



Applying a Pattern-Centered Approach to Assess the Effect of a School-Based Drug Use Prevention Program in Brazil: A Cluster Randomized Controlled Trial

Juliana Y. Valente¹ · Hugo Cogo-Moreira² · Zila M. Sanchez³

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Abstract

This study evaluated the effectiveness of a drug and violence resistance educational program (Programa Educacional de Resistência às Drogas e à Violência—PRO-ERD) on latent substance use profiles over a 9-month follow-up period. Two PRO-ERD curricula were evaluated through a cluster randomized controlled trials with two parts that included a total of 4030 fifth-and seventh-grade students in 30 public schools in São Paulo. The intervention groups received 10 PROERD classes delivered by trained police officers, while the control group received no intervention. The primary outcome measures were drug use (any alcohol use, binge drinking, tobacco, marijuana, and inhalants) in the past 6 months, which was assessed using a pretest and a posttest 9 months later. Latent transition analysis was employed to investigate the effect of the intervention on the probabilities associated with the transition across drug use profiles. Latent drug use profiles are underlying subgroups of individuals similar to each other regarding their pattern of polysubstance use. Two different latent drug use profiles were revealed among the fifth graders (abstainers/low users and alcohol users/binge drinkers) and three drug use profiles among the seventh graders (abstainers/low users, alcohol users/binge drinkers, and polydrug users). For both, there was no evidence of the effect of PROERD on drug transition probabilities. In conclusion, the intervention was not successful in changing transitions across adolescent drug use profiles. Thus, the failure of the intervention to affect students' substance use profiles suggests that it should be reconsidered before it is implemented further in Brazilian schools.

✉ Juliana Y. Valente
juliana.valente@unifesp.br

¹ Department of Psychiatry, Universidade Federal de São Paulo, Rua Botucatu, 740, São Paulo, Brazil

² Department of Education, ICT and Learning, Østfold University College, Halden, Norway

³ Department of Preventive Medicine, Universidade Federal de São Paulo, São Paulo, Brazil

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Introduction

Universal school-based prevention programs are effective strategies for adolescent substance use prevention (Strøm et al., 2014), especially programs that employ interactive techniques aiming at developing life skills (Cuijpers, 2002). Keepin' it REAL (kiR) is a North American universal school-based drug use prevention program that promotes anti-substance use norms and strengthens drug resistance and decision-making skills through culturally grounded strategies (Hecht et al., 2003). However, past evaluations of the program have shown contradictory results in preventing adolescent drug use. Among seventh-grade students, kiR demonstrated positive results in preventing alcohol consumption (Gosin et al., 2003; Kulis et al., 2007), marijuana, and tobacco use (Kulis et al., 2007, 2019); however, the fifth-grade kiR curriculum revealed a significantly increased prevalence in substance use (Elek et al., 2010).

In 2009, the kiR program was adopted by DARE (Drug-Abuse Resistance Education) America to create a version of kiR named DARE-kiR. DARE's decision to replace its previous curriculum, which focused on instructing students as to the dangers of drug use, was based on evidence that the previous curriculum produced iatrogenic effects (Lynam et al., 1999). During the past decade, DARE-kiR has been widely implemented in United States schools by police officers.

In 2014, the Brazilian Military Police Office, responsible for the implementation and dissemination of the drug and violence resistance educational program (Programa Educacional de Resistência às Drogas e à Violência—PROERD), under a contract with DARE America, replaced the previous DARE curriculum (Shamblen et al., 2014) with the new DARE-kiR curriculum, translated and renamed as “Caindo na Real” in Brazil. Note that no cultural adaptation of the DARE-kiR was attempted before implementation in Brazilian schools.

Even though DARE kiR is the most widely delivered school-based prevention program in the country (Pereira & Sanchez, 2020), with mandatory implementation in all public schools in the State of São Paulo (State Law 17, 171/2019), no effectiveness evaluation has yet been conducted to assess the effects of the curriculum. Moreover, note that none of the previously published studies refer to the DARE-kiR version as translated and implemented in Brazil by PROERD. Instead, all published studies refer to the DARE curriculum before the DARE-kiR curriculum replaced it (Lynam et al., 1999) and to other evaluations of the kiR program prior to its affiliation with DARE (Hecht et al., 2003). Because of the absence of evidence from the North American DARE-kiR curriculum and lack of its cultural adaptation for use with students in Brazil, we assessed whether PROERD is achieving its preventive goals or whether it might be ineffective or even producing harmful effects (Halladay et al., 2020).

