Cannabis supply and demand reduction: Evidence from the ESPAD study of adolescents in 31 European countries

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Abstract
Aims: Most national drug policies target both the supply side and the demand side of illicit drug use. Although such policies are intended to affect individual choices, they by definition operate on a national level and cannot be evaluated solely on the basis of individual-level differences. This study aims to evaluate the impact of country-level differences in the availability and perceived risk of cannabis use on individual-level adolescent cannabis use.

Method: The study is based on an analysis of 84,711 students in 31 European countries. Multilevel modelling techniques are used to estimate the effects of country-level differences in the perceptions of availability and risk among non-users on individual-level odds of 30-day cannabis use.

Findings: On the individual level, adolescents who use cannabis find it easier to obtain and less risky if they have used the drug. Controlling for these individual-level associations, adolescents are also found to be less likely to use cannabis in countries where non-users report less availability and more risks associated with cannabis use.

Conclusions: These findings support the notion that both supply reduction and demand reduction may reduce the prevalence of adolescent substance use.

Keywords: Adolescents, European, cannabis, prevention
Supply reduction and demand reduction are the two major types of policies that guide efforts to curb drug use in Western societies (Coggans, 2006; European Monitoring Centre for Drugs and Drug Addiction (EMCDDA), 2008; Hakkarainen, Tigerstedt, & Tuukka, 2007; Hanson, Venturelli, & Fleckenstein, 2004). Supply reduction policies rely primarily on law enforcement efforts to reduce the production, trafficking and sale of drugs, while demand reduction policies rely on public health efforts and specific prevention and treatment programmes to reduce the initiation and persistence of substance use. These policies are not mutually exclusive and international agencies such as the United Nations Office on Drugs and Crime (UNODC, 2007) and the EMCDDA (2007) have called for comprehensive national drug policies that target both the supply side and the demand side of the drug problem. Such policies by definition operate on the national level and although they are intended to affect individual choices they cannot be evaluated solely on the basis of individual-level factors. It is necessary to measure supply and demand independently of the prevalence of individual drug use in order to estimate the effects of reduced supply or reduced demand on such use. However, such an analytical distinction has proven elusive to maintain empirically.

The country-level supply of cannabis is difficult to assess, in particular, among adolescents. Drug-related arrests and the amount of confiscated drugs are, for instance, notoriously unreliable indicators of the supply of drugs in society (Thorisdottir, 2002). Although arrests and confiscations may indicate more drug offences coming to the attention of police because of greater availability, they also reflect differences in law enforcement policies and the success of police efforts to reduce availability. Paradoxically, police statistics may therefore either reflect increased supply or greater success of supply reduction efforts. Drug prices are also quite unreliable indicators of availability since they are not only a function of supply and demand, but also reflect differences in the level of risk of arrest and the severity of penalties (Bretteville-Jensen, 2006). As a result there does not appear to be a clear association between price and either rates of regular cannabis use or cessation, even though higher income and lower cannabis prices may encourage cannabis initiation among adolescents (Desimone & Farrelly, 2003; McCrystal, Percy, & Higgins, 2007; van Ours & Williams, 2007).

In addition to the challenges of mapping local, national and international illicit drug markets (Ritter, 2006), the access of adolescents to such markets is also difficult to assess. Adolescents typically obtain illicit drugs through informal social networks rather than regular contacts with drug dealers (Coomber & Turnbull, 2007; Harrison, Fulkerson, & Park, 2000). The supply of illicit drugs in the general population does, therefore, not translate directly into availability among adolescents. Surveys among adolescent populations can give some indication of their perceptions of cannabis availability. However, given the clandestine nature of illicit drug markets, it is difficult to separate the perceived availability of
cannabis from the actual use on the individual level. Simply put, perceived availability tends to be high among users and low among non-users.

A wide variety of adolescent drug use prevention programmes aimed at demand reduction has been proposed and implemented over the past half century. Some programmes attempt to raise awareness of the danger of drug use in the general population, while other programmes target specific schools, parents or at-risk groups by providing information about the consequences of drug use, building resistance through enhanced personal and social skills, providing alternative activities, and enhancing support systems (Cuijpers, 2003; Mallick, 2007; Streke, 2004). Meta-analyses of drug prevention programmes among adolescents have generally found minimal effects of lecture-oriented programmes emphasising knowledge about the dangers of cannabis use, while small-scale interactive programmes fostering the social competencies seem to yield the largest effects (Streke, 2004; Tobler, Lessard, Marshall, Ochshorn, & Roona, 1999).

