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# Alcohol as a Gateway Drug: A Study of US 12th Graders

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## ABSTRACT

**BACKGROUND:** The Gateway Drug Theory suggests that licit drugs, such as tobacco and alcohol, serve as a ''gateway'' toward the use of other, illicit drugs. However, there remains some discrepancy regarding which drug—alcohol, tobacco, or even marijuana—serves as the initial ''gateway'' drug subsequently leading to the use of illicit drugs such as cocaine and heroin. The purpose of this investigation was to determine which drug (alcohol, tobacco, or marijuana) was the actual ''gateway'' drug leading to additional substance use among a nationally representative sample of high school seniors.

**METHODS:** This investigation conducted a secondary analysis of the 2008 Monitoring the Future 12th-grade data. Initiation into alcohol, tobacco, and other drug use was analyzed using a Guttman scale. Coefficients of reliability and scalability were calculated to evaluate scale fit. Subsequent cross tabulations and chi-square test for independence were conducted to better understand the relationship between the identified gateway drug and other substances' use.

**RESULTS:** Results from the Guttman scale indicated that alcohol represented the ''gateway'' drug, leading to the use of tobacco, marijuana, and other illicit substances. Moreover, students who used alcohol exhibited a significantly greater likelihood of using both licit and illicit drugs.

**CONCLUSION:** The findings from this investigation support that alcohol should receive primary attention in school-based substance abuse prevention programming, as the use of other substances could be impacted by delaying or preventing alcohol use. Therefore, it seems prudent for school and public health officials to focus prevention efforts, policies, and monies, on addressing adolescent alcohol use.

**Keywords:** alcohol; gateway drug; substance use; Guttman scale; adolescents.

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Underage alcohol consumption represents a nationwide public health concern.[1-4] Despite being illegal, 11% of the nation's annual alcohol consumption is performed by persons between the ages of 12 and 20 years.[5] Moreover, the majority of underage drinkers report drinking heavily (5 or more drinks at a sitting).[5]

According to the Centers for Disease Control and Prevention's 2009 Youth Risk Behavior Surveillance System (YRBSS) that monitors youth risk behaviors in grades 9-12, 72.5% of students have consumed at least 1 drink of alcohol during their life (ie, ever drank alcohol).[1] In 2009, rates of current alcohol use were 3.5% among persons aged 12 or 13, 13.0% of persons aged 14 or 15, 26.3% of those aged 16 or 17 years, and 49.7% of those aged 18 to 20.[3] Thus, there is a clear upward trend of increased alcohol use among minors as they develop and get older. Among 8th-grade students participating in the 2008 Monitoring the Future (MTF) study, nearly 4 out of 10 (39%) reported some alcohol use in their lifetime, and 16% self-identified as a current (past 30-day) drinker.[2]

In addition to the legal ramifications associated with underage drinking, alcohol consumption by minors can lead to numerous harmful consequences, including academic problems, delinquent behavior, and substance use.[6] A strong relationship appears to exist between alcohol use among youth and many social, emotional, and behavioral problems, such as fighting, stealing, skipping school, feeling depressed, and deliberately trying to hurt or kill themselves.[7] In addition, high rates of absenteeism and truancy were characteristic of substance use among elementary, middle, and high school students.[8] High school seniors who engage in increased alcohol abuse and/or truant behavior also exhibit decreased educational aspirations, in that fewer students indicate a desire to attend a 4-year college/university.[9] Stueve

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and O'Donnell[10] found that in a sample of urban African American and Hispanic youths, early drinking was associated with sexual risk taking, including unprotected sexual intercourse, multiple partners, being drunk during intercourse, and pregnancy.[10]

