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The great decline in adolescent cigarette smoking since 2000: consequences for drug use among US adolescents

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Abstract

Objective—Adolescent cigarette smoking declined steadily and substantially from 2000 to 2018. This paper considers the potential consequences of this ‘great decline’ for the prevalence of other drug use among adolescents.

Methods—Data are annual, cross-sectional, nationally representative Monitoring the Future surveys of more than 1.2 million US students in 12th, 10th and 8th grades from 2000 to 2018. Analyses include trends in the past 12 months’ non-medical amphetamine, tranquillisers and opioid use overall, among ever and never cigarette smokers, and projected if adolescent cigarette smoking levels had remained at 2000 levels.

Results—Within groups of ever and never cigarette smokers, the prevalence for each of the three substances has either changed little or overall increased in 2018 as compared with 2000. When the two groups were combined into one pool, the overall prevalence for each of the drugs declined by about half. The decline resulted from the growing group of never smokers, whose levels of non-medical drug use over the study period were at least four times lower than the levels of ever smokers.

Conclusions—The results support the ‘gateway’ prediction that declines in cigarette smoking among adolescents pull downward their non-medical use of amphetamines, tranquillisers and opioids. Continuing to reduce adolescent smoking through policy and programmatic prevention efforts should have further positive spillover effects on adolescent drug use.

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INTRODUCTION

The decline in adolescent cigarette smoking over the past two decades is a remarkable public health achievement. From the years 2000 to 2018 adolescent cigarette smoking declined gradually and steadily and did not once significantly increase in any year during this 19-year period.¹ The result was that the nationwide percentage of students who had ever smoked a cigarette dropped dramatically from 65% to 24% in 12th grade, as well as dropping among younger students from 55% to 20% in 10th grade, and 41% to 9% in 8th grade.¹ Throughout this paper we refer to this decline in cigarette smoking from 2000 to 2018 as the ‘great decline’, which has led adolescent cigarette smoking to the lowest levels ever recorded.

One public health benefit of the great decline not yet widely recognised or considered is that it would be expected to reduce other substance use. Adolescents who have never smoked a cigarette in their life have substantially lower levels of drug use than those who have smoked.² As the size of the group of adolescents who have never smoked has increased, their low levels of drug use would be expected to pull downward drug use levels for the total adolescent population.

This paper considers how the growing percentage of adolescents who have never smoked a cigarette since 2000 has affected the prevalence trends in non-medical use of tranquillisers, amphetamines and opioids. These three drugs had the highest prevalence of non-medical use among the total adolescent population over the past two decades, other than alcohol and marijuana,¹ and carry high potential to be addictive.³

Background

The Master Tobacco Settlement Agreement of 1998 paved the way for the great decline in adolescent cigarette smoking.⁴ It created policies and programmes targeted at reducing adolescent cigarette smoking, and these programmes have been funded in part by payments from major tobacco companies to the US states set at over \$205 billion during the first 25 years of the agreement. These policies and programmes resulted in increased cigarette prices for consumers; restrictions on advertising, sponsorship and lobbying activities targeting youth; the creation of a National Public Education Foundation to create nationwide media and education campaigns to reduce youth smoking and to conduct related research (since renamed the ‘Truth Initiative’); and substantial payments to the US states to aid their implementation of additional state-specific antismoking programmes.

The sum total effect of these programmes and policies was to reverse what had been an alarming increase in adolescent cigarette smoking that began in the 1990s⁵ and to kick off what became the ‘great decline’.^{6–8} With the numerous policies and programmes set in place all at once it is difficult to disentangle the effect of each specific one. Yet there can be little doubt that as a whole they contributed to a long-standing reduction of adolescent smoking.

With the substantial decline in adolescent cigarette use comes a unique opportunity to test two competing predictions from drug policy and theory. On the one hand, the ‘great decline’ may have reduced adolescent use of other drugs as well. Adolescents who have never smoked a cigarette have traditionally had very low levels of other drug use. If these low

levels continued then as the never smoked group grew steadily larger in size it would pull downward the levels of drug use for the total adolescent population.

