a friend and 10.5% ($n$ = 18) stole these medications from a family or friend. Almost 40% (39.6%, $n$ = 89) reported they bought the prescription stimulants from dealers. Other means of procurement were one's own prescription from one or several doctors (24.4%, $n$ = 55), trading for it (17.8%, $n$ = 40), or buying online without having seen a doctor (5.3%, $n$ = 12). Remaining sources, all of which counted for <1%, were stealing (from an unknown person, $n$ = 2), writing or buying a fake prescription ($n$ = 1), or other ($n$ = 2).

### 3.4. Motivation for prescription stimulant non-oral NMU by route of adminstration

Table 2 summarizes primary motivations for non-oral prescription stimulant NMU stratified by route of administration. The primary reasons for prescription stimulant NMU were desired performance enhancement at work or school or to get high. The most endorsed motivation to take prescription stimulants orally or intranasally was to enhance performance at work or school (63.0% of oral users, 55.6% of

**Table 1**
Sample Demographic Characteristics.

| Variable | | (N = 225) | |
|---|---|---|---|
| | Response | n | % |
| Sex | Male | 194 | 86.2 |
| Spanish, Latino, or Hispanic origin or descent | No | 208 | 92.4 |
| Race | White | 176 | 78.2 |
| | Black | 16 | 7.1 |
| | Hispanic | 12 | 5.3 |
| | Other | 21 | 9.3 |
| Age distribution | 18–24 years | 108 | 48.0 |
| | 25–34 years | 97 | 43.1 |
| | 35–44 years | 17 | 7.6 |
| | 45 years and older | 3 | 1.3 |
| Highest level of education | No high school degree | 4 | 1.8 |
| | High school graduate | 38 | 16.9 |
| | Some college, but no | 76 | 33.8 |
| | degree (yet) | 19 | 8.4 |
| | 2-year college degree | 77 | 34.2 |
| | 4-year college degree | 11 | 4.9 |
| | Postgraduate degree | | |
| Marital status | Married, living with | 27 | 12.0 |
| | spouse | 2 | 0.9 |
| | Separated | 13 | 5.8 |
| | Divorced | 0 | 0.0 |
| | Widowed | 152 | 67.6 |
| | Single, never married | 31 | 13.8 |
| | Domestic partnership | | |
| Employment status | Working full-time now | 108 | 48.0 |
| | Working part time now | 28 | 12.4 |
| | Temporarily laid off | 5 | 2.2 |
| | Unemployed | 6 | 2.7 |
| | Retired | 0 | 0.0 |
| | Permanently disabled | 1 | 0.4 |
| | Taking care of home or | 4 | 1.8 |
| | family (homemaker) | 70 | 31.1 |
| | Student | 3 | 1.3 |
| | Other | | |
| Family annual income | Less than $10,000 | 8 | 3.6 |
| | $10,000–$29,999 | 20 | 8.9 |
| | $30,000–$49,999 | 38 | 16.9 |
| | $50,000–$69,999 | 42 | 18.7 |
| | $70,000–$99,999 | 31 | 13.8 |
| | $100,000–$149,999 | 12 | 5.3 |
| | $150,000 or more | 9 | 4.0 |
| | Prefer not to answer | 65 | 28.9 |
| Psychiatric Diagnosis | Depression | 74 | 32.9 |
| | Anxiety | 65 | 28.9 |
| | ADHD | 62 | 27.6 |
| | Substance Use Disorder | 28 | 12.4 |
| | (other than alcohol) | 21 | 9.3 |
| | Alcohol Use Disorder | 19 | 8.4 |
| | Bipolar Disorder | 14 | 6.2 |
| | Other behavioral or mental | 11 | 4.9 |
| | health disorders | 9 | 4.0 |
| | Learning disability | 5 | 2.2 |
| | Oppositional defiant | 101 | 44.9 |
| | disorder | | |
| | Conduct disorder | | |
| | No lifetime diagnosis of | | |
| | any listed condition | | |
| Lifetime Prescription Substance Use (with or without one's own prescription) | Prescription opioid | 100 | 44.4 |
| | Prescription sedative or | 92 | 40.9 |
| | tranquilizer | 55 | 24.4 |
| | Prescription muscle | 53 | 23.6 |
| | relaxant | 8 | 8.0 |
| | Prescription sleep aid | | |
| | Prescription diet aid or | | |
| | appetite suppressant | | |