The age at which young people begin drinking alcohol has also been linked to later alcohol misuse and dependence, such that the earlier one begins to drink the greater the risk of abusive consumption.[11-13] Dawson et al contend that individuals who begin using alcohol in the pre- and early adolescent years (prior to age 15) are at significantly greater risk of developing *Diagnostic and Statistical Manual of Mental Disorders, 4th edition* (DSM-IV) alcohol use disorders.[14] Moreover, early drinking onset is associated with subsequent alcohol abuse and alcohol-related problem behaviors in later adolescence, including alcohol-related violence, injuries, driving under the influence of alcohol and drugs, and alcohol- and drug-related absenteeism from school or work.[15] Considering the negative outcomes associated with underage/adolescent alcohol consumption, and the increased likelihood of associated negative health outcomes, alcohol use by minors represents an obstacle to positive growth and development, as well as a potential stepping stone to future drug use.

### Gateway Theory

Formerly known as the Stepping Stone Hypothesis and Multiple Stage Progress Theory,[16] the Gateway Drug Theory suggests that licit drugs, such as tobacco and alcohol, serve as a ''gateway'' toward the use of other, illicit drugs.[17] In other words, the use of licit drugs (eg, alcohol, tobacco) will lead to the use of illicit substances (eg, cocaine, heroin). First discussed in the 1930s, the Stepping Stone Theory historically considered the progression into drug involvement to be unalterable, with the use of marijuana inevitability leading to heroin addiction.[18] This position was derived from erroneous interpretation of data gathered from heroin addicts which found that all participants using marijuana would eventually also use heroin. Subsequent studies among the general population later rebuked these contentions.[18] More specifically, Kandel[19] asserted that adolescent drug users progressed through 4 stages/sequences of substance use: (1) nonusers to beer/wine drinkers; (2) from beer/wine drinkers to cigarettes and hard liquor; (3) from cigarettes/hard liquor users to marijuana; and (4) from marijuana to other illicit drug use. This progression became known as the multiple stage progress theory,[16] laying the foundation for the development of the Gateway Hypothesis.

Emerging in the 1980s, the Gateway Hypothesis asserts that entry into a particular drug stage is a common, and perhaps even a necessary step, but is not a sufficient prerequisite for entry into the next higher stage.[18] Said another way, the use of a licit drug is a common step toward using illicit drugs; however, licit drug use does not predict later illicit drug use. The Gateway Hypothesis holds that substance use typically follows a series of stages or progressions. Specifically, individuals typically progress from nonuse of any substance as a child to use as a child, to use of alcohol and/or tobacco in early adolescence, potentially followed by use of marijuana and/or other illicit drugs.[18]

Despite the historic literature base associated with the Gateway Hypothesis, this theory is not universally accepted. Critics contend that a sequence of initiation does not necessarily demonstrate a causal link/chain in the initiation into, and use of, different drugs.[18] Perhaps the most controversy surrounding the Gateway Hypothesis stems from discrepancy regarding which drug—alcohol, tobacco, or marijuana—serves as the initial ''gateway'' drug subsequently leading to the use of other illicit drugs. After examining the behaviors of a sample of New York teenagers, Welte and Barnes asserted that unless alcohol was used first, there was a very small likelihood that any other drug, including cigarettes and over-the-counter drugs, would be used later in life.[20] Utilizing a longitudinal sample, Kosterman et al demonstrated that youth who had initiated alcohol use were more likely to initiate marijuana use.[21] Conversely, Torabi et al reported that among Indiana students grade 5-12, cigarette smoking predicted later use of alcohol and other drugs.[22] In adolescents of diverse ethnic groups, Chen et al confirmed Torabi, Bailey, and Majd-Jabbari's results, reporting that prior initiation of cigarette smoking predicted current alcohol use.[16] Lai et al also reported that those who smoked cigarettes before age 15 were up to 80 times more likely to use illegal drugs than those who did not.[23] However, Yamaguchi and Kandel contend that adolescents are unlikely to use marijuana without prior experimentation with alcohol or with cigarettes; few try illicit drugs without prior use of marijuana.[24] Kandel, Yamaguchi, and Chen reported that between 86% and 90% of persons using both marijuana and other illicit drugs used marijuana prior to the use of other illicit drugs.[25] Tartar et al found that in neighborhoods where there is high drug availability, youth who have low parental supervision are likely to regularly consume marijuana before alcohol and/or tobacco.[26]

