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Exploring the Geographical Diffusion of Prescription Drug Misuse by Teens

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Abstract

This paper examines the geographical diffusion of prescription drug misuse by teens in the United States and compares it with the geographical diffusion of methamphetamine, marijuana, and alcohol. Currently, there is no systematic evidence of how usage patterns of potentially addictive but licit drugs, such as prescription drugs, geographically diffuse, raising questions of how to best prevent their abuse and treat their consequences. We find evidence that the geographical diffusion of drugs of abuse by teens varies by the drugs' social acceptability, supply, legal status, and use in medical treatments. We also find that the diffusion of prescription drug misuse among teens fails to resemble the patterns of methamphetamine, marijuana, and alcohol, raising the need for a national prevention effort to stem this growing public health problem.

This paper examines the geographical diffusion of prescription drug misuse by teens in the United States and compares it with the geographical diffusion of methamphetamine, marijuana, and alcohol. We define geographical diffusion as the change in locational usage patterns of a particular type of drug. Public health professionals, public policymakers, and law enforcement officials have long considered how illicit drugs diffuse geographically, and there is some evidence that usage migrates during the lifecycles of illicit drugs.¹ But there is no systematic evidence of how usage patterns of potentially addictive but licit drugs, such as prescription drugs, geographically diffuse, raising questions of how to best prevent their abuse and treat their consequences.

To address this gap in the literature, we use a four-fold categorization methodology to predict the level and type of diffusion of these four drugs and secondary data and information sources to ascertain diffusion patterns. We find evidence that the geographical diffusion of drugs of abuse by teens varies by the drugs' social acceptability, supply, legal status, and use in medical treatments. We also find that the diffusion of prescription drug misuse among teens fails to resemble the patterns of methamphetamine, marijuana, and alcohol, raising the need for a national prevention effort to stem this growing public health problem.

Why Study the Geographical Diffusion of Drugs of Abuse by Teens?

There are two reasons to study the geographical diffusion of drug of abuse by teens. First, there is a high prevalence of teen drug use and substantial personal and social consequences associated with the behavior. Usage information suggests that, over a recent 12-month period, 66 percent of 12th graders reported using alcohol, 33 percent reported the use of marijuana, 3 percent indicated using inhalants, and up to 10 percent noted the use of other drugs, including hallucinogens, cocaine, heroin, methamphetamine, and prescription drugs.² Teen drug use has wide-scale physical and social consequences. From a physical perspective, drugs alter the way the brain works and processes information. Because the brain continues to develop until age 25, the disruption in normal neurotransmission in adolescence can lead to short and long-term structural damage and cognitive impairment.³⁻⁸ Crystal methamphetamine particularly damages the brain and may lead to severe and long-

term disturbances in neural functioning.^{9,10} Early initiation of drug use increases the likelihood of long-term addiction,¹¹⁻¹³ and long-term drug abuse can lead to liver, heart, kidney, lungs and stomach disease, cancer, cardiovascular complications, skin and vascular changes, periodontitis and other oral health problems, and a weakened immune system.¹⁴⁻²⁴

From a social perspective, teen drug users are more likely to engage in risky behaviors, such as driving while under the influence, violence, and unsafe sexual behaviors.^{11,25-29} Girls who are under the influence of drugs or alcohol are more likely to be the victims of physical and sexual assault.^{29,30} Adolescent substance abuse also relates to depression and other mental health problems.^{11,31-33} Teens who abuse drugs and alcohol are also more likely to struggle academically and drop out of school than those students who do not abuse drugs,^{12,34,35} making them less competitive for jobs and participation in the labor market.

The second reason to study geographical diffusion patterns is that adolescent drug use varies in its historical distributional patterns,³⁶ making it difficult to develop and formulate regional or localized prevention and policy efforts. For example, the western and northeastern regions of the United States exhibit generally higher rates of adolescent substance abuse than the rest of the nation, but the usage patterns tend to vary by drug type and states within a single region, which may relate to the effectiveness of local prevention approaches. For example, Komro et al. examined the effectiveness of a multi-component alcohol prevention program in schools in Chicago.³⁷ Although effective in reducing alcohol use and related risk factors in adolescents in Minnesota in 1996, the program was ineffective in reducing alcohol use in teens in Chicago in 2005. The authors suggest regional and local differences in the evaluation settings along with historical patterns of drug abuse may explain the findings.