Studies focusing on the effectiveness of specific prevention programmes by necessity use either matched comparison groups or estimates of societal levels of substance use as their baseline. Such studies are therefore limited to evaluating the marginal yield of a single programme implemented in the wider context of various nationwide campaigns, curriculum-based education and a multitude of other targeted prevention and intervention programmes. They are by design unable to assess the combined effect of demand reduction efforts in a given country. Adolescent drug surveys can give some indication of the perceived risk of cannabis use but the individual-level dynamic between attitudes and behaviours is far from simple. While more positive attitudes towards drug use are associated with a greater risk of initiation, the use of drugs has also been found to change perceptions of risk among users (Adalbjarnardottir, Dofradottir, Thorolfsson, & Gardarsdottir, 2003). Perceptions of the risks associated with drug use simply tend to be low among users and high among non-users. It is, therefore, also difficult to assess the success of cannabis demand reduction strategies on the individual level.

This dilemma can partly be solved by moving from the individual to the national level of analysis. While perceptions of availability and risk are inextricably tied up with actual use on the individual level, the perceptions of non-users are by definition unaffected by their own use. Indeed, acceptance among non-users has been argued to be a crucial aspect of the normalization of cannabis in society (Parker, Aldridge, & Measham, 1998; Roy, Wibberley, & Lamb, 2005). The collective perceptions of non-users can therefore be expected to tap the conditions and normative structure of adolescent society in a particular country. The proportion of non-users who think cannabis is easily available can thus be used as a proxy measure of cannabis supply in adolescent society as a whole and successful supply reduction policies should be reflected in a lower proportion of non-users who know where they could obtain cannabis if they wanted. Similarly, the proportion of non-users who believe there are serious risks associated with cannabis use can be used as a proxy measure of cannabis demand in adolescent
society as a whole and successful demand reduction policies should be reflected in a greater perception of cannabis risk among non-users.

In this article, we will assess the effects of availability and perceived risk on self-reported cannabis use among 84,711 adolescents in 31 European countries. At the individual level, adolescents who use cannabis can be expected to find it easier to obtain and less risky than their peers that have never used cannabis. This unique dataset allows us to assess the extent to which these individual-level covariances are invariant across European countries. More importantly, however, these data allow us to address important questions regarding the effects of societal-level perceptions of availability and risk on individual behaviours. Using multi-level modelling techniques we estimate the effect of societal availability on the odds of individual cannabis use, holding constant the fact that cannabis users are better able to obtain the drug. Similarly, the effect of societal perceptions of risk on the odds of individual cannabis use will be estimated, holding constant the beliefs of individual users that cannabis is relatively harmless. In the multivariate model the independent effects of perceived availability and perceived health risks can be assessed on both the individual level and the societal level.

Data and methods

The current study is based on data from the European School Survey Project on Alcohol and Other Drugs (ESPAD), a collaborative research project implemented by a network of European researchers (Hibell et al., 2004). The primary goal of the project is to provide comparative data on adolescent substance use in Europe for the purposes of research and policy formation. Independent research teams in each country survey 15–16-year-old students at 4-year intervals according to the ESPAD (2008) research protocol. Standardized questionnaires are administered to students in the classroom with the use of a blank envelope procedure to ensure anonymity (Bjarnason, 1995). For the current study, data were available from 31 European countries that participated in the third wave of the ESPAD project in 2003.

Table I provides demographic and survey information for the countries included in the current study. These countries reflect the diversity of European countries, including, for instance, the Faroe Islands (48 thousand inhabitants, 98% Lutheran), Austria (8 million, 78% Roman Catholic), Greece (11 million, 98% Orthodox), Ukraine (48 million, 70% Orthodox), the United Kingdom (59 million, 47% Anglican) and Turkey (70 million, 99.8% Muslim) (World Factbook, 2003). Some of these countries are among the oldest and most stable democracies in the world, while others have only recently achieved independence or democratic self-determination.