Considering the discrepancy stemming from which substance represents the gateway to illicit drug use, 2 questions are manifest: (1) Which substance—alcohol, tobacco, or marijuana—comes first (ie, ''gateway'') in the temporal order of substance use? (2) Does the gateway and subsequent drug use, in fact, follow a progression from licit to illicit? Consequently, the purpose of this investigation was to determine which drug (alcohol, tobacco, or marijuana) represents the

actual ''gateway'' drug leading to additional substance use among a nationally representative sample of high school seniors. By examining a national sample, this investigation will account for the limitations associated with state-specific sampling frames that pervade previous gateway hypothesis and drug progression research.[16,17,19,20,22,24]

## METHODS

### Procedures

***Data Collection.*** This investigation constitutes a secondary analysis of 2008 MTF 12th-grade data. Monitoring the Future has been conducted annually by the University of Michigan's Institute for Social Research since its inception in 1975. It is supported under a series of investigator-initiated, competing research grants from the National Institute on Drug Abuse.[2] The primary focal areas of the MTF study are use and abuse of tobacco, alcohol, and other drugs by young adults, and their perceptions and attitudes toward these substances. Approximately 14,600 12th graders from a nationally representative sample participated in the 2008 MTF. For more detailed information regarding the MTF project, interested readers are referred to www.monitoringthefuture.org.

This investigation examined MTF items assessing one's lifetime/ever-use of alcohol, tobacco, and other drugs (ATOD). For example, items inquired ''On how many occasions (if any) have you used alcohol in your lifetime.'' Response options included 0 occasions, 1-2 occasions, 3-5 occasions, 6-9 occasions, 10-19 occasions, 20-39 occasions, and 40 or more occasions. A total of 11 ATOD items reported in MTF were analyzed. These items addressed each respondent's use of alcohol, cigarettes, marijuana, cocaine, LSD, heroin, amphetamines, tranquilizers, sedatives, hallucinogens other than LSD, and other narcotics.

***Data Analysis.*** To accomplish the primary objectives of this investigation (establish the temporal order and subsequent progression of substance use), ATOD initiation data were analyzed using a Guttman scale. Once the gateway drug for this sample was established via the Guttman scale, cross tabulations and chi-square tests for independence were conducted to further understand the relationship between the gateway drug and other licit and illicit substances.

Guttman scales represent a set/series of scores in which an answer to an earlier item predicts answers to all subsequent items in a series. In other words, Guttman scales create a response order/pattern in which a single score can elicit the overall response pattern. Guttman scale analysis is well suited to the study of stages of drug use progression because of its underlying assumptions of cumulativeness and unidimensionality.[18] A perfectly unidimensional Guttman scale features that a participant who gives the positively keyed response (ie, reports using a given drug) to a more ''difficult'' (ie, illicit drugs) item will also give the positive response to all items that are less ''difficult.''[27] In other words, if a respondent reports heroin use, then he will also report alcohol, tobacco, and marijuana use. The Guttman scale is a cumulative scale because all participants ''accumulate'' positive responses to the items—in this case indicators of increasing drug use—in the same order, from the ''easiest'' to the most ''difficult.''[27] Using the Guttman scale model related to adolescent drug use implies that youth at any 1 step have used the drug at that particular level as well as all lower ranked drugs, but they have not used any of the higher ranked drugs.[19]