(continued on next page)

**Table 1** (*continued*)

| Variable | | (N = 225) | |
|---|---|---|---|
| | Response | n | % |
| Past Year Prescription Substance Use (with or without one's own prescription) | Prescription opioid | 52 | 23.1 |
| | Prescription sedative or tranquilizer | 63 | 28.0 |
| | Prescription muscle relaxant | 26 | 11.6 |
| | Prescription sleep aid | 27 | 12.0 |
| | Prescription diet aid or appetite suppressant | 7 | 3.1 |
| Past 30-day Prescription Substance Use (with or without one's own prescription) | Prescription opioid | 20 | 8.9 |
| | Prescription sedative or tranquilizer | 37 | 16.4 |
| | Prescription muscle relaxant | 12 | 5.3 |
| | Prescription sleep aid | 13 | 5.8 |
| | Prescription diet aid or appetite suppressant | 2 | 0.9 |
| Prescription Stimulant NMU | | | |
| Lifetime | Prescription Amphetamine | 209 | 92.9 |
| | Prescription Methylphenidate | 103 | 45.8 |
| Past Year | Prescription Stimulants | 171 | 76.0 |
| Past 30-day | Prescription Stimulants | 81 | 36.0 |

intranasal users), followed by to get high. The most endorsed motivation to inject or smoke prescription stimulants was to get high (57.1% injecting, 62.5% smoking), followed by to enhance performance at work or school.

### 3.5. Concurrent substances used during prescription stimulant nonmedical use

Table 3 summarizes the degree of polysubstance use undertaken by almost 80% of the sample (79.1%, $n = 178$): 57.3% reported using tobacco and 52% reported using marijuana at the same time as prescription stimulant NMU. Other commonly reported substances used with prescription stimulants included caffeine and alcohol, as well as cocaine/crack, tranquilizers/sedatives, prescription opioids or methamphetamine. Almost 20% reported using one other substance (licit or illicit) and 60% reported using 2 or more substances (licit or illicit) during prescription stimulant NMU. When tobacco, alcohol and caffeine were excluded from these calculations, 30.7% reported using one illicit substance and 25.3% reported using 2 or more illicit substances concurrently during prescription stimulant NMU.

### 3.6. Additional factors affecting prescription stimulant NMU

Table 4 presents factors that influenced the decision to use prescription stimulants non-medically (top) and the various routes of administration (bottom). Of the full sample, (Total Sample, $n = 225$), almost half were influenced to undertake prescription stimulant NMU because of their work or school schedules ($n = 110$, 48.9%) or the locale of their use (e.g., home, school, or at a party) ($n = 109$, 48.4%). The primary factor affecting route of administration was the feeling or effect that was desired from the medication ($n = 128$, 56.9%). The specific medication that was available to respondents (36.4%) and who they were with (33.8%) were also commonly selected as impacting route of administration.

### 3.7. Illicit substance use and routes of administration

Illicit substance use (including marijuana), categorized by lifetime, past-year, past 30-day use, and the primary route of administration is summarized in Table 5. Most of the sample reported lifetime (98.2%), past year (76.4%) and past 30-day (51.6%) use of marijuana, followed by use of cocaine. Marijuana was smoked by almost all who used it (99.6%), whereas cocaine was primarily snorted (98.5%).

### 3.8. Characteristics of individuals who reported prescription stimulant NMU by injection ($n = 14$)

Respondents who reported lifetime prescription stimulant injection ($n = 14$) were male (11/14), 18–34 years of age (11/14), non-Hispanic white (10/14), with some college education (10/14). More than half reported receiving a lifetime psychiatric diagnosis (9/14) including: anxiety (5/14), substance use disorder (5/14), depression (4/14), bipolar disorder (4/14), ADHD (3/14), alcohol use disorder (3/14), oppositional defiant disorder (2/14), learning disorder (2/14) or conduct disorder (1/14). Sources of obtaining prescription stimulants for injection were primarily family or friends (bought/given/stolen) (12/14), a dealer (8/14), trading for it (6/14), or one's own prescription (3/14). Also reported were NMU of prescription opioids (9/14), prescription sedatives or tranquilizers (8/14), prescription muscle relaxants (7/14), prescription sleep aids (7/14), prescription diet aids (4/14), or appetite suppressants (4/14).