The ‘gateway’ perspective provides theoretical reason to expect that the never smoked group would maintain its low levels of drug use as it grew in size during the ‘great decline’. It builds on the observation that drug use typically follows a sequence in which use of cigarettes precedes non-medical use of other drugs; consequently, fewer youth initiating this sequence could result in fewer youth ending up as drug users. Researchers working along these lines posit that youth who do not use cigarettes are less likely to experience associated processes that promote drug use, such as the ‘priming’ of the brain’s reward system for drug use⁹¹⁰ and exposure/entry to drug-using peer networks.¹¹

The competing prediction is that the ‘great decline’ may have had little to no effect on adolescent use of other drugs. Stated in simple terms, this prediction posits that some adolescents are going to use drugs, and taking cigarettes out of their hands will not stop them from finding other drugs to use. The ‘liability’ perspective¹²¹³ provides theoretical rationale to support this prediction. It posits that a subset of adolescents have a high propensity for general drug use, and those with this propensity who do not smoke may instead take up non-medical use of other drugs,¹⁴ such as the ones considered in this study. In this scenario, the levels of non-medical drug use in the never smoking group would increase as the great decline progressed, in order for overall levels of non-medical drug use to hold steady or even increase.

With these considerations in mind this study empirically tests the prediction supported by the ‘gateway’ hypothesis that adolescent use of amphetamines, tranquilisers and opioids declined after the year 2000 as a result of the growth of the group of never smokers, who have traditionally had low levels of drug use. The competing prediction supported by the ‘liability’ hypothesis is that adolescent use of these drugs stayed steady or even increased as adolescents continued to use these drugs regardless of whether they smoked.

METHODS

Data

Data come from the annual Monitoring the Future study, which uses self-administered questionnaires in school classrooms to survey US students. Independent nationally representative samples of 8th, 10th and 12th grade students were surveyed each year from 2000 to 2018. The cumulative sample size is 473 112 in 8th grade, 431 715 in 10th grade and 410 524 in 12th grade. Student response rates for the survey averaged 90%, 87% and 82% in 8th, 10th and 12th grades, respectively. Non-response is largely due to student absence. Sample sizes for specific drug outcomes are noted in the online supplementary table 1 and are slightly lower than the overall total due to missing data on use of a specific drug (5% or less missing data for all drugs) or missing data on whether the student has ever smoked a cigarette (3% or less in all grades). This study focuses primarily on 12th grade students, who have the highest prevalence of both cigarette and other drug use, with results for 10th and 8th grade students reported in the supplementary analyses.

Table 1 lists the text and coding of the study measures, including the specific drug examples listed in the survey questions. Opioid use in 8th and 10th grades is not included in the study analyses due to concerns about the validity of reports of these substances in these grades. The analyses present means and SEs for drug use outcomes. All analyses were performed in STATA MP V.¹⁵ and use the ‘svy:’ suite of commands to take into account sample weights, as well as clustering of respondents in primary sampling units and strata.¹⁵

The analyses also include estimates of a hypothetical standard population and project estimates of overall prevalence for each drug in 2000 and later if the size of the ever smoked group had stayed at 2000 levels, using observed levels of non-medical drug use for the ever smoked and never smoked groups. The overall projected prevalence was computed as the average year-specific, observed drug prevalence within the never and ever smoked groups weighted per their proportions as of 2000. Variance of projected prevalence for each of the drugs is estimated as:

$$\text{var}\left(\sum_{g=1}^2 \hat{p}_{g,2000} * \hat{p}_{g,nm,t}\right) \cong \sum_{g=1}^2 \left\{ \hat{p}_{g,nm,t}^2 * \text{var}(\hat{p}_{g,2000}) + \hat{p}_{g,2000}^2 * \text{var}(\hat{p}_{g,nm,t}) \right\}$$

Where:

$\hat{p}_{g,2000}$ = the 2000 estimate of proportion of students in the two groupings of ever smoked and never smoked, $g=1,2$.

$\hat{p}_{g,nm,t}$ = the time t estimate of non-medical drug use prevalence for group g .

Time t ranged from 2000 to 2018; group g took on two values, one for ever smokers and one for never smokers; nm refers to the prevalence of non-medical drug use. The estimation assumes time t samples are independent (negligible design covariance). The last expression within the summation sign is expression 11.8.6 in Kish,¹⁶ with appropriate substitution of $\tilde{N} = \hat{p}_{g,2000}$ and $\tilde{y} = \hat{p}_{g,nm,t}$.