### Guttman Scale Coding Procedures

To construct the Guttman scale for this investigation, lifetime/ever-used drug data from each respondent was categorized into a matrix using Microsoft Excel 2010 (Microsoft Corporation, Redmond, WA). Students who indicated using a substance at any point in their lifetime (ie, use on at least 1 or more occasions) were coded as ''1'' (initiation). Responses were coded ''0'' (abstention) if participants indicated that they had never used the substance (ie, 0 occasions) in their lifetime. We chose to employ dichotomous lifetime/ever-use measures of ATOD for several reasons. First, MTF does not document age of initiation data. Second, previous investigations indicate that Guttman scale fit is the strongest when utilizing dichotomous lifetime use, even when compared to scales based upon age of initiation data.[28]

After all respondents were included in this matrix, the ever-used ATOD items (ie columns) were rearranged by item score, from the highest to the lowest proportion of positive responses. Next, the respondents (ie, rows) were arranged so that the participants were ranked from the greatest number of favorable responses to the fewest. Therefore, respondents with equal scores should also have identical responses to the items in the Guttman scale.[29] At the conclusion of the restructuring, the matrix should reflect a triangular pattern, similar to that of a correlation table (Figure 1).

### Evaluating Guttman Scale Fit

A perfect Guttman scale will form a triangle of 1s, as depicted in Figure 1. In other words, a matrix with no errors will exhibit a triangle consisting of only interior 1s (ie, indication of ATOD use), such that all 0s (ie, non-use) fall outside of the triangle. In simplest terms, a 0 in the interior of the matrix triangle represents an error in a Guttman scale. Error represents deviation of the observed response pattern from the ideal pattern required by the cumulative model.[30] For this analysis, scale errors were calculated using the perfect reproducibility method for counting errors.[31,32]

Figure 1. **Guttman Scale Developed During Current Investigation**

| Subjects | Alcohol | Cigarettes | Marijuana | Other Narcotics | Amphetamine | Tranquilizers | Sedatives | Other Hallucinogens | Cocaine | LSD | Heroin | Scale Score* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 11 |
| B | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 10 |
| C | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 9 |
| D | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 8 |
| E | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 7 |
| F | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 6 |
| G | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| H | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| I | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| J | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| K | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| L | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

N = 14,577

* Scale score represents the subject's total responses to ever-used ATOD items, ranked from highest to the lowest proportion of positive responses. A 1 would signify ever-use of a particular drug and a 0 would indicate never use.

The perfect reproducibility method (also known as the Goodenough method) counts each incorrectly predicted item response as an error.[31] For example, if the ideal response pattern is (1 [alcohol], 0 [tobacco]) and an erroneous response pattern of (0 [alcohol], 1 [tobacco]) were observed, 2 errors would be found. Specifically, 1 error was counted to change the first 0 to 1 (1, 1) and 1 error was reflected in changing the second 1 to 0 (1, 0). Missing data were omitted from the calculation of errors in the Guttman scale.

The index of reproducibility and the index of scalability were employed to evaluate how much of this deviation from a perfect scale is tolerable. Or, said differently, whether or not the Guttman scale created for this investigation accurately predicted alcohol, tobacco, and other illicit drug usage among high-school seniors. The coefficient of reliability (CR) is a measure of goodness of fit between the observed and the predicted ideal response patterns (ie the ratio of successful reproductions/estimates to total responses, or how well one can predict any given response based upon position within the Guttman scale). The formula for the CR was expressed as $CR = 1.0 - (\#\ errors/total\ responses)$, where $total\ responses = (\#\ items) \times (\#\ respondents)$.[30] Coefficient of reliability scores have a possible range from 0 (minimal reproduction success) to 1 (perfect reproduction success); however, a $CR \geq 0.90$ constitutes the minimum standard of acceptability.[29,33]