Latent transition analysis (LTA) is a powerful tool for testing the effects of drug use interventions because it estimates the effect of an intervention on the probabilities of individuals' transition from one latent drug use profile to another

over time (Collins & Lanza, 2009). Latent drug use profiles are underlying subgroups of individuals similar to each other regarding their drug consumption pattern. LTA is an alternative approach to subgroup analysis that seeks to determine whether individuals respond differently to an intervention when considering a group of potential outcomes such as different types of substances (alcohol, tobacco, marijuana, and inhalants). Thus, LTA supports the study of changes in the composition of students' trajectories across these groups over time. In contrast to a variable-centered approach that performs multiple comparisons for each observed drug use variable, LTA uses a pattern-centered approach to assess changes in underlying drug use profiles (Lanza et al., 2010). Moreover, it offers a better strategy to evaluate the effects of interventions by reducing the challenges that may arise in subgroup analysis, including lower statistical power, high Type I error, and limitations in examining higher-order interactions (Lanza & Rhoades, 2013).

Considering that the LTA approach offers a promising tool for the evaluation of drug use interventions and that there is a lack of studies applying this technique (Graham et al., 1991; Spoth et al., 1999; Strøm et al., 2014; Valente et al., 2018), this study aimed to analyze the effectiveness of the PROERD/Caindo na Real on the probabilities that students will transition across drug use profiles over a 9-month follow-up period following exposure to the intervention.

Methods

Intervention

PROERD is a Brazilian translation of DARE-kiR (Day et al., 2017), renamed as "Caindo na Real." The program comprises 10 lessons that are delivered by trained military state police officers to students in the classroom, and supported by a student and teacher manual. The instructors' handbook provides information about each lesson's procedures, objectives, required materials, and activities to be performed. Each lesson lasts an average of 50 min and includes one to three activities that addressed drug prevention. Although the curricula for the fifth and seventh grades differ, both offer activities to strengthen drug resistance and decision-making skills through interactive techniques. The main focus of the fifth-grade curriculum lessons is on teaching students how to make responsible and healthy decisions. All 10 lessons of the program are based on the program's decision-making skills model as taught through a four-step model: Define, Analyze, Act, and Evaluate. There are also lessons on bullying, drug use information, peer pressure, self-control, and communication skills. In contrast, the seventh-grade curriculum is based on adolescents' narratives of drug use resistance strategies summarized as "REAL": Refuse, Explain, Avoid, and Leave. There are also lessons on drug normative beliefs, communication skills, and decision-making skills.

The curriculum was built on principles related to: (1) narrative engagement (Miller-Day & Hecht, 2013), which highlights the importance of employing personal narratives in preventive drug messages; (2) cultural grounding, which argues

that preventive messages should be informed by the culture of the target population (Hecht & Krieger, 2006); (3) social and emotional learning, which helps children better comprehend their feelings and demonstrate empathy for others (Durlak et al., 2015); and (4) normative beliefs about using drugs, suggesting the importance of engaging adolescents to think critically about their perceptions of their peers' approval of drug use (Cialdini et al., 1990).

The police instructors who delivered the program were trained in an 80-h training session offered by the military police, under the guidance of the developers of the original program (D.A.R.E. America). The Military Police of the State of São Paulo was responsible for implementing the program, and they did not publish or provide any information regarding the cultural adaptation process. A comparison of the manuals (the original DARE-kiR and PROERD) suggests that no cultural adaptation was performed, and the original program was simply translated for use in Brazil.

Study Desing

A cluster randomized controlled trials (cRCT) with two parts, each comprising two arms, were conducted to evaluate the effectiveness of the PROERD school-based program on preventing adolescent substance use. Participants comprised 4,030 students (1,727 fifth graders and 2,303 seventh graders) in 30 public schools in the city of São Paulo, Brazil, in 2019. Considering that the PROERD has a discrete curriculum designed for each of the two grades, we evaluated the effectiveness of the curricula through two cRCTs. Both intervention groups received 10 classes of the PROERD curriculum, as implemented by trained police officers, whereas the control groups received no intervention.