RESULTS

Figure 1 presents the trends in ever smoked one or more cigarettes from 1991 to 2018 for 12th grade students. It shows that the prevalence of having ever smoked was endemic through the 1990s and then began a decline around the year 2002 that continued in all the following years. The group of 12th graders who never smoked nearly doubled in size after 2000, from 39% in 2001 to 76% by 2018.

Figure 2 presents the trends in non-medical amphetamine use in the past 12 months among 12th grade students. Figure 2A presents the observed trends among the never smoked and ever smoked groups, as well as all students overall. Among the group that had never smoked a cigarette, the prevalence of non-medical amphetamine use has changed little throughout the study period. It was 3% in 2000 and 2% in 2018, and varied between the narrow windows of 1% and 3% in the intervening period. Among the group that had ever smoked a

cigarette, the prevalence was about five times higher. In this group, the prevalence was 15% in both 2000 and 2018, a midpoint between windows of 13% and 18% over the study period.

The overall trend in figure 2A shows a substantial decline in prevalence from 2000 to 2018, when it halved from 10% to 5%. Each year's value is a weighted average of amphetamine prevalence in the never smoked and ever smoked groups. In 2000, the overall prevalence was closer to the prevalence of the ever smoked group, which contained the majority of all 12th grade students. By 2018, the overall prevalence was closer to the never smoked group, which had grown in size and contained the majority of 12th grade students.

Figure 2B projects the overall prevalence of non-medical amphetamine use if the proportions in the never and ever smoked groups had remained at their 2000 levels. The projections average the observed levels of non-medical amphetamine use in the two groups weighted per their size in 2000. In these projected results, the overall prevalence in 2018 would be 10%, the same level as in 2000.

Figure 3 presents the trends in non-medical tranquilliser use in the past 12 months among 12th grade students. Figure 3A shows that both the never smoked and ever smoked groups had somewhat higher prevalence in 2018 than in 2000. Among the 12th graders who never smoked, the prevalence increased from 1% to 2% over the study period, while among those who had ever smoked, the increase was from 8% to 11%. Despite these increases, the overall prevalence decreased from 6% to 4% over the study period as larger portions of the more recent cohorts were in the never smoked group and had the group's low prevalence of non-medical tranquilliser use.

Figure 3B projects the overall prevalence of non-medical tranquilliser use if the proportions in the never smoked and ever smoked groups had remained at their 2000 levels. In these projected results, the overall prevalence would have actually increased slightly, from 6% at the start to 7% in 2018.

Figure 4 presents the trends in non-medical use of opioids in the past 12 months among 12th grade students. Figure 4A shows that the prevalence levels have changed little within the never and ever smoked groups in 2018 as compared with 2000. Among the never smoked group, the prevalence was 1% in both 2000 and 2018. Among the ever smoked group, the prevalence was 10% in 2000 and 9% in 2018, and in the intervening years the prevalence increased to 18% around the year 2009 and then receded. From 2000 to 2018, the overall prevalence declined by more than half from 7% to 3% as the size of the never smoking group increased and maintained its low level of non-medical use of opioids.

Figure 4B projects the overall prevalence of opioids if the proportions in the never smoked and ever smoked groups had remained at their 2000 levels. In these projected results, the overall prevalence would have been much less pronounced, with a decrease from 7% to 6%.

The supplementary analyses report the results for parallel analyses of 10th and 8th grade students in online supplementary tables S1–S8 and online supplementary figures S1–S5. The findings replicate in these grades, each of which are separate, independently drawn, nationally representative samples. Specifically, the great decline in cigarette smoking is

present for both grades, and for all drugs considered overall declines from 2000 to 2018 resulted in large part from increasingly larger portion of adolescents in the never smoked group, which maintained its low level of non-medical drug use throughout the study period.

DISCUSSION

This study set out to examine the non-medical use of amphetamines, tranquillisers and opioids among adolescents from 2000 to 2018, a period when adolescent cigarette use declined markedly. The results support the prediction of the gateway hypothesis that declines in cigarette smoking would pull downward use of these substances among adolescents. Levels of non-medical drug use were at least four times lower for never smokers as compared with ever smokers, and within both groups the levels of non-medical drug use were essentially unchanged at the end as compared with the start of the study period. The overall levels of non-medical drug use declined substantially over the study period as the group of never smokers grew and a greater proportion of the total sample had their associated low levels of drug use.

