Canadian Centre on Substance Abuse
Centre canadien de lutte contre les toxicomanies
Partnership. Knowledge. Change.
Collaboration. Connaissance. Changement.

www.ccsa.ca • www.cclt.ca

Topic Summary

Neuroscience in Youth Drug Prevention Programs

Key Messages

- Evaluations of prevention programs based on neuroscience are promising in terms of enhancing awareness about the effects of drugs on the brain among youth.
- Although research is limited, in some cases neuroscience-based programs can influence perceptions of drug-related risks.
- Prevention programs that incorporate neuroscience should be evaluated over a longer period to examine their impact in preventing substance use.

Objective

The objective of this topic summary was to examine youth drug prevention programs that have a focus on educating youth about the effects of drugs on the brain and to assess evidence of their effectiveness to help further our understanding of promising prevention strategies. The examination of the effectiveness of complementary approaches, such as science-based drug education programs, will help further our understanding of promising prevention strategies.The literature search was conducted using the databases PubMed and PsycNET. A secondary search was conducted on Google Scholar to ensure that articles that were not captured from the above databases were retrieved.[i]

Background

Adolescence represents a period of rapid psychosocial and biological development that influences decision making and behaviours,[1] and is also a period in which substance use is often initiated. Indeed, according to the 2013 Canadian Tobacco, Alcohol and Drugs Survey (CTADS), the average reported age of first use among youth (aged 15–19 years) for alcohol and cannabis was 15.6 and 15.1 years, respectively. Moreover, 60% of youth reported past-year alcohol use and the most commonly reported illicit substance used in the last year was cannabis (22%). Reported use of any five illicit drugs excluding cannabis (i.e., cocaine–crack, speed, ecstasy, hallucinogens and heroin) is close to five times higher among youth (aged 15–19 years) than adults (4.7% vs. 0.9%). These findings, coupled with the observation that youth (aged 15–24 years) are four times more likely to report experiencing drug-related harms,[2] highlight the continued need to focus on ways to delay or prevent the onset of substance use among this population. This summary is intended for a broad audience, including educators, curriculum developers, youth prevention planners, researchers and policy makers.

[i] Several combinations of search terms were used, including "neuroscience" or "brain" and "drug education" or "prevention." The initial search yielded nine articles that were deemed potentially relevant by an information specialist. Seven of these articles were found not to be relevant for the purposes of the current review. A broader literature search was conducted through Google and a Google Custom Forum designed to search organizations in the field of addiction that might have grey literature on the topic (e.g., the Centre for Addiction and Mental Health, National Institute on Drug Abuse, etc.). This search yielded an additional ten journal articles that were relevant to the current review.

Many drug prevention programs have focused on developing youths' skills to resist drugs or peer influences, as well as enhancing coping methods to deal with stressful life experiences.[3] Evaluations of certain social resistance programs, however, have determined that they have minimal to no effect on youth substance use, and small effects on attitudes about drugs in comparison to programs that are interactive in nature.[4,5,6] Instead, the incorporation of several elements from prevention models might be most beneficial. A meta-analysis examining the effectiveness of 15 school-based prevention programs on cannabis use indicated that programs that employed multiple approaches from various prevention models and were longer in duration were most effective at reducing cannabis use.[7] Indeed, there are emerging programs that have focused on reducing risk factors (e.g., behavioural issues) and enhancing protective factors (e.g., social support) among youth, and these programs show greater successes.[8] As well, in the Canadian Standards for Youth Substance Abuse Prevention, it is recommended that prevention programs adopt multiple strategies to enhance the likelihood that prevention efforts will be successful.[9] Despite these advances, existing prevention programs can be improved, and there remains a great need to investigate evidence-based alternatives or complementary approaches that can prevent or delay the onset of substance use among youth.