While CR is a necessary assessment of a scale's estimating abilities, alone it is not a wholly accurate measure of scalability because scale reproducibility can be impacted by the marginal distributions of scale items.[33,34] Consequently, the index of scalability, which produces a coefficient of scalability (CS), provides a ''check'' against an inflated CR.[34] In other words, if perfect scalability were obtained, one could exactly reproduce or predict participants' responses by only knowing (a) the order of the categories and (b) the number of items to which an individual indicated usage.[34] Instead of taking into account scale scores, the CS reflects the degree to which responses to scale items can be predicted given only knowledge of the marginal frequencies of the scale item responses.[28] Brown and Hudson explain that the formula for CS is expressed as $CS = PI/1 - MMR$, where PI is the percentage improvement ($CR - MMR$), MMR is the minimal marginal reproducibility, or p (or q, whichever is larger)/k, with p is % initiates for each scale item (calculated by dividing the number of 1s by the total number of participants), q is % abstainers for each scale item (calculated by dividing the number of 0s by the total number of participants), and k the number of scale items.[28,35] Ranging from 0 to 1, an acceptable indicator of scalability is $CS \geq 0.60$. A CS of 0.60 simply means that 60% of the total possible errors actually are not errors, but are responses consistent with those that are hypothesized.[34]

## RESULTS

Demographic characteristics of the total sample (N = 14,577) are provided in Table 1. Overall, the majority

Table 1. **Percent Ever-Used Drug Categories by US 12th-Grade Students**

| | N* | Alcohol | Cigarettes | Marijuana | Other Narcotics | Amphetamine | Tranquilizers | Sedatives | Other Hallucinogens | Cocaine | LSD | Heroin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Overall | 14,577 | 72.2 | 45.0 | 43.4 | 13.2 | 10.4 | 9.1 | 8.7 | 7.9 | 7.3 | 3.9 | 1.3 |
| Male | 6,644 | 48.1 | 49.6 | 51.3 | 53.7 | 47.7 | 49.2 | 48.8 | 62.8 | 54.7 | 68.8 | 62.9 |
| Female | 7,068 | 51.9 | 50.4 | 48.7 | 46.3 | 52.3 | 50.8 | 51.2 | 37.2 | 45.3 | 31.2 | 37.1 |
| Age <18 | 5,969 | 42.4 | 40.9 | 41.6 | 40.2 | 41.2 | 38.4 | 39.9 | 38.9 | 38.9 | 38.8 | 38.5 |
| Age 18+ | 8,101 | 57.6 | 59.1 | 58.4 | 59.8 | 58.8 | 61.6 | 60.1 | 61.1 | 61.1 | 61.2 | 61.5 |
| White | 8,334 | 71.0 | 72.9 | 70.8 | 87.3 | 82.7 | 85.1 | 81.7 | 86.5 | 78.2 | 82.5 | 71.7 |
| Hispanic | 2,156 | 17.4 | 17.3 | 16.6 | 8.8 | 12.6 | 11.9 | 12.6 | 10.1 | 19.0 | 11.6 | 20.0 |
| Black | 1,799 | 11.6 | 9.8 | 12.6 | 3.9 | 4.6 | 3.0 | 5.7 | 3.4 | 2.8 | 5.9 | 8.3 |

*Ns of subgroups do not add up to overall N because variables defining subgroups were occasionally missing.

of respondents were White (67.8%) students less than 18 years of age (57.6%). Sex was fairly evenly distributed (51.5% female) across the sample. Alcohol represented the most commonly used substance, with a majority of students (72.2%) reporting alcohol consumption at some point in their lifetime. A large percentage of respondents also self-reported the use of tobacco (45.0%) and marijuana (43.4%).