Specifically, observed levels of non-medical use of amphetamines in the past 12 months reduced by half from 10% to 5% from 2000 to 2018 for the overall group of 12th graders. Observed levels of non-medical tranquilliser use in the past 12 months also declined from 6% to 4%. Within the never smoked and ever smoked groups levels of use of these drugs were essentially constant over the study period. The lack of any substantial change in drug prevalence within the never and ever smoked groups suggests that no change in overall drug prevalence would have taken place if these groups had not changed their size relative to each other, a point demonstrated by the study projections.

Observed levels of non-medical use of opioids in the past 12 months also declined from 7% to 3% over the study period. As with amphetamines and tranquillisers, the growth of the never smoked group—and its concomitant low levels of opioid use—played a major role in the overall decline. At the same time, the results suggest other influences affected the overall opioid prevalence. For both the never and ever smoked groups the prevalence of opioids increased about twofold from 2000 to 2009 and then receded back to the starting levels by the end of the study period in 2018. In both the never and ever smoked groups, the declines since 2009 are statistically significant, as indicated by non-overlapping 95% CIs.

Simultaneous changes for opioid prevalence in both the never and ever smoked groups indicate the influence of a factor independent of cigarette smoking. One potential candidate is the substantial change in the number of legitimate medical opioid prescriptions issued throughout the study period. This number was increasing at the beginning of the study period and decreasing at the end,¹⁷ and population levels of medical prescribing for adolescents are highly correlated with population levels of non-medical use among adolescents.¹⁷

The study results provide substantial support for the gateway perspective and point to a central role for cigarette smoking that any alternative explanation would need to address. The influence of cigarette smoking is not easily explained as an artefact of a single,

unmeasured confounder, given the specific pattern of study findings. In the case of amphetamines and tranquillisers no decline in their use took place independent of smoking, given that both drugs had near-constant prevalence in the two smoking groups over the study period (with the constant level relatively much lower for never smokers). Absent a decline in these drugs independent of smoking, the study results do not support a direct role for a typical confounder, which would be expected to cause an independent decline in drug use while also exerting a concurrent, independent decline in smoking.

The findings for opioids provide more room for influences on drug prevalence in addition to those resulting from changes in smoking prevalence. Parallel changes in the prevalence of opioids in the never and ever smoking groups indicate that a factor independent of smoking was at work over the study period. Nevertheless, the shift in smoking, combined with the relatively lower levels of opioid use among never smokers, substantially pulled downward the overall levels of opioid use in the same way that it did for amphetamines and tranquillisers.

The links between smoking and non-medical drug use remain an important topic for future research. It is possible that factors other than those suggested by gateway theory may have also tamped down non-medical drug use among the never smoked group over the course of the study, thereby contributing to the reduction of overall adolescent substance use. Future consideration of such factors is important to test and further develop gateway theory, as well as to inform policies and programmes aimed at reducing adolescent substance use. Work along these lines could confirm the role of such gateway factors as substance-using peer groups and neurochemistry. It could also potentially identify new factors not currently recognised that emerged during the great decline.

We note two implications of the study findings. First, they suggest that progress in the reduction of non-medical drug use among adolescents since 2000 has resulted in large part from the great decline in cigarette smoking and the associated, low levels of drug use among never smokers. These secondary benefits of smoking reduction are not widely recognised and indicate that the population health consequences of smoking declines are likely even more beneficial than currently estimated. Tobacco control is one of a limited number of policies and programmes proven to effectively reduce substance use at the population level, and the results of this study justify further actions to continue and augment these efforts. Substantial room for progress still remains, given that one-quarter of the 12th grade population had smoked a cigarette as of 2018.¹⁸

A second related implication is that these results suggest cigarette smoking exerts a population cost that extends well beyond its direct, negative health effects on smokers. The financial calculations of Tobacco Master Settlement Agreement of 1998 centred largely on the direct effects of smoking on health and healthcare costs. The results of this study indicate that they extend further to additional costs associated with non-medical use of amphetamines, tranquillisers, opioids and theoretically most other drugs as well. Such costs are substantial, with estimated overall, yearly costs of non-medical drug use and prescription opioid abuse at \$271 billion as of 2013.^{19,20}

We note three study limitations. First, the study's research design cannot prove or disprove causation. Consequently, the study set out not to test causality per se but to test predictions from gateway theory, which posits causality between smoking and drug use, as well as competing predictions from its major competitor the liability perspective. While the study results support the gateway perspective for the specific research question of this study, predictions from the liability perspective may find more relative support in examination of other issues.