An alternative approach to drug education programs are those that do not overtly attempt to influence youths' substance use. Such education programs deliver evidence-based scientific information on the effects of drugs on the brain and body to inform youth of the impact of substance use. Beginning early in childhood, children tend to hold negative expectancies (i.e., beliefs that using drugs will result in negative outcomes) about the behavioural effects of drug use; however, by mid-elementary school attitudes about drug use begin to shift towards a more positive view.[10,11] This shift is concerning given that lower negative perceptions of drugs are associated with subsequent substance use.[10,11,12] It has been suggested that teaching children that drugs act on the brain to negatively affect behavior and health outcomes could be effective in limiting positive attitudes about drugs.[13] These science-based education programs differ from traditional prevention programs in several ways. In particular, their goal is to teach about the effects of drugs on the brain and body, but to avoid "just say no" or other blatant anti-drug commands, to present information on the effects of drugs in a neutral manner, and to avoid using descriptive terms such as "bad" or "unsafe."[14] In essence, proponents of these programs propose that by increasing youths' knowledge about the adverse neurological and health effects of drugs, youth will be empowered to make their own appraisals about the effects of drugs, and will subsequently make informed decisions about substance use in their own lives, ultimately resulting in delayed or decreased use of substances.

By middle school (e.g., ages 11–14 years) , students usually know that substance use and abuse can have serious health effects; what is often absent from their understanding is exactly how and why.[15] For example, a study of 121 students in elementary, middle school and college levels in which students were asked about the effects of drugs on the body indicated that in relation to drugs, younger children emphasized their actions on body parts such as the arms and legs. In contrast, older children and adolescents described their effects on organs such as the heart and lungs. Only among the college levels was there an emphasis on drugs affecting the brain. Moreover, very few in any age group understood how drugs act on the brain to produce their effects.[16] These findings point to an important gap in young peoples' understanding of the effects of drugs, and although neuroscientific concepts are complex, studies have indicated that accurate information on how drugs affect the brain can be taught and understood by children and youth.[13,14,17]

Findings

Although several programs have been developed that aim to raise awareness about the effects of drugs on the brain, there have been few programs that have been evaluated for their efficacy in

changing knowledge, attitudes and behaviours towards substance use among youth. However, there are a few neuroscience-based drug curriculums that have been developed and evaluated in some manner. For instance, the National Institute on Drug Abuse (NIDA) in the United States (U.S.) has funded programs as part of its focus on science education in response to findings that many youth and adults lack an understanding of the neurobiological underpinnings of drug use and addiction (NIDA, 2002). One such program, called *Brain Power!*, provides teachers with curricula on the brain, nervous system and body, and the effects of drugs on these systems. The lessons cover a broad range of substances, including alcohol, cannabis, inhalants, cocaine and prescription drugs. In addition, the curriculum is tailored for specific age groups from kindergarten to Grade 8. One study that used a pre-test/post-test quasi-experimental design among 112 grades 4 and 5 students found that the curriculum was effective in enhancing science-based knowledge of the effects of drugs, compared to students assigned to the control group who did not receive the curriculum. However, students were tested following completion of the curriculum only and it is not certain if knowledge gains were long lasting.[14]

Other programs such as *The Doubles* cover a broad scope of science-based lessons, such as basic brain structure and function, how drugs affect the brain, the role of genetics in drug use, risk and protective factors, and the consequences of substance abuse and its treatment.[17] This program was assessed among 274 grades 3 and 4 students (8–10 years of age) in five U.S. elementary schools. Findings from this evaluation revealed that the program was successful in promoting significant knowledge gains on the biological basis of the effects of drugs. Despite this success, attitudes towards drug use did not change as a result of the program, which the authors' suggested could have been a result of negative attitudes being quite high at baseline.[17] Similarly, a curriculum designed to teach a scientific, brain-mediated theory of the effects of drugs by teaching students about how drugs enter the body and travel to the brain, and the distinction between stimulants and depressants, was effective in increasing knowledge among students in grades 3 to 6, but did not influence attitudes.[13]