Data were collected simultaneously for the control and intervention groups. The baseline assessment was conducted before program implementation (February/March 2019), and follow-up data were collected 9 months after the baseline assessment (November/December, 2019). Implementation was the responsibility of the São Paulo State Military Police, and an independent team from universities performed the evaluation.

The study was registered in the Brazilian Ministry of Health Register of Clinical Trials (REBEC) under protocol number 6q23nk. The Research Ethics Committee approved the study protocol of the Federal University of São Paulo (number:1327/2018), and all procedures were in accordance with the ethical standards of the institutional and/or national research committee. Consent to participate in the study was written and obtained from the schools' directors before randomization and from the students after randomization occurred.

Sampling

Given that PROERD has two different curricula designed for different grades, two different sample sizes were calculated to evaluate the effects of the program (Ahn et al., 2014). For the seventh grade, we estimated that the sample size should be

1,608 students (67 per group) for a power of 80%, a significance level of 5%, a difference of proportions of 7%, and an interclass correlation (ICC) of 0.02. The primary outcome for the seventh-grade curriculum was alcohol initiation, and the difference that we expected to find between groups, as well as the mean of similarities of students within schools, was based on findings from a previous evaluation of school-based prevention programs in Brazil (Sanchez et al., 2018).

For the fifth grade, we estimated that the sample size should be 1,820 students (70 per group) for a power of 80%, a significance level of 5%, an effect size of 0.3, and an ICC of 0.02. Considering that drug use prevalence was very low in this age group (approximately 11 years old), the expected primary outcome was bullying (Solberg & Olweus, 2003). We calculated the sample size based on previous findings from the evaluation of school-based prevention programs in Brazil (Gusmões et al., 2018).

Eligible to participate in the study were public state schools in the municipality of São Paulo that included both fifth and seventh grades, and in which PROERD had not been implemented for at least three years prior to enrollment.

We identified a total of 155 schools from the universe of state schools in the municipality of São Paulo that included both the fifth and seventh grades, as specified by the National Institute of Studies and Research Education, Anísio Teixeira (INEP). We excluded 96 schools that had implemented PROERD during the previous three years, based on data from the Military Police. Fifty-nine schools were included in the randomization process.

Randomization

From these remaining 59 schools, we randomly selected 30 for our sample. Schools (both grades in one school) were randomly assigned to either an intervention or a control group. Random assignment was performed using Efron's biased coin, which ensured a balanced sample (1:1 allocation ratio) and was implemented in PASS version 22. All fifth- and seventh-grade students participated in the PROERD program in the intervention schools. Among the 30 schools selected, 28 schools offered only the seventh grade in 2019 (contrary to the previous information provided by the INEP registry). So, the fifth-grade sample included 28 schools (14 received the intervention), and the seventh-grade sample included 30 schools (15 received the intervention).

Instruments and Measures

Students completed an anonymous self-reported audio-guided questionnaire on smartphones, administered by the researchers in the classroom in the absence of teachers or police officers. The fifth-grade questionnaire had approximately 80 questions, and the seventh-grade questionnaire had 50 questions, taking a maximum of 50 min for the students to complete. The instruments were based on the European Drug Addiction Prevention Trial (EU-DAP) questionnaire (Faggiano et al., 2010) and translated and adapted into Brazilian Portuguese (Galvão et al., 2021). The

questionnaires have been used in previous studies to evaluate school drug prevention programs in Brazil (Sanchez et al., 2018).

Study outcomes were any drug use in the past 6 months (yes or no) at pretest and the 9-month follow-up. The substances to which fifth-graders responded were alcohol, binge drinking, tobacco, and marijuana; for the seventh-grade students, we also included questions on inhalant consumption. For this assessment, we used the same questions to assess the consumption of each substance, e.g., “In the past 6 months, have you consumed alcoholic beverages?” and “In the past 6 months, have you consumed five doses of alcoholic beverages on a single occasion?” We considered binge drinking as the consumption of five or more drinks on a single occasion (ESPAD Group, 2020).

We used sociodemographic variables, such as age, sex, socioeconomic status (SES), and baseline drug use, to control for possible confounders. SES was assessed using the scale of the Brazilian Association of Research Companies (ABEP), which considers the education level of the head of the household and goods and services used. The ABEP is scored from 1 to 100 points, with categories ranging from A (highest) to D/E (lowest) according to the cutoff points established in the literature: A (45–100), B (29–44), C (17–28), and D/E (0