The current study is based on responses from 84,711 of students in the 31 participating countries. The national samples were in the range of 1663–5087 students, with the exception of Greenland, Faroe Islands and Isle of Man where the total cohort of 15–16-year-old students was <1000 and the entire cohort was
Table I. Overview of 31 countries participating in the 2003 European school project on alcohol and other drugs.

<table>
<thead>
<tr>
<th>Countries</th>
<th>National population</th>
<th>15 to 16-year-old</th>
<th>Sample size</th>
<th>Response rate (%)</th>
<th>30-day cannabis use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>8102</td>
<td>94</td>
<td>2377</td>
<td>90</td>
<td>10</td>
</tr>
<tr>
<td>Belgium</td>
<td>10,356</td>
<td>122</td>
<td>2320</td>
<td>81</td>
<td>17</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>7846</td>
<td>103</td>
<td>2739</td>
<td>85</td>
<td>8</td>
</tr>
<tr>
<td>Croatia</td>
<td>4442</td>
<td>55</td>
<td>2884</td>
<td>88</td>
<td>8</td>
</tr>
<tr>
<td>Cyprus</td>
<td>715</td>
<td>11</td>
<td>2152</td>
<td>88</td>
<td>2</td>
</tr>
<tr>
<td>Czech</td>
<td>10,203</td>
<td>130</td>
<td>3172</td>
<td>95</td>
<td>19</td>
</tr>
<tr>
<td>Denmark</td>
<td>5384</td>
<td>59</td>
<td>2519</td>
<td>89</td>
<td>8</td>
</tr>
<tr>
<td>Estonia</td>
<td>1356</td>
<td>22</td>
<td>2463</td>
<td>86</td>
<td>6</td>
</tr>
<tr>
<td>Faroe Islands</td>
<td>48</td>
<td>0.7</td>
<td>591</td>
<td>86</td>
<td>1</td>
</tr>
<tr>
<td>Finland</td>
<td>5206</td>
<td>62</td>
<td>3222</td>
<td>91</td>
<td>3</td>
</tr>
<tr>
<td>France</td>
<td>61,832</td>
<td>816</td>
<td>2320</td>
<td>91</td>
<td>22</td>
</tr>
<tr>
<td>Germany</td>
<td>82,537</td>
<td>952</td>
<td>5087</td>
<td>89</td>
<td>12</td>
</tr>
<tr>
<td>Greece</td>
<td>11,006</td>
<td>117</td>
<td>1906</td>
<td>83</td>
<td>2</td>
</tr>
<tr>
<td>Greenland</td>
<td>57</td>
<td>0.9</td>
<td>554</td>
<td>68</td>
<td>11</td>
</tr>
<tr>
<td>Hungary</td>
<td>10,142</td>
<td>124</td>
<td>3143</td>
<td>82</td>
<td>6</td>
</tr>
<tr>
<td>Iceland</td>
<td>288</td>
<td>4</td>
<td>1663</td>
<td>81</td>
<td>4</td>
</tr>
<tr>
<td>Isle of Man</td>
<td>78</td>
<td>0.9</td>
<td>721</td>
<td>85</td>
<td>21</td>
</tr>
<tr>
<td>Latvia</td>
<td>2331</td>
<td>38</td>
<td>2841</td>
<td>84</td>
<td>4</td>
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<tr>
<td>Lithuania</td>
<td>3463</td>
<td>57</td>
<td>5036</td>
<td>88</td>
<td>6</td>
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<tr>
<td>Malta</td>
<td>397</td>
<td>6</td>
<td>3500</td>
<td>83</td>
<td>4</td>
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<tr>
<td>Netherlands</td>
<td>19,193</td>
<td>196</td>
<td>2095</td>
<td>93</td>
<td>13</td>
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<tr>
<td>Norway</td>
<td>4552</td>
<td>56</td>
<td>3833</td>
<td>87</td>
<td>3</td>
</tr>
<tr>
<td>Romania</td>
<td>21,773</td>
<td>354</td>
<td>4371</td>
<td>84</td>
<td>0</td>
</tr>
<tr>
<td>Russia (Moscow)</td>
<td>10,383</td>
<td>176</td>
<td>1925</td>
<td>80</td>
<td>7</td>
</tr>
<tr>
<td>Slovakia</td>
<td>5379</td>
<td>82</td>
<td>2276</td>
<td>87</td>
<td>10</td>
</tr>
<tr>
<td>Slovenia</td>
<td>1995</td>
<td>26</td>
<td>2785</td>
<td>88</td>
<td>14</td>
</tr>
<tr>
<td>Sweden</td>
<td>8941</td>
<td>111</td>
<td>3232</td>
<td>87</td>
<td>1</td>
</tr>
<tr>
<td>Switzerland</td>
<td>7314</td>
<td>84</td>
<td>2613</td>
<td>83</td>
<td>20</td>
</tr>
<tr>
<td>Turkey</td>
<td>69,770</td>
<td>1238</td>
<td>4177</td>
<td>91</td>
<td>2</td>
</tr>
<tr>
<td>Ukraine</td>
<td>48,004</td>
<td>746</td>
<td>4173</td>
<td>83</td>
<td>5</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>59,438</td>
<td>778</td>
<td>2031</td>
<td>84</td>
<td>20</td>
</tr>
<tr>
<td>All countries</td>
<td>482,531</td>
<td>6622</td>
<td>84,721</td>
<td>86</td>
<td>9</td>
</tr>
</tbody>
</table>