Attitudinal shifts might be an important aspect of youth drug prevention as there have been reports that higher perceptions of risk towards drugs are associated with lower subsequent drug use.[12] Some neuroscience-based programs have had success in producing shifts in youth's attitudes towards drugs. Students (n = 327) in grades 3 to 6 who were randomly assigned to a drug curriculum that taught about how alcohol and cocaine have physiological and neurobiological effects, displayed a greater understanding of cocaine and alcohol's effects compared to students who were part of a control curriculum (e.g., taught about the flu and other health conditions). Moreover, students who received the drug curriculum reported significantly lower positive attitudes towards cocaine and fewer intentions to use cocaine as adults one year following the intervention.[18] It is difficult to ascertain why this program was effective in promoting attitudinal shifts and decreased intention to use, whereas many others are not. A very similar program, previously described, that was guided by the same theories was implemented;[13] however, this study did not assess attitudes or intentions to use over a longer time period, which might have resulted in similar findings across the two programs.

Another project aimed at teaching the general public about basic concepts in neuroscience as well as the neurotoxic effects of methamphetamine abuse used an interactive museum exhibit of a 3-D graphical brain model.[19] This program found significant knowledge gains and less positive attitudes towards the impact of methamphetamine abuse following attendance at the exhibit. Youth who attended the exhibit also showed these same outcomes, as did individuals who scored high on sensation seeking, which is a known risk factor for substance abuse. Despite these findings, there was no follow-up beyond the post-exhibit assessment, so it is uncertain whether such effects were sustained.

Other programs have examined the use of computer games to deliver neuroscience-based information on drugs in an engaging way. For example, the program *Uncommon Scents* is a science education game where students analyze magnetic resonance images of the brain to determine the effects of long-term inhalant use. *Uncommon Scents* was assessed among 444 students in grades 6 to 8 and was successful in producing increased knowledge and more negative attitudes toward inhalant use.[15] In addition, a game in which students gather scientific facts about prescription drug abuse across two sessions lasting approximately one hour each was effective in reducing the normative beliefs of grades 11 and 12 students' about prescription drugs (i.e., that use is prevalent and acceptable among their peers) and enhancing beliefs that prescription drug abuse can be as harmful as illicit drugs.[20] A neuroscience-based series of computer games called *The Reconstructors™*, which covers a broad range of concepts such as neural communication, brain function and the effects of drugs such as ecstasy on the brain, was also found to be successful in improving the knowledge of students in grades 7 and 8 about neuroscience concepts and the effects of drugs.[21]

Media campaigns have also been developed to help raise awareness of the effects of drugs on the brain among youth and parents. Focusing on the prevention of cannabis and prescription drug abuse among youth, Health Canada developed a major television advertisement campaign in 2014 that featured imagery and key messages about the harms of these drugs on youth's brains and bodies. Preliminary results from the focus groups of parents of youth (ages 13–15) and youth (ages 13–18) revealed that the main messages were clear and understood. As well, parents understood that smoking cannabis could have serious consequences on the adolescent developing brain (e.g., memory loss, decreased IQ). The findings did not report whether youth shared the same understanding.[22] Further research will need to be conducted to examine the effectiveness of the advertisements on promoting conversations among adolescents and parents about drug use, as well as on cannabis use outcomes.[22] As well, research examining other avenues, such as through social media, outside of traditional television campaigns could be helpful in determining if they are effective in influencing substance use among youth.

Discussion

Overall, there are a limited number of evaluations of neuroscience-based youth drug prevention programs. One compelling reason to further examine neuroscience-based approaches to youth drug prevention is that, unlike other programs where resources have to be allocated outside of the standard education curriculum, many of these drug programs can be implemented into science education. Indeed, the majority of programs covered in this review indicated that they met the national standards of learning within the United States and can be implemented during regular class time as part of the standard science curriculum. Determining how these programs could be incorporated into standard science curriculums in Canada is an area for further investigation. In addition, the premise behind these programs to maintain a neutral stance in messaging about drug use choices might be advantageous, as there are reports that indicate that direct and fear-based anti-drug messages can be less effective than indirect non-threatening messages.[23,24] Indeed, in a study examining Canadian youths' perceptions of cannabis it was observed that youth (ages 14–19) were skeptical of messages that they deemed to be inaccurate. As well, participants perceived prevention messages that focused on abstinence as less effective than those aimed at reducing the harms of cannabis.[25] Further research is required to determine if non-threatening forms of messaging are more effective across a variety of youth and settings. Science-based drug education programs might be particularly useful in helping youth appraise the available information about drug use.[26] Indeed, a survey of youth (ages 15–24) reported that over half of students in grades 7 to 12 used the Internet to look up health information on an issue either they or someone they knew was