Twice as many individuals reported lifetime injection of prescription amphetamine (14/14) than prescription methylphenidate (7/14). Those who injected prescription stimulants for NMU endorsed using multiple substances at the same time as prescription stimulants. The most commonly reported were tobacco (10/14), marijuana (8/14), caffeine (8/14), or alcohol (7/14). Other concurrently used substances were prescription opioids or gabapentin (4/11 each); cocaine/crack, methamphetamine, heroin, street fentanyl, other illicit substances (3/11 each); or tranquilizers/sedatives (1/11).

Table 4 top, right columns, summarizes influential factors for undertaking prescription stimulant NMU via injection. Injection of prescription stimulants was influenced by access to the medication (9/14), the effect that was desired (9/14), social company at the time/who they were with (8/14) and the specific medication available (8/14). Most individuals indicated they did not escalate dosage over time to achieve the desired effect when they were injecting prescription stimulants for NMU (10/14) (data not shown).

### 3.9. Discussion & conclusion

This epidemiological study sought to define characteristics of non-oral prescription stimulant NMU by recruiting a convenience sample of adults who endorsed past 5-year non-oral prescription stimulant NMU from Reddit. Non-oral NMU inclusion criteria assume more advanced substance use because non-oral use typically involves manipulation of medication formulations to obtain a desired psychoactive effect, a strategy that is not typically undertaken by new users (Parran & Jasinski, 1991; Guarino et al., 2018; Katz et al., 2011). A recent Federal Register notice issued by the FDA (FDA-2019-N-3403; Federal Register 84 (183), September 20, 2019) sought to solicit comment on how to interrupt the transition from oral to non-oral use of prescription stimulants. Given this national-level goal of operationalizing the trajectory of prescription stimulant NMU, an investigation into characteristics associated with the full range of adults who engage in prescription stimulant NMU via non-oral routes that is not limited to college students is important.

The current sample consisted exclusively of adults endorsing past 5-year non-oral prescription stimulant NMU, a targeted, unique sample. A subset of individuals who reported injecting prescription stimulants for NMU were also evaluated because of the risks and severe outcomes associated with drug injection (Surratt et al., 2011; Katz et al., 2011; Surratt et al., 2017). Several findings are consistent with the broader NMU literature. For example, most of the sample was male, with approximately half being 18–24 years which is also the age of highest misuse rate (McCabe et al., 2019; Faraone et al., 2019).

In addition to prescription stimulants, a substantial percentage

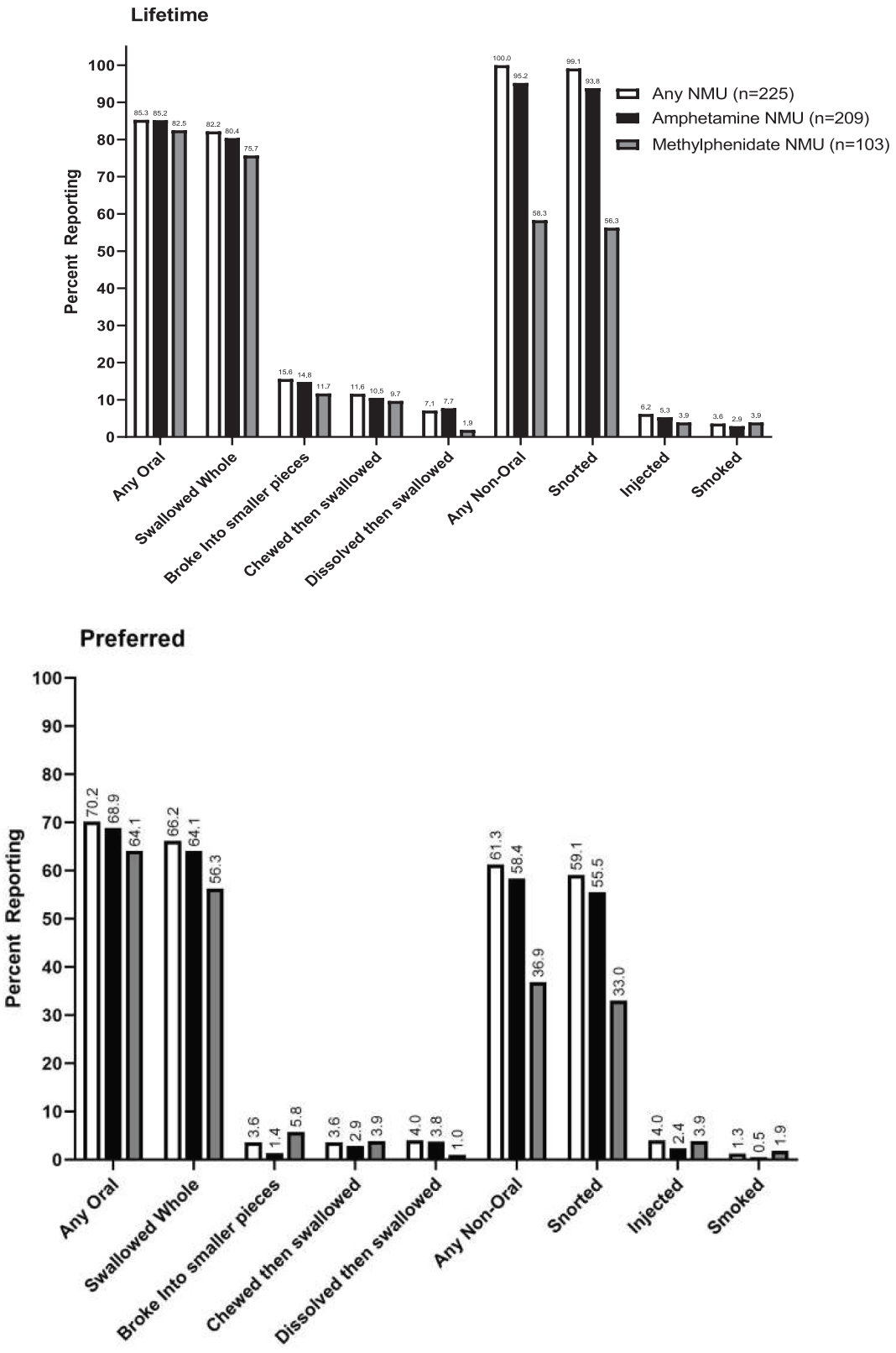


**Fig. 1.** Routes of prescription stimulant administration employed (top) and preferred (bottom) for NMU among study participants. The white bar represents respondents who reported any NMU (n = 225), the black bar represents respondents who reported any amphetamine NMU (n = 209), the gray bar represents respondents who reported any methylphenidate NMU (n = 103).

**Table 2**
Self-reported motivations for prescription stimulant NMU among study participants by route of administration.

| Motivation for Prescription Stimulant NMU | Full sample (N = 225) | | Oral* (n = 192, 85%) | | Intranasal* (n = 223, 99%) | | Injected* (n = 14, 6%) | | Smoked* (n = 8, 4%) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | n | % | n | % |
| Attempted performance enhancement at work\school | 126 | 56.0 | 121 | 63.0 | 124 | 55.6 | 7 | 50.0 | 7 | 87.5 |
| To get high | 75 | 33.3 | 58 | 30.2 | 75 | 33.6 | 8 | 57.1 | 8 | 100.0 |
| To improve my mood or elevate my spirit | 30 | 13.3 | 24 | 12.5 | 30 | 13.5 | 2 | 14.3 | 2 | 25.0 |
| To treat ADD/ADHD | 28 | 12.4 | 23 | 12.0 | 28 | 12.6 | 0 | 0.0 | 0 | 0.0 |
| For energy | 26 | 11.6 | 25 | 13.0 | 26 | 11.7 | 2 | 14.3 | 2 | 25.0 |
| To enhance effect of other drugs | 3 | 1.3 | 3 | 1.6 | 3 | 1.3 | 2 | 14.3 | 2 | 25.0 |
| To prevent or treat withdrawal symptoms | 2 | 0.9 | 2 | 1.0 | 2 | 0.9 | 1 | 7.1 | 1 | 12.5 |
| By mistake (ex. forgot you already took it) | 1 | 0.4 | 1 | 0.5 | 1 | 0.5 | 1 | 7.1 | 1 | 12.5 |
| To control appetite or for weight loss | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Other reason | 1 | 0.4 | 1 | 0.5 | 1 | 0.5 | 0 | 0.0 | 0 | 0.0 |

* Responses are not mutually exclusive and do not add to 100%.

**Table 3**
Self-reported Concurrent Substance Use during Prescription Stimulant NMU.

| Other Substances Used Concurrently during Prescription Stimulant NMU Among Those Reporting Lifetime Prescription NMU via Non-Oral Routes (n = 225) | Number (%) Reporting Concurrent Use with Prescription Stimulant NMU | |
|---|---|---|
| | n | % |
| Any Concurrent Substance Use | 178 | 79.1 |
| Tobacco | 129 | 57.3 |
| Marijuana | 117 | 52.0 |
| Caffeine | 107 | 47.6 |
| Alcohol | 94 | 41.8 |
| Cocaine or crack | 34 | 15.1 |
| Tranquilizers or sedatives | 30 | 13.3 |
| Prescription opioids | 28 | 12.4 |
| Methamphetamine | 25 | 11.1 |
| Other illicit drug | 15 | 6.7 |
| Gabapentin | 13 | 5.8 |
| Heroin | 11 | 4.9 |
| Street fentanyl | 6 | 2.7 |
| Number of Substances* Used Concurrently during Prescription Stimulant NMU | | |
| None/zero | 47 | 20.9 |
| 1 substance | 43 | 19.1 |
| 2 or more substances | 135 | 60.0 |
| Number of Substances* Used Concurrently during Prescription Stimulant NMU (Excluding tobacco, alcohol and caffeine) | | |
| None/zero | 99 | 44.0 |
| 1 substance | 69 | 30.7 |
| 2 or more substances | 57 | 25.3 |

* Includes marijuana, cocaine or crack, tranquilizers or sedatives, prescription opioids, methamphetamine, gabapentin, heroin, street fentanyl and 'other' illicit drugs.

**Table 4**
Self-reported Influential Factors for Undertaking Prescription Stimulant NMU and Choice of Route of Administration for Prescription Stimulant NMU.

| Influential Factors | Total Sample (n = 225) | | Prescription Stimulant Injectors (n = 14) | |
|---|---|---|---|---|
| Why Undertake Prescription Stimulant NMU | n | % | n | % |
| Work or school schedule (such as days off from work or school, deadlines/exams) | 110 | 48.9 | 3 | 21.4 |
| Where I am using (such as home, school, work, or party) | 109 | 48.4 | 5 | 35.7 |
| Mood | 100 | 44.4 | 5 | 35.7 |
| Access to medication | 91 | 40.4 | 9 | 64.3 |
| Who I am with | 83 | 36.9 | 8 | 57.1 |
| Life events (either celebrations or events that cause stress such as accidents or loss of relationship) | 57 | 25.3 | 1 | 7.1 |
| Cost of medication | 43 | 19.1 | 1 | 7.1 |
| Difficulty accessing other medications or drugs | 36 | 16.0 | 5 | 35.7 |
| Route of Administration | | | | |
| The feeling or effect I want to get from using the medication or the reason you are using (to get high versus to enhance performance or for energy or treat withdrawal) | 128 | 56.9 | 9 | 64.3 |
| The specific medication I have available | 82 | 36.4 | 8 | 57.1 |
| Who I am with | 76 | 33.8 | 5 | 35.7 |
| Where I am using (such as home, school, work, or party) | 67 | 29.8 | 5 | 35.7 |
| Mood | 61 | 27.1 | 4 | 28.6 |
| How easy the product is to crush, chew, or dissolve | 52 | 23.1 | 4 | 28.6 |
| Work or school schedule (such as days off from work or school, deadlines, or exams) | 44 | 19.6 | 3 | 21.4 |
| Access to supplies needed to crush, dissolve, snort, smoke/vape or inject | 37 | 16.4 | 5 | 35.7 |
| Life events (either celebrations or events that cause stress such as accidents or loss of relationship) | 35 | 15.6 | 1 | 7.1 |

*Responses are not mutually exclusive and do not necessarily add to 100%.

reported lifetime use of other substances (Compton et al., 2018; Wilens et al., 2007; Rad et al., 2020; Grant et al., 2016). Compared to methylphenidate, more participants reported non-oral use and preference of amphetamine, which may be reflective of greater amphetamine prescription to adults (Burcu et al., 2016; Safer et al., 2016) hence more amphetamine circulating in the population and greater access. Non-oral amphetamine NMU elevates the risk of medical morbidity and mortality (Faraone et al., 2019); highlighting a concerning pattern of potential advancement along a prescription amphetamine non-oral NMU trajectory.

Motivations for non-oral use were primarily for desired work or school performance enhancement and less for the recreational-use motivations such as getting high (Compton et al., 2018) which is another consistent finding in the literature (Rabiner et al., 2009; Cassidy et al., 2015b; Schepis et al., 2020; Drazdowski et al., 2020; Schepis et al., 2020). However, to date, the degree of actual performance enhancement accomplished by prescription stimulant NMU is not clear (Arria et al., 2017, 2013; Donaldson et al., 2020; Ilieva et al., 2013; Smith & Farah, 2011), and seems not to be the case when considering academic GPA (Arria et al., 2017, 2013).

One novel addition of this study is a possible interaction between route of administration and motivation for use. Over half of the individuals who indicated they took prescription stimulants intranasally or orally did so in an attempt to enhance performance at work or school, whereas over half of the participants who injected or smoked indicated they did so to get high, a finding reflected in high school age adolescents (Liu et al., 2020). These findings may serve to generate hypotheses for future study.

**Table 5**
Self-reported Lifetime, Past Year, Past 30-day Use and Primary Route of Administration for Illicit Substances.

| Drug | Lifetime Use n (%) | Past Year Use n (%) | Past 30-day Use n (%) | Primary Route of Administration n (%) | Never Used n (%) |
|---|---|---|---|---|---|
| Marijuana | 221 (98.2) | 172 (76.4) | 116 (51.6) | Smoked, n = 220 (99.6) | 4 (1.8) |
| Cocaine or crack | 137 (60.9) | 62 (27.6) | 20 (8.9) | Snorted, n = 135 (98.5) | 88 (39.1) |
| Hallucinogens | 115 (51.1) | 51 (22.7) | 14 (6.2) | Chewed or dissolved in mouth, then swallowed, n = 80 (69.6) | 110 (48.9) |
| Illicit amphetamines/ methamphetamine | 82 (36.4) | 38 (16.9) | 14 (6.2) | Swallowed whole, n = 46 (56.1) | 143 (63.6) |
| Inhalants | 45 (20.0) | 19 (8.4) | 9 (4.0) | Smoked, n = 8 (17.8) | 180 (80.0) |
| Heroin | 35 (15.6) | 12 (5.3) | 5 (2.2) | Injected, n = 19 (54.3) | 190 (84.4) |
| Barbiturates | 25 (11.1) | 8 (3.6) | 4 (1.8) | Swallowed whole, n = 22 (88.0) | 200 (88.9) |
| Street fentanyl | 13 (5.8) | 5 (2.2) | 4 (1.8) | Injected, n = 5 (38.5) | 212 (94.2) |
| Other illicit drug | 17 (7.6) | 10 (4.4) | 3 (1.3) | Snorted, n = 10 (58.8) | 208 (92.4) |

In addition, these data also reveal that access to medication was an important influence for NMU, particularly among individuals reporting prescription stimulant injection. Access is accomplished, in part, through diversion, and in the present sample, 86.7% using diverted medication for prescription stimulant NMU. Three out of four obtained medication for NMU from friends or family, by either buying, being given or stealing the medicines.

Change in access has been found to decrease after college (Allen et al., 2017), however, over one-half of the present sample was beyond their college years underscoring continued access within this group of adults. Endorsed strategies of diversion (buying or selling from friends and family) coincide with more problematic substance use (Schepis et al., 2020), indirectly supporting this study's recruitment premise. The degree of diversion further underscores the need for greater awareness and education surrounding this issue (Compton et al., 2018; Colaneri et al., 2017, 2020; Wilens & Kaminski, 2020). A number of individuals received psychiatric diagnoses over the course of their lifetimes and may have access to various medications as a result.

Concurrent substance use with prescription stimulant NMU has been reported previously (Compton et al., 2018; Faraone et al., 2019; Schepis et al., 2020; Arria et al., 2013; Wilens et al., 2020; McCabe et al., 2015). In particular, alcohol and prescription stimulant use among college students was associated with negative outcomes (Schepis et al., 2019). The present study found that when tobacco, alcohol and caffeine were eliminated, 30.7% of the sample reported using 1 illicit substance concurrently with prescription stimulants and 25.3% reported using 2 or more illicit substances with prescription stimulants during NMU. Use of prescription stimulants with other substances was found to be associated with greater odds of having used prescription stimulants non-orally (McCabe et al., 2015), identifying an area where manipulation deterrent formulations may have a role.

Concurrent use of prescription stimulants and opioids is a particular combination of concern (Wei et al., 2018). Recent overdose data suggest a 'fourth wave' of the opioid epidemic that involves the increased use of illicit or prescription stimulants together with opioids resulting in fatal outcomes (Kariisa et al., 2019). These overdose data also reveal increases in deaths solely related to both illicit and prescription stimulant use (Kariisa et al., 2019). The present data reveal risky concurrent substance use patterns, including concurrent use of prescription stimulants with prescription or illicit opioids, as well as concurrent use of prescription and illicit stimulants, supporting an ongoing polysubstance landscape that can lead to fatal outcomes (Kariisa et al., 2019), particularly when injection substance use is included.

The primary reason for the decision to inject prescription stimulants was access to the medication and the desired effect. In fact, access to supplies and the ease of product preparation were reasons selected by approximately a quarter of injectors. Taken together, these data reveal a pattern of prescription stimulant NMU that involves both oral and non-oral polysubstance use that could potentially be impacted by efforts to limit inappropriate access to supplies, reduce stimulant diversion and modify products to resist physical manipulation necessary for non-oral routes of administration.

The strengths of the study include the recruitment of a unique adult sample with past 5-year non-oral prescription stimulant NMU, and the capture of specific details regarding non-oral NMU. However, limitations must be considered. This was an internet survey that relied on self-report, where the actual dates and frequency of participants' non-oral use were not collected. Data were a convenience sample of limited demographic diversity that is subject to various biases and error that accompany any self-report study. However, it should be emphasized that certain data that describe individual use, such as route of administration or motivations for use can only be accessed via self-report. Nonetheless, these data cannot be used to draw nationally-representative inferences about non-oral prescription stimulant NMU patterns. Asking participants to recall their non-oral, NMU over a 5-year period is a long time-window for recollection. However, one purpose of this study was to determine whether it was possible to recruit a large-enough sample based on the non-oral NMU criterion, which, to the best of our knowledge, is a novel undertaking. Typically, samples with NMU are recruited and subgroups are created with the characteristics of interest (cf. Burtner et al., 2018; Cassidy et al., 2015a; McCabe et al., 2015). In this case, we wanted to include as many individuals as possible to achieve an enriched sample of individuals engaged in prescription stimulant NMU by various routes of administration. A sensitivity analysis conducted with the n = 171 individuals who reported past-year prescription stimulant NMU revealed a similar pattern of findings. Furthermore, findings reported here are similar to other studies involving national survey data and nationally representative data as detailed herein (Cassidy et al., 2015b, 2015a; Burtner et al., 2018; McCabe et al., 2019). The number of prescription stimulant injectors was small hence these data should be interpreted with caution.

In summary, this study characterizes the complex substance use profile associated with non-oral prescription stimulant NMU among adults. These data describe substantial risky behavior, including polysubstance use and alternate routes of administration, as well as diversion. These findings are critical to provider and patient education and contribute to the study of substance use transitions and the development of medications that deter physical manipulation necessary to prepare medications for non-oral use.

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RR and JLG are employees of Inflexxion, an IBH Company. SKV is an independent scientific writer who contracts with Inflexxion.

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He is Program Director of www.adhdinadults.com.

## CRediT authorship contribution statement

**Suzanne K. Vosburg:** Conceptualization, Writing – original draft, Writing – review & editing, Visualization. **Rebekkah S. Robbins:** Methodology, Visualization, Data curation, Formal analysis, Software. **Kevin M. Antshel:** Writing – review & editing, Conceptualization. **Stephen V. Faraone:** Writing – review & editing, Conceptualization. **Jody L. Green:** Conceptualization, Methodology, Project administration, Resources, Supervision, Funding acquisition.

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