In regard to the Guttman scale, a total of 12,717 errors (ie, deviations of the observed response pattern from the ideal pattern) were identified.[30] Taking into account these errors, the number of scale items (11), and the number of cases (14,577), a CR of 0.92 was produced. This value exceeded the 0.90 benchmark of minimal acceptability.[29,33] With an MMR of 0.796 and a percentage improvement value of 0.125, a CS of 0.61 was obtained. Again, this scale fit index was found to exceed the minimal scalability benchmark of 0.60.[34] These coefficients indicate that not only can one predict with 92% accuracy the scale item responses of a given student simply by knowing that student's scale score, but substance use progression also can be predicted with 92% accuracy given knowledge of students' scale scores. Also, 61% of the total possible errors actually represented responses consistent with the hypothesized substance use progression. Moreover, the Guttman scale created for this investigation indicated that alcohol represented the ''gateway'' drug, leading to the use of tobacco, marijuana, and other illicit substances.

To improve understanding of the relationship between one's alcohol consumption (gateway) and use of tobacco and other drugs, a series of cross tabulations and chi-square test for independence were conducted. Specifically, 2 × 2 contingency tables were developed comparing ever drank status to lifetime/ever-use of each of the other 10 substance categories (eg, tobacco, marijuana, cocaine, etc) included in the Guttman scale. Before interpretation, we ensured that the underlying chi-square assumption of minimum expected cell frequency had not been violated. No cells in our analyses had less than 5 expected frequencies, thus meeting the necessary cell sizes. Table 2 outlines the Pearson chi-square value for each association, the more conservative Yates contingency correlation (which accounts for Pearson's tendency to make a type I error when using 2 × 2 contingency tables), as well as the overall effect size and strength of associations, as determined by Phi.[36] In addition, odds ratios are reported in Table 2 as an additional measure of the effect size between drinking and other substance use. Odds ratios were calculated based on the results from the 2 × 2 contingency table.

As evident in Table 2, both the chi-square and more conservative contingency corrections measuring the association between one's drinking status to the use of another substance were all statistically

Table 2. **Association Between Drinking Status and Use of Other Licit and Illicit Substances***

| | $\chi^2$ | Yate's Contingency Correction | p | Phi | Odds Ratio |
|---|---|---|---|---|---|
| Cigarettes | 2,221.92 | 2,219.95 | .001 | .439 | 12.84 |
| Marijuana | 2,331.39 | 2,329.35 | .001 | .452 | 15.94 |
| Other narcotics | 550.05 | 548.61 | .001 | .220 | 16.04 |
| Amphetamines | 356.10 | 354.83 | .001 | .176 | 8.29 |
| Tranquilizers | 338.45 | 337.13 | .001 | .172 | 10.91 |
| Sedatives | 286.38 | 285.15 | .001 | .158 | 7.45 |
| Other hallucinogens | 309.89 | 308.55 | .001 | .164 | 14.21 |
| Cocaine | 277.03 | 275.70 | .001 | .156 | 13.32 |
| LSD | 131.35 | 130.11 | .001 | .107 | 10.10 |
| Heroin | 30.09 | 29.06 | .001 | .051 | 5.07 |

*N = 14,577.

significant ($p < .001$). Thus, it appears that use of alcohol significantly impacts use of other licit and illicit substances. These highly significant associations reflect the fact that among students who had consumed alcohol in their lifetime, approximately 59% had used tobacco, 58% had used marijuana, 18% had used other narcotics, 14% had used amphetamines, 13% had used tranquilizers, 12% had used sedatives, 11% had used other hallucinogens, 10% had used cocaine, 5% had used LSD, and 2% had used heroin—percentages exceeding usage rates observed within the overall sample (Table 1). Moreover, these relationships, particularly among alcohol use and cigarette and marijuana use, exhibited moderate/medium effect sizes.[37] The overall effect of alcohol consumption on tobacco and other drug use is further outlined by the calculated odds ratios. Twelfth-grade students who had consumed alcohol within their lifetime were far more likely to use other substances. For instance, students reporting ever-use of alcohol were 13 times more likely to use cigarettes, 16 times more likely to use marijuana and other narcotics, and 13 times more likely to use cocaine.