This paper can serve as both motivation and justification for future studies to consider potential causation in more detail. The challenge for such studies is to assess causality with observational data, given that randomised controlled trials are not possible to evaluate the consequences of cigarette smoking. Such observational studies could include cross-national analyses that compare countries with different levels of decline in adolescent cigarette smoking, as well as policy analyses that consider the impact of specific tobacco control components, such as cigarette prices, on adolescent use of other drugs.

A second limitation is that the sample does not contain adolescents who have dropped out of school. We expect that inclusion of dropouts would not change the main study results or substantive conclusions because the findings replicate for 8th and 10th grade students, who have very low levels of school dropout. Similarly, school absenteeism also holds the potential to affect the study results, but replication of the study findings in 8th grade, in which absenteeism is the lowest, suggests this influence does not alter the study's main conclusions.

Finally, this study focused on a specific set of three drug outcomes and results may differ for different substances. For example, more evidence for a 'liability' perspective could come from analysis of nicotine vaping, for which prevalence has increased substantially in recent years as cigarette smoking has continued to decline.²¹

CONCLUSION

With the increasing proportion of adolescents who have never smoked came reductions in overall, non-medical use of amphetamines, tranquillisers and opioids, as predicted by the gateway perspective. These results point to a largely unheralded benefit of tobacco control efforts on drug use, and thereby underscore the importance of continuing and augmenting policies to reduce adolescent tobacco use further.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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What this paper adds

- Adolescent cigarette smoking declined markedly by more than half from 2000 to 2018.
- The consequences of this decline for adolescent use of other drugs are not known.
- Results support a large role for the decline of smoking in the decline of adolescent use of amphetamines, tranquillisers and opioids, each of which declined in prevalence by about half over the study period.

Figure 1.
Prevalence of ever smoked a cigarette in 12th grade, by year.

Figure 2.
Prevalence of non-medical amphetamine use in the past 12 months in 12th grade, by year.

Figure 3.
Prevalence of non-medical tranquilliser use in the past 12 months in 12th grade, by year.

Figure 4.
Prevalence of non-medical opioid use in the past 12 months in 12th grade, by year.

Table 1

Text of questions used in the analysis

Question topic	Question text and coding
Never smoked cigarettes	Never smoked is coded 1 for students who mark the response 'never' to the question 'Have you ever smoked cigarettes?' and 0 for students who mark a response to indicate lifetime use of one or more cigarettes.
Ever smoked cigarettes	Coded as 1—(Never smoked).
Non-medical use of amphetamines in the past 12 months *	Coded 1 for students who checked a response of one or more to the question 'Amphetamines and other stimulant drugs are sometimes prescribed by doctors for people who have trouble paying attention, are hyperactive, have ADHD, or have trouble staying awake. They are sometimes called uppers, ups, pep pills, and include drugs like Adderall and Ritalin. Drugstores are not supposed to sell them without a prescription from a doctor. They do NOT include any nonprescription drugs such as over-the-counter diet pills or stay-awake pills. On how many occasions (if any) have you taken amphetamines or other prescription stimulant drugs on your own—that is, without a doctor telling you to take them...'; and coded 0 for students who report no use occasions.
Non-medical use of tranquilizers in the past 12 months *	Coded 1 for students who checked a response of one or more to the question '4. Tranquilizers are sometimes prescribed by doctors to calm people down, quiet their nerves, or relax their muscles. Librium, Valium, and Xanax are all tranquilizers. On how many occasions (if any) have you taken tranquilizers on your own—that is, without a doctor telling you to take them—during the last 12 months?'; and coded 0 for students who report no use occasions.
Non-medical use of opioids in the past 12 months *	Coded 1 for students who checked a response of one or more to the question 'There are a number of narcotics other than heroin, such as methadone, opium, morphine, codeine, Demerol, Vicodin, OxyContin, and Percocet. These are sometimes prescribed by doctors. On how many occasions (if any) have you taken narcotics other than heroin on your own—that is, without a doctor telling you to take them—during the last 12 months?'; and coded 0 for students who report no use occasions.

* Updates to this question over the study period had minor or no effect on prevalence estimates in the years they were implemented.²²

ADHD, attention deficit hyperactivity disorder.