included in the study. All but three of the samples were nationally representative. In Turkey the sample was representative of the regions of Adana, Ankara, Diyarbakir, Istanbul, Izmir and Samsun; in Germany the sample was representative of the states of Bayern, Brandenburg, Berlin, Hessen, Mecklenburg-Vorpommern and Thüringen. In Russia the sample was representative of Moscow only. Response rates in individual countries ranged from 68% to 95%, with an average of 86%. Further information about sampling and field procedures in each country is provided by Hibell et al. (2004).
Outcome measurement

The dependent variable is cannabis use in the past 30 days (0: None; 1: Any cannabis use). This dichotomous variable was recoded from the standard ESPAD seven-point response set. As shown in Table I, the 30-day cannabis use ranged from 0% to 22%, with an average of 9% when all participating countries are given equal weight irrespective of population size. If the results are weighted by the size of each country, the estimated prevalence of 30-day cannabis use in the population of European adolescents is 10%.

Gender

Gender was recoded into the dichotomous variable Male (0: No; 1: Yes). It is necessary to control for gender in the following analysis as some of the association of perceived availability and perceived risk with cannabis use may be attributed to gender differences in both perceptions and behaviour.

Perceptions of availability

These were based on responses to the standard ESPAD question asking how difficult students thought it would be to obtain different substances if they wanted (1: Impossible; 5: Very easy).

Aggregate availability

This was computed as the mean of individual availability in each country. Both individual perceptions and aggregate perceptions of availability were standardized across all countries with a mean of 0 and standard deviation of 1 in order to facilitate the comparison of effect sizes.

Perceptions of risk

These were based on responses to three items asking how much students thought people risked harming themselves physically or in other ways by using cannabis: (1) once or twice, (2) occasionally or (3) regularly (1: No risk; 4: Great risk) (Bjarnason & Jonsson, 2005). The three items formed a reliable short scale of perceived risk of cannabis use (Cronbach’s $\alpha$: 0.81). Factor analysis was used to extract factor scores for the single underlying factor.

Aggregate risk

This was computed as the mean of perceived risk in each country. Both individual and aggregate perceptions of risk were standardized across all countries with a mean of 0 and standard deviation of 1.

Modelling strategy

The following data analysis is based on multilevel modelling techniques (Bryk & Raudenbush, 1992), and was conducted by use of the HLM 6.0 software
This methodology allows several important theoretical and conceptual issues to be empirically tested. Hierarchical regression involves the estimation of individual-level and country-level effects of availability and perceived risk on cannabis use, as well as, allowing the estimation of variable slopes for individual-level predictors across countries.