Although there is limited research on the geographical diffusion of adolescent drugs of abuse, Golub and Johnson modeled the lifecycles of certain illicit drugs, including marijuana, heroin, crack, and MDMA, and found four phases of drug diffusion: incubation, expansion, plateau, and decline.^{1,38-40} In the incubation period, a drug gains popularity in localized geographical regions and subgroups of the population. Next, the drug expands beyond these localized regions or subgroups through better production

methods, increased supply, or heightened popularity in mainstream social networks. Expansion will continue if there is sufficient supply and demand of the drug. Third, drug use plateaus due to changes in supply and demand, influenced in part by public attitudes. Finally, the drug declines because of supply disruptions, public policy and public health efforts, such as increased drug enforcement and changes in treatment and prevention, and the availability and rise in popularity of new drugs.

Although the Golub and Johnson model informs our understanding of the lifespan and diffusion of particular types of drugs of abuse, we hypothesize that their model may be less efficacious in explaining the geographical diffusion of drugs that are not expressly illegal, such as alcohol and prescription drugs. Indeed, though alcohol is illegal for those under 21 years of age, it is not a generally banned substance. In addition, it is heavily advertised, which may lower perceptions of risk about its use, particularly among adolescents.⁴¹ Prescription drugs have different and potentially more vexing factors to address than alcohol. First, in addition to their widespread availability in unlocked medicine cabinets in many homes, teens may have their own prescriptions for controlled medications with the potential for abuse. Second, unlike illicit drugs and alcohol, prescription drugs may be beneficial when used as prescribed by physicians. Compared with other drugs, the potentially beneficial nature of prescription medication may further lower an adolescent's risk calculation about the drug, thereby increasing the probability of abuse.

In this paper, we build on the work by Golub and Johnson to descriptively explore the geographical diffusion of adolescent alcohol and prescription drug use and how these diffusion patterns compare with illicit drugs, such as methamphetamine and marijuana. By taking a new comparative look at the historical and geographical patterns, public health professionals and public policy makers may be better equipped to formulate and time prevention efforts to match local considerations.

Methodology

To examine the geographical diffusion of drugs among adolescents in the U.S., we used three information sources. First, we used the National Survey on Drug Use and Health (NSDUH) to understand marijuana, alcohol, and prescription drug use in 12-17 year olds from 2002-2008.⁴² The NSDUH presents

national and statewide estimates of licit and illicit drug use among people ages 12 and older. Households are randomly selected to participate in the NSDUH, and multiple people from a single household may participate. Approximately 70,000 people are surveyed annually. Researchers administer the survey in-person through a computerized system that allows participants to confidentially record their responses to questions about demographics, substance use, behaviors, and mental health. Results are reported by drug, region, state, age, and across years, allowing for multiple comparisons of patterns in use and geographical diffusion.

Second, we used the National Institute on Drug Abuse's Monitoring the Future (MTF) report,² to ascertain information from 1991 to 2007 on licit and illicit drug use among secondary school and college students in the United States. Approximately 50,000 randomly selected students participate in the annual survey. The MTF reports usage by age and type of drug.

Third, we used information from the Drug and Alcohol Services Information System (DASIS) report to examine the geographical diffusion patterns of methamphetamine and marijuana use among adolescents.⁴³ The DASIS report draws on data from the Treatment Episode Data Set (TEDS) for the geographical differences in substance abuse treatment admissions for alcohol, methamphetamine, and marijuana among 12 to 20 year olds from 1995 to 2005. The TEDS includes demographic characteristics and substance abuse problems of those admitted to publically supported treatment facilities in the United States.

The data in this analysis are cross-sectional and lack the inferential strength of longitudinal studies, where the same cohort is studied at multiple time intervals. Thus, statistical measures were taken to standardize drug usage rates to the 2007-2008 values to allow for comparison over time, including a survey-weighted hierarchical Bayes estimation approach and a Bayes posterior probability of no change.

We used these data and information sources to descriptively examine the geographical diffusion of four drugs: methamphetamine, marijuana, alcohol, and prescription drugs. We hypothesize that these drugs diffused differently due to their variability along four categorical dimensions, namely, social acceptability, supply, legality, and medical use. We describe each dimension below.

- Social acceptability is the degree to which norms about the recreational or therapeutic use of the drug supports or discourages its use. Other components of social acceptability include the stigma associated with use and frequency and valence of media portrayals of the drug and those that use it.
- Supply is the availability of the drug in a local area and the types and severity of barriers to obtaining the drug.
- Legality: Drugs vary in the legal requirements to possess and use them. This dimension means the degree to which the drug is legally available, as a whole or to certain subgroups, and the legal penalties for its misuse.
- Medical use is the extent to which the drug, when used as directed, has a documented medical use and/or application to prevent or treat disease.