affected by,[27] which underscores the need to equip youth with the facts so that they are able to critically assess what can often be conflicting or incorrect information.

Advocates of neurobiological-based drug prevention programs have suggested there needs to be an emphasis on the developing brain. Indeed, Breyer and Winters (2005) outline three key messages children should be taught:

1. How the pre-frontal cortex, or the "judgement" location of the brain is still developing well into young adulthood;
2. Drugs can take control of the brain to cause substance use disorders; and
3. The adolescent brain is more vulnerable to substances because it is still developing.

In addition, it was suggested that parents need to be informed about the principles of neurodevelopment to enhance their own prevention efforts. For example, teaching parents to promote activities that capitalize on the developing brain (e.g., sports or music) and not to minimize the vulnerability of the developing brain to drugs could be helpful in preventing the initiation and use of drugs.[28]

Taken together, the findings from evaluations of neuroscience-based drug prevention programs are promising in terms of enhancing knowledge about the effects of drugs on the brain among youth, and in some instances changing their perceptions of drug-related risks. However, many of the studies examined were quasi-experimental or comprised a small sample size; randomized controlled trials that follow a greater number of students for longer periods of time are required to determine if these changes are long lasting. The most pressing gap in our knowledge about the effectiveness of neuroscience-based drug prevention programs is the lack of assessment of actual drug use behaviours after completion of the program. In addition to these major limitations, further research is required to determine whether such programs are efficacious among certain at-risk groups. For example, disengaged students are not as committed to learning, have poorer connections with teachers and peers, and are also more likely to use substances.[29] This group might be the least likely to benefit from a science-based program. Indeed, an assessment of the program *Brain Power!* demonstrated that higher positive attitudes toward science predicted greater knowledge change following completion of the program.[14]

Ultimately, drug prevention programs that employ a neuroscience-based perspective should be considered as only one strategy to prevent or delay the use of substances among youth. Indeed, the Canadian Standards for Youth Substance Abuse Prevention recommend that enhancing life skills (e.g., coping, decision making, social skills, etc.) among youth, promoting family skills, and linking schools and families with other community groups (e.g., recreation centres, bars etc.) are all critical components to successful youth drug prevention.[9] As a complementary approach, science-based drug education programs that aid students in understanding how different substances affect brain functioning and in turn have negative behavioural and health outcomes might provide students with base knowledge that could facilitate later drug prevention efforts. More than this, it has been suggested that enhancing science literacy about the biological foundations of addiction could help reduce stigmatizing attitudes toward substance abuse.[30]

Neuroscience has transformed what we know about the effects of drugs on the brain and the biological mechanisms underlying substance use disorders. However, few neuroscientists have translated their findings into forms that are accessible to teachers and prevention planners.[26] Moving forward, finding ways to facilitate collaborations between teachers and scientists to develop drug prevention curricula that are accurate and engaging for youth might be an effective means to promote further progress in science-based drug prevention programs. As well, examining how youth can be involved in developing and implementing these programs should be examined, as youth

engagement is a critical component to enhancing the effectiveness of prevention strategies.[31] Despite the promising evidence outlined in this review, critical to advancing our knowledge about the efficacy of these programs are larger studies examining a diverse range of youth, as well as longitudinal studies that determine their impact beyond just knowledge and awareness, but also on actual substance use.

Additional Resources

- Evaluating Substance Use Prevention Campaign Messages for Youth Audiences
- Monitoring and Evaluation Toolkit
- The Effects of Cannabis Use during Adolescence

To find out more about how CCSA's Canadian Standards for Youth Substance Abuse Prevention can help you in your prevention efforts, contact youth-jeunes@ccsa.ca.

---

[1] Blakemore, S. J., & Choudhury, S. (2006). Development of the adolescent brain: implications for executive function and social cognition. *Journal of Child Psychology and Psychiatry, 47*(3–4), 296–312.

[2] Statistics Canada. (2015). *Canadian Tobacco, Alcohol and Drugs Survey: Summary of results for 2013*. Ottawa, Ont.: Author.

[3] Tobler, N. S., Roona, M. R., Ochshorn, P., Marshall, D. G., Streke, A. V., & Stackpole, K. M. (2000). School-based adolescent drug prevention programs: 1998 meta-analysis. *Journal of Primary Prevention, 20*(4), 275–336.

[4] Clayton, R. R., Cattarello, A. M., & Johnstone, B. M. (1996). The effectiveness of Drug Abuse Resistance Education (Project DARE): 5-year follow-up results. *Preventive Medicine, 25*(3), 307–318.

[5] Ennett, S. T., Tobler, N. S., Ringwalt, C. L., & Flewelling, R. L. (1994). How effective is drug abuse resistance education? A meta-analysis of Project DARE outcome evaluations. *American Journal of Public Health, 84*(9), 1394–1401.

[6] West, S. L., & O'Neal, K. K. (2004). Project D.A.R.E. outcome effectiveness revisited. *American Journal of Public Health, 94*(6), 1027–1029.

[7] Porath-Waller, A. J., Beasley, E., & Beirness, D. J. (2010). A meta-analytic review of school-based prevention for cannabis use. *Health Education & Behavior*, *37*(5), 709–723.

[8] Catalano, R. F., Fagan, A. A., Gavin, L. E., Greenberg, M. T., Irwin, C. E., Ross, D. A., & Shek, D. T. (2012). Worldwide application of prevention science in adolescent health. *The Lancet, 379*(9826), 1653–1664.

[9] Canadian Centre on Substance Abuse. (2014). *The Canadian Standards for Youth Substance Abuse Prevention: An overview*. Ottawa, Ont.: Author.

[10] Dunn, M. E., & Goldman, M. S. (1998). Age and drinking-related differences in the memory organization of alcohol expectances in 3rd-, 6th-, 9th-, and 12th-grade children. *Journal of Consulting and Clinical Psychology, 66*(3), 579–585.

[11] Dunn, M. E., & Goldman, M. S. (2000). Validation of multidimensional scaling-based modeling of alcohol expectancies in memory: age and drinking-related differences in expectancies of children assessed as first associates. *Alcoholism: Clinical and Experimental Research, 24*(11), 1639–1646.

[12] Johnston, L. D., O'Malley, P. M., Miech, R. A., Bachman, J. G., & Schulenberg, J. E. (2014). *Monitoring the Future national results on drug use: 1975–2013: Overview, Key Findings on Adolescent Drug Use.* Ann Arbor, MI: University of Michigan:

[13] Sigelman, C. K., Bridges, L. J., Leach, D. B., Mack, K. L., Rinehart, C. S., Sorongon, A. G., . . . Wirtz, P. W. (2003). The efficacy of an education program to teach children a scientific theory of how drugs affect behavior. *Journal of Applied Developmental Psychology, 24*(5), 573–593.

[14] Holtz, K. D., & Twombly, E. C. (2007). A preliminary evaluation of the effects of a science education curriculum on changes in knowledge of drugs in youth. *Journal of Drug Education, 37*(3), 317–333.

[15] Klisch, Y., Miller, L. M., Wang, S., & Epstein, J. (2012). The impact of a science education game on students' learning and perception of inhalants as body pollutants. *Journal of Science Education and Technology, 21*(2), 295–303.

[16] Sigelman, C. K., Silk, A., Goldberg, F., Davies, E. P., Dwyer, K. M., Leach, D., & Mack, K. (1999). Developmental differences in beliefs about how alcohol and cocaine affect behavior. *Journal of Applied Developmental Psychology, 20*(4), 597–614.

[17] Epstein, J., Collins, K. K., Thomson, N. R., Pancella, T., & Pauley, D. (2007). The Doubles: evaluation of a substance abuse education curriculum for elementary school students. *Journal of Child & Adolescent Substance Abuse, 16*(4), 1–22.

[18] Sigelman, C. K., Rinehart, C. S., Sorongon, A. G., Bridges, L. J., & Wirtz, P. W. (2004). Teaching a coherent theory of drug action to elementary school children. *Health Education Research*, *19*(5), 501–513.

[19] Cheng, M. T., Annetta, L., Folta, E., & Holmes, S. Y. (2011). Drugs and the brain: learning the impact of methamphetamine abuse on the brain through a virtual brain exhibit in the museum. *International Journal of Science Education, 33*(2), 299–319.

[20] Klisch, Y., Bowling, K. G., Miller, L. M., & Ramos, M. A. (2013). The impact of science education games on prescription drug abuse attitudes among teens: a case study. *Journal of Drug Education, 43*(3), 255–275.

[21] Miller, L., Moreno, J., Willcockson, I., Smith, D., & Mayes, J. (2006). An online, interactive approach to teaching neuroscience to adolescents. *CBE-Life Sciences Education, 5*(2), 137–143.

[22] Harris/Decima Inc. (2014). *Success Check of Marijuana and Prescription Drug Abuse Television Advertisements*. Ottawa, Ont.: Health Canada.

[23] Crano, W. D., Siegel, J. T., Alvaro, E. M., & Patel, N. M. (2007). Overcoming adolescents' resistance to anti-inhalant appeals. *Psychology of Addictive Behaviors, 21*(4), 516–524.

[24] Frey, K. P., & Eagly, A. H. (1993). Vividness can undermine the persuasiveness of messages. *Journal of Personality and Social Psychology, 65*(1), 32–44.

[25] Porath-Waller, A. J., Brown, J. E., Frignon, A. P., & Clark, H. (2013). *What Canadian Youth Think About Cannabis*. Ottawa, Ont.: Canadian Centre on Substance Abuse.

[26] Cameron, W., & Chudler, E. (2003). A role for neuroscientists in engaging young minds. *Nature Reviews Neuroscience, 4*(9), 763–768.

[27] Rideout, V. J., Foehr, U. G., & Roberts, D. F. (2010). *Generation M²: media in the lives of 8-to 18-year-olds*. Menlo Park, CA: Henry J. Kaiser Family Foundation.

[28] Breyer, J., Winters, K. C., & Mentor USA. (2005). *Adolescent brain development: implications for drug use prevention*. Minneapolis, MN: University of Minnesota.

[29] Fletcher, A., Bonell, C., & Hargreaves, J. (2008). School effects on young people's drug use: a systematic review of intervention and observational studies. *Journal of Adolescent Health, 42*(3), 209–220.

[30] Institute of Medicine. (1997). *Dispelling the myths about addiction: strategies to increase understanding and strengthen research.* Washington, DC: National Academies Press.

[31] Kahn, R., Lynn, J., Braga, A., Hoxworth, T., & Donovan, K. (2008). *Engage youth! Colorado's guide to building effective adult-youth partnerships*. Retrieved from Denver, CO: Colorado Department of Public Health and Environment

ISBN 978-1-77178-311-8

Canadian Centre on Substance Abuse
Centre canadien de lutte contre les toxicomanies

The Canadian Centre on Substance Abuse changes lives by bringing people and knowledge together to reduce the harm of alcohol and other drugs on society. We partner with public, private and non-governmental organizations to improve the health and safety of Canadians.

CCSA activities and products are made possible through a financial contribution from Health Canada. The views of CCSA do not necessarily represent the views of the Government of Canada.