Regular multivariate regression is based on the assumption that there is a single constant intercept and a single constant slope for each predictor in the regression model. In contrast, hierarchical regression defines both intercept and each slope as variables that can in turn be regressed on various predictors. This strategy allows us to estimate the association between country-specific levels of cannabis use and individual-specific aggregate perceptions of availability and risk among non-users (Level-2 variables), after taking into account the association between individual cannabis use and individual perceptions of availability and risk (Level-1 variables). It also allows us to estimate the extent to which the strength of the association between individual cannabis use and individual perceptions of availability and risk varies across countries.

The Bernoulli model for dichotomous dependent variables extends this basic approach by transforming the predicted value into \( \eta_{ij} \) by use of the logit link function:

\[
\eta_{ij} = \left( \log \frac{\Phi_{ij}}{1 - \Phi_{ij}} \right) = \beta_{0j} + \sum \beta_{qj}X_{qij}
\]

The predicted value of a dichotomous dependent variable is equal to the probability of cannabis use, \( \Phi_{ij} \) for student \( i \) in country \( j \) and \( \eta_{ij} \) is the log of the odds of cannabis use, \( \beta_{0j} \) is the individual-level intercept for each country, \( \beta_{qj} \) the \( q \)th individual-level slope for each country \( j \), and \( X_{qij} \) is the \( q \)th individual-level predictor for student \( i \) in country \( j \).

**Results**

The results of the multilevel analyses are given in Table II. The first column shows the bivariate results obtained by including one predictor at a time, and the second column shows the multivariate results obtained by including all individual-level and country-level predictors simultaneously in a single model. Males are found to be 1.4 times as likely as females to have used cannabis in the past 30 days. Controlling for gender differences in perceived availability and risk, males are 1.3 times as likely to have used cannabis in the past 30 days in the multivariate model.

**Perceived risk**

The perception of cannabis use as potentially harmful is associated with less 30-day cannabis use at both the individual level and the country level. An increase of one standard deviation in individual perceptions of risk is associated with a decrease in cannabis use by a factor of 0.38 in the bivariate analyses.
Similarly, an increase of one standard deviation in country-level average perceptions of risk among non-users is associated with a decrease in cannabis use by a factor of 0.16. Controlling for individual perceptions of availability, a standard deviation increase in individual perceptions of risk is associated with a decrease in cannabis use by a factor of 0.52 in the multivariate analysis. Net of this, a standard deviation increase in country-level perceptions of risk among non-users is associated with a decrease in cannabis use by a factor of 0.43. In other words, for each standard deviation that individual perceptions of risk decrease, the odds of individuals using cannabis double (1/0.52). Similarly, for each standard deviation that societal perceptions of health risks decrease among non-users, the odds of individuals in that country using cannabis increase by a factor of 2.33 (1/0.43) in the multivariate analysis.

**Perceived availability**

At the individual level, an increase of one standard deviation in perceived availability is associated with a 2.5-fold increase in cannabis use in the bivariate analysis. Similarly, an increase of one standard deviation in country-level average perception of availability among non-users is associated with an increase in cannabis use by a factor of 6.3. Controlling for individual-level perceptions of risk, a standard deviation increase in individual availability is associated with an increase in cannabis use by a factor of 1.6. Net of this, a standard deviation increase in country-level perceptions of availability among non-users continues to be associated with an increase in cannabis use by a factor of 2.3 in the multivariate analysis.

**Variation in slopes**

The variances in individual-level slopes for perceived availability and perceived risk are highly significant ($p < 0.001$). This indicates that neither the individual-

<table>
<thead>
<tr>
<th></th>
<th>Bivariate OR (95% CI)</th>
<th>Multivariate OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.09 (0.07; 0.13)</td>
<td>0.06 (0.04; 0.08)</td>
</tr>
<tr>
<td>Country-level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived availability among non-users</td>
<td>6.31 (2.89; 13.79)</td>
<td>2.25</td>
</tr>
<tr>
<td>Perceived risk among non-users</td>
<td>0.16 (0.07; 0.35)</td>
<td>0.43 (0.20; 0.90)</td>
</tr>
<tr>
<td>Individual-level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>1.43 (1.33; 1.53)</td>
<td>1.33 (1.17; 1.51)</td>
</tr>
<tr>
<td>Perceived availability for each student</td>
<td>2.52 (2.25; 2.82)</td>
<td>1.62 (1.49; 1.76)</td>
</tr>
<tr>
<td>Perceived risk for each student</td>
<td>0.38 (0.36; 0.41)</td>
<td>0.52 (0.49; 0.56)</td>
</tr>
</tbody>
</table>

Note: Bernoulli models with dichotomous dependent variables, coefficients are odds ratios with 95% confidence intervals in parentheses. Country-level coefficients are all statistically significant at $p < 0.05$. Individual-level coefficients are all statistically significant at $p < 0.001$. Country-level variances in intercepts and slopes are all significant at $p < 0.001$.  