## DISCUSSION

In regard to drug sequencing literature, this investigation made several important contributions. Primarily, the research outlined herein answered 2 important questions: (1) Which substance represents the ''gateway'' drug leading to the use of other licit and/or illicit drugs? and (2) Does substance use follow a progression from licit to illicit? Results corroborate previous research[20,21,28] identifying alcohol use as the first step (ie ''gateway'') in the temporal ordering of substance use. Among the national sample of high school seniors examined in this investigation, the use of alcohol represented a powerful predictor for the use of tobacco, marijuana, and other illicit drugs. In other words, alcohol use greatly increased the likelihood that other licit (tobacco) and illicit drugs (marijuana, cocaine, narcotics, etc) would also be used. Results of the current investigation also indicated that drug use follows a progression from licit to illicit. These findings lend credence to Kandel's drug sequencing hypothesis[18,19] that drug involvement begins with the most socially acceptable drugs, alcohol, and cigarettes (stage 1), proceeds to marijuana use (stage 2), and finally to illegal drugs (stage 3).[28] Specifically, the Guttman-based drug sequence model developed for this investigation infers that alcohol is the ''gateway'' drug potentially leading to additional substance use. However, due to the cross-sectional nature of the data utilized, our findings cannot necessarily speak to specific *stages* (time-ordered and cumulative) in the developmental sequence of ATOD use. Longitudinal data would be necessary to address level of involvement (ie., stages) across time. That said, our results do speak to the *order* of substance use, as demonstrated by the unidimensional scalogram analysis, and supported by the subsequent cross tabulations. Moreover, these findings build upon those of the National Survey on Drug Use and Health, which document alcohol initiation as the first substance of use among adolescents who use alcohol, tobacco, and marijuana.[38]

In addition to these contributions, this investigation also accounted for several limitations afflicting previous drug sequencing literature. Specifically, the order/progression of drug involvement outlined in this investigation was demonstrated among a nationally representative sample of high school seniors. Previous research by Torabi et al reported that among Indiana students grades 5-12, cigarette smoking predicted later use of alcohol and other drugs.[22] Differences between the current research (which documents alcohol as the gateway drug leading to tobacco, marijuana, and other drug use) and Torabi, Bailey, and Majd-Jabbari's findings may be attributed to the sampling frame employed. Specifically, their investigation was based in Indiana, a state with particularly high rates of smoking. According to CDC data, the youth smoking rate was 31.6% in Indiana in 2000, compared to the national average of 28.5%.[39] By examining a national sample, this investigation accounted for the state-specific sampling frames, and subsequent lack of external validity, associated with previous gateway hypothesis and drug progression research.[16,17,19,20,22,24] In addition to being one of the more representative samples to date, this Guttman scale investigation represented one of the largest samples utilized to examine adolescent drug sequencing.

### Limitations

Several study limitations should be considered in unison with the results reported. The primary limitation of using secondary data analysis is being restricted

to the methods and variables utilized in the primary data collection. Therefore, this investigation inherited limitations associated with MTF. One such limitation was the exclusion of male and female high school dropouts, representing approximately 13% and 20% of each national age cohort nationally.[2] Additionally, as with all longitudinal researches, such as MTF, attrition also represented a limitation. Monitoring the Future researchers contended, however, that their retention rates ''compare favorably with those of most longitudinal studies.''[2(p70)] Another inherited limitation was the self-report nature of the data collected. Nevertheless, MTF asserted there was strong inferential evidence demonstrating that the self-report questions employed are able to produce valid data.[2] Furthermore, missing data on several variables precluded their inclusion into the current analysis. Specifically, high percentages of missing data existed in the MTF 2008 data for ever-use of crystal methamphetamine (67.5%), anabolic steroids (56.3%), and inhalants (51.9%). According to the MTF National Survey Results, the missing data rates for the self-reported use questions were only slightly higher than for the preceding nonsensitive questions. However, the significant amount of missing data in the primary data for crystal meth, inhalants, and steroids resulted in omission from the current analysis. Finally, this investigation did not utilize age of initiation data (which are not documented by MTF) and/or measures of frequency and quantity of ATOD use. It is important to note, however, that investigations which compare drug sequencing using both age of initiation data and dichotomous ever-use items reach the same conclusion as this study: the temporal ordering of initiation begins with alcohol use.[28] In addition to documenting similar sequencing patterns as age of initiation measures, dichotomous usage data have the added benefit of greater reproducibility and scalability due to the decrease in identified Guttman scale errors.[28] Yet, as previously mentioned, temporal ordering can only be implied when using dichotomous initiation data. Thus, future research investigating the gateway effect of alcohol consumption should build off this investigation by examining whether age of initiation and/or patterns of alcohol consumption influence the relationship documented herein. In addition, emerging substance use behaviors such as prescription drug use, which are unaccounted for in the Gateway Theory literature, should be considered in future investigations.