We assess methamphetamine, marijuana, alcohol, and prescription drugs with a three-fold relative categorization scheme, including low, moderate, and high dimensions. As noted in Table 1, the four drugs vary substantially along these conceptual criteria.

Table 1. Criteria for Predicting Geographical Diffusion

Criterion	Low	Moderate	High
Social Acceptability	Methamphetamine	Marijuana	Alcohol, Prescription drugs
Supply	Methamphetamine	Marijuana	Alcohol, Prescription drugs
Legality	Methamphetamine	Marijuana	Alcohol, Prescription drugs
Medical Use	Methamphetamine	Marijuana, Alcohol	Prescription drugs

Methamphetamine

Methamphetamine is a chemically-synthesized, artificial stimulant drug that is highly neurotoxic and addictive. As a dopamine agonist, it causes intense euphoria followed by a severe crash and craving for more of the drug. When synthesized as an illegal drug, methamphetamine has no known medical uses.

Because of its negative social and physical side effects, including increased involvement in the legal system and distinctive changes in physical appearance associated with use, the drug has relatively low social acceptability. Compared with other drugs in Table 1, methamphetamine also has low supply: it is illegal to possess, purchase, and use under all circumstances. Given these factors, we expect that the diffusion of methamphetamine will follow a relatively linear pattern, in which subsequent geographical locations and subpopulations will become attracted to and use the drug.

Marijuana

Marijuana is the dried leaves of the cannabis plant. When smoked, THC, a chemical in the marijuana, binds with receptors in the brain and causes sedative and hallucinogenic effects. Marijuana is the most commonly used illicit drug among youth in the United States, with 33 percent of 12th graders reporting usage in the last year.² Marijuana use is addictive and often produces negative outcomes, including impaired cognitive development and amotivational syndrome. Marijuana is particularly damaging to the developing adolescent brain, resulting in poor spatial working memory, damaged brain white matter, decreased attention, learning, and brain processing speeds, poor mental flexibility and abstraction, altered neurotransmission and central nervous system cell apoptosis, and decreased memory functioning and recall.^{4-8,44,45}

Relative to the other drugs in this analysis, marijuana has moderate social acceptability and, despite interdiction efforts by the federal government and state and local law enforcement, a moderate level of supply. In fact, a predominance of marijuana that is sold in the U.S. is locally grown and produced.⁴⁶ Marijuana is also legal in some circumstances for applicable medical uses. We expect that the diffusion of marijuana use by adolescents will differ from methamphetamine inasmuch as it will be less geographically linear.

Alcohol

Alcohol is a legal drug for adults over the age of 21. Alcohol enters the bloodstream by drinking and binds with neurotransmitters in the brain to sedate brain activities. Alcohol is, by far, the drug most commonly used by youth. Over 70 percent of high school seniors report the use of alcohol in their

lifetime.² Alcohol use relates to high risk activities, such as early sexual initiation, violence, and accidents, and negative physical consequences, including damaged white brain matter, liver damage, alcohol poisoning and death.^{5,27-29} Alcohol use may result in addiction.

Compared with methamphetamine and marijuana, alcohol has a high degree of social acceptability and supply, evidenced by heavy advertising, media exposure in print, multimedia, and points of purchase. Though illegal in the U.S. for adolescents to purchase or consume, alcohol is legal for those 21 years of age or older. The health risks of heavy alcohol use are well documented, but there are statistically established medical benefits of the moderate consumption of alcohol, particularly red wine. Taken together, these factors may reduce the perceived risk of alcohol use among adolescents and make usage patterns more geographically diffuse.

Prescription Drugs

Prescription drugs have shown recent increases in use among adolescents and are now used more than any illicit drug, with the exception of marijuana. Each day, 2,700 teens abuse prescription drugs for the first time (DHHS & SAMHSA, 2009a). Increasing numbers of teens are abusing scheduled prescription drugs, including opioids (e.g. OxyContin), stimulants (e.g. Adderall and Ritalin) and sedatives (e.g. Xanax).^{2,47} In fact, one in four teens knows at least one classmate or friend who abuses prescription drugs, which is a 19 percent increase since 2007.²⁹

Of the four drug categories in this analysis, only prescription drugs rank high on four of the classification criteria. Indeed, because of their potential medical benefits, when used as directed, they have a high level of social acceptability. They are readily available, not only in institutional settings, such as pharmacies, but also through internet purchases and in the home. When prescribed by a physician, prescription drugs are legal throughout the United States, and their role in treating a wide array of physical and mental conditions is well documented. On the whole, the ubiquity of prescription drugs may produce the most highly geographically diffuse usage pattern among adolescents, compared with methamphetamine, marijuana, and alcohol.

Findings

The data and information sources yield several findings about the diffusion of the use of methamphetamine, marijuana, alcohol, and prescription drugs among adolescents. For the purposes of this study, we use four regions – Northeast, Midwest, South, and West, which correspond to the regional definitions used by the U.S. Bureau of the Census, to discuss their geographical diffusion.

Methamphetamine

The geographical diffusion of methamphetamine generally followed the Golub and Johnson model by tracking on a relatively linear pattern across the U.S. The use of methamphetamine began in the early 1990s among bikers primarily in select areas of western states, including California, Nevada, Oregon, Montana and Colorado.⁴⁸ By 1997, methamphetamine production and abuse had spread through the West and into the Midwest, but states in the Northeast and South were virtually unaffected. By 2002, methamphetamine had diffused into the South, while usage rates began to plateau in Western and Midwestern states with a concomitant increase in methamphetamine-related rehabilitation admission rates. States in the Northeast, including Pennsylvania, New York, Massachusetts, Rhode Island, New Jersey, and Delaware, remained largely unaffected by methamphetamine through 2006.⁴⁸ By 2007, overall methamphetamine use began to decline. Indeed, 41 states reported reductions in usage and treatment rates. However, Northeastern and Southern states, such as Massachusetts, New Jersey, New York, Rhode Island, Kentucky, Louisiana, and Virginia, experienced an increase in rehabilitation admission rates, despite the overall national trend of reduction, indicating methamphetamine's geographical diffusion into these states.

Marijuana

Compared with methamphetamine, marijuana use followed a less linear geographical pattern. Indeed, as the inner city crack epidemic of the 1980s declined, New York and other urban centers experienced a rise in marijuana use and distribution among adolescents. During the 1990s, marijuana use expanded from the inner cities and subgroups into mainstream youth culture across the U.S.^{49,50} As of 1995, marijuana had expanded primarily into states in the Pacific Northwest, Midwest, and Northeast, with Oregon, Montana, Iowa, and Colorado seeing the largest impact.³⁶ By 2005, marijuana use had

plateaued in much of the Pacific Northwest and Midwest and had expanded heavily into other states in the West, Northeast, and South.

Among teens aged 12-17, slight regional differences existed in 2007 in terms of reported marijuana use, though marijuana use remained relatively high and geographically diffuse throughout the U.S. The Western and Northeastern regions reported the heaviest marijuana use among teens, though there were outliers, including Idaho and Utah, which had marijuana usage rates that were significantly below the national average. The Midwestern and Southern regions ranked three and four, respectively, in terms of reported teen marijuana use in the last year with rates lower than the national average. Though only Mississippi and Utah were significantly below the regional and national average, many states reported higher than average prevalence rates. These states generally clustered in the Northeast (Maine, Massachusetts, New Hampshire, Rhode Island, Vermont) and West (Colorado, Montana, New Mexico, Oregon, Wyoming). Two states, New Jersey and North Carolina, experienced a statistically significant reduction in teen marijuana use from 2006-2007 to 2007-2008, while one state, Pennsylvania, showed a statistically significant increase.⁴² The statistically significant decrease in New Jersey may indicate the decline phase of Golub and Johnson model and the statistically significant increase in Pennsylvania may show the presence of the expansion period in their model. The increase in Pennsylvania brings the state in line with the rest of the region, where the prevalence of marijuana use in teens is the highest among all regions. As with the regional and state differences in expansion and plateau, the model of diffusion combined with geographical diffusion patterns suggests that the decline may vary in degree and timing across the U.S.

Alcohol

Compared with methamphetamine and marijuana, alcohol followed a less linear geographical diffusion pattern. Indeed, the overall position of regions, in terms of magnitude of prevalence, has remained relatively constant. The Northeast and Midwest regions consistently rank first and second, respectively, with prevalence rates higher than the national average. In 2003, the Western region eclipsed the Southern region to take the third position in terms of prevalence, but both regions consistently have

prevalence rates below the national average. Nonetheless, reports of lifetime use of alcohol among 12th grade students remained high,² and reports of past month use of alcohol among teens and young adults ages 12-20 held relatively constant, from 2002 to 2009.⁴²

Past month alcohol use in teens aged 12-17 decreased slightly each year in the Northeast, Midwest, South, and West from 2003-2008, but the regions retained these same relative positions. Notable differences in use among teens exist between regions, however, with the Northeast and West reporting higher rates of alcohol use than the Midwest and South. The states with usage rates significantly below the national average followed this regional diffusion and clustered around the South (Washington DC, Georgia, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee) and West (Idaho, Utah). Those with rates significantly above the national average also followed the regional split, clustering around the Northeast (Connecticut, Massachusetts, New York, Rhode Island, and Vermont), Midwest (North Dakota, South Dakota, and Wisconsin) and West (Montana and Wyoming). All regions exhibited statistically significant reductions in teen alcohol prevalence rates at the 0.05 level between 2006-2007 and 2007-2008. As with the regional and state differences in expansion and plateau, Golub and Johnson diffusion model, combined with geographical diffusion patterns, may suggest that the decline will vary in degree and timing in the U.S.

Prescription Drugs

Because prescription drugs are typically prescribed legally, it is difficult to accurately track their misuse and abuse, a statistical problem that is compounded by the rapid escalation in the number of prescriptions that are written in the U.S. Indeed, between 1992 and 2002, the number of prescriptions for controlled medications rose by 154 percent, a rate that is 12 times faster than the growth of the population and significantly higher than the growth rate for non-controlled medication prescriptions.⁴⁷ Still, there is emerging evidence on the geographical diffusion of prescription drug abuse among teens. Similar to methamphetamine, the rise in abuse started in adults and spread into the teen population. There is some evidence that the incubation period in prescription drug abuse among teens began in the West and South in the late 1990s, which correlated with the reported decline in marijuana abuse among this

population.^{47,51} Prescription drug misuse among teens expanded nationally in the early 2000s and declined slightly until 2008 to a national rate of roughly 2.3 percent in 2008.⁴² Indeed, the national average of nonmedically used prescription pain relievers in teens ages 12-17 was 2.3 percent in 2008,

But peeling back these national rates shows largely geographically diffuse usage patterns. Indeed, compared with the other three substances, prescription drugs show the least linear geographical diffusion. The only constant is that the Northeast has had the lowest prevalence rates of nonmedical use of pain relievers since NSDUH began collecting data on it in 2003. In contrast, the Western, Midwestern, and Southern regions fluidly change positions each year. What is more, while the southern region on the whole exhibited a statistically significant decrease in teen prescription drug prevalence rates between 2003 and 2008, three states in South showed significant increases at the 0.05 level (Alabama and Louisiana) and 0.10 level (Florida). Adding to the complexity of understanding the geographical diffusion of prescription drugs is that states, including Connecticut, Washington DC, Hawaii, Indiana, Maryland, Mississippi, Nebraska, New Jersey, New York and South Dakota, that report below average rates of abuse are not geographically clustered.⁴²

Implications

The findings of this paper suggest that methamphetamine and to a lesser extent marijuana followed relatively linear geographical diffusion patterns, while alcohol and prescription drugs show substantially less linearity in their diffusion. Indeed, alcohol consumption by teens remains at a relatively high and stable level and shows limited geographical linear diffusion. And though data are slowly emerging on the diffusion of prescription drug misuse by teens, initial results show nearly no geographical linearity. With respect to prescription drugs, the lack of geographical linearity in teen misuse may relate to the interacting nature of their social acceptability, plentiful supply, legal status, and legitimate medical uses, when used as prescribed. The combination of these effects makes prevention efforts problematic, particularly in crafting public health initiatives and law enforcement policy. Indeed, unlike methamphetamine, which due to its geographical diffusion pattern provided public health and law enforcement officials some predictive warning on emerging drug issues in their communities, prescription

drug misuse by teens has no significant and discernible pattern of geographical diffusion. The prevention and policy question that flow from these findings is how can public officials overcome the lack of geographical linearity in the diffusion of prescription drug misuse by teens.

In order to address this question, we suggest that public officials scale consider mounting a widescale national campaign, using multiple forms of media, to publicize the hazards of teens' misuse of prescription drugs. Such an approach may overcome the geographically diffuse nature of the problem by reaching not only geographical locations where prescription drug misuse is a public problem, but also those that have not been adversely impacted. One may argue that a dedicated campaign toward the prevention of prescription drug misuse, particularly by teens, could shine a brighter light on this public problem than subsuming it with illicit drugs that fail to share similar characteristics.

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