Table II. Multilevel models of 30-day cannabis use among 15 to 16-year-old students in 31 countries participating in the 2003 ESPAD survey.
level association between perceptions of availability and 30-day cannabis use nor
the individual-level association between perceptions of risk and 30-day cannabis
use are invariant between countries. Availability appears to be a stronger predictor
of actual use in some countries than in others, even controlling for differences in
perceived risk of cannabis use. The strongest effects of perceived availability were
found in the United Kingdom and Switzerland while the weakest effects were
found in Romania and Cyprus. Conversely, perceived risk is a stronger obstacle to
cannabis use in some countries than others after taking into account the effects of
perceived availability. The strongest effects of perceived risk were found in France
and the Czech Republic, while the weakest effects were found in Romania and
the Faroe Islands.

Conclusion
An estimated 10% of the total population of 15–16-year-old European
adolescents have used cannabis in the past 30 days. This is considerably less
than in the United States where the same measure yielded an estimated 30-day
prevalence of 17% (Johnston, O’Malley, Bachman, & Schulenberg, 2004). Across
the 31 countries under analysis, individuals who use cannabis find it more easily
available and less risky than those who do not use it. However, there is a
considerable geographical and cultural variation within Europe. Prevalence rates
of 19–22% were, for instance, found in Britain, the Czech Republic, France and
Switzerland, while countries as diverse as the Faroe Islands, Greece, Romania,
Sweden and Turkey reported 30-day prevalence rates of 2% or less. There is also
substantial variation in the individual-level association between 30-day cannabis
use and perceptions of availability and risk.

Future studies should explore why availability and perceived risk have stronger
effects in some countries than others. It is, for instance, possible that the effects of
perceived risk are stronger in countries that have experienced declining cannabis
use than in countries where such use is on the rise. The cross-sectional design of
the current study does not allow us to evaluate our findings in the context of such
different national trajectories. It should nevertheless be noted that the multilevel
approach goes beyond the limitations of both cross-sectional and longitudinal
studies of individual-level processes. Relying on the responses of non-users, we
were able to obtain country-level estimates of both perceived availability and
perceived risk of cannabis use among adolescents. However, while perceptions
of availability and risk among non-users are not contaminated by their own
substance use, their distance from specific locations and instances of substance
use may introduce a different kind of bias. It is, for instance, possible that
successful demand reduction policies may affect perceptions of availability as well
as perceptions of risks among non-users. More importantly, it is possible that
underlying cultural values of the populace account for differences in policies,
perceptions among non-users, and the prevalence of substance use alike.

Our analysis nevertheless shows that in countries where non-users report
more availability, students are also more likely to have used cannabis in the
past 30 days. Furthermore, in countries where non-users believe cannabis use to be more risky, fewer students have used cannabis in the past 30 days. Importantly, these country-level effects on individual behaviour persist after individual-level differences in perceived availability and risk have been taken into account. In other words, the perceptions of non-users predict individual cannabis use independently of the perceptions of the individual user in question. Regardless of their own perceptions of risk and availability, individuals are more likely to have used cannabis if they live in countries where non-users perceive cannabis to be easily available and benign. Conversely, regardless of their own perceptions, individuals are more likely to have used cannabis in countries where non-users perceive cannabis to be dangerous and difficult to obtain.

The current study assumes a link between national policies of supply reduction and demand reduction on one hand and adolescent perception of availability and risk on the other. This includes the intervening efforts of law enforcement and public health agencies as well as a myriad of regional and local prevention and treatment programmes. While future studies must examine this crucial link between public policy and individual behaviour, these results nevertheless strongly suggest that both supply-reduction and demand-reduction efforts may have a substantial effect on adolescent cannabis use.

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Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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