## IMPLICATIONS FOR SCHOOL HEALTH

Black, Tobler, and Sciacca assert ''if priorities [relating to substance abuse prevention programming] must be set due to limited resources, it is advocated, because of greater public health benefits, that legal drugs [alcohol and tobacco] receive primary attention.''[40] The findings from this investigation support this notion, and, in fact, highlight alcohol as the ''gateway'' drug leading to the use of other licit (tobacco) and illicit substances (marijuana, etc). Therefore, considering the recent constriction of school drug prevention budgets, it seems prudent to focus prevention efforts, policies, and monies, on addressing adolescent alcohol use.[41] By preventing or delaying the onset of alcohol initiation, rates of both licit and illicit drug use will subsequently be positively affected. Evaluations of school-based drug prevention (SDBP) programs support the idea that preventing alcohol initiation and targeting risk factors for alcohol initiation among youth can indirectly prevent and/or delay subsequent tobacco and other drug use and initiation.[42,43] In other words, by recognizing the important predictive role of alcohol, school officials and public health leaders can effectively impact the progression of substance use and protect adolescents from additional health risks and sources of morbidity and mortality. School-based drug prevention programs targeting a single substance, such as alcohol, are best suited for older children and adolescents.[44-46]

In addition to focusing specifically on alcohol use, SBDP programs should implement evidence-based components. For instance, meta-analyses document ''interactive'' SBDP programs (eg., those offering much opportunity for interaction and communication among the adolescents) as more effective than ''non-interactive'' programs (eg., didactic presentations).[47] Interactivity has been specifically highlighted as an important factor in SBDP programs focusing on the prevention of licit substances, such as alcohol.[46] Moreover, interactivity has also been shown to impact the effectiveness of booster sessions (ie., sessions intended to reinforce original program content).[48,49]

Additional key components of effective SBDP programs include involving students in the delivery of a program and integrating the ''social influence model.''[48,50] As part of the social influence approach, SBDP programs should focus on norms, commitment of students to not use substances, and intentions not to use.[48] Adding life-skills training to social influence programs may also increase the effects of such programs.[50] There is also evidence suggesting that more intense SBDP programs (ie., consisting of multiple sessions) generate more behavior change and are associated with great effectiveness.[44,45,49,50]

In regard to classroom instructional strategies, teachers should employ research-based and theory-driven practices, addressing social pressures and influences (eg., media, peer pressure) to engage in risky behaviors, and building essential skills (eg, communication, decision making, refusal, self-management) that enable students to build personal ability and self-efficacy to avoid and/or reduce risk behaviors. Conversely, simple knowledge dissemination and affective

education (discussing the relationship between emotions and substance use) have not been found to significantly impact student substance use.[44,45,48] All classroom instructional strategies should be grounded in the National Health Education Standards and the Centers for Disease Control and Prevention's Characteristics of an Effective Health Education Curriculum.[51,52]

### Human Subjects Approval Statement

This study was vetted and approved by the Purdue University Institutional Review Board prior to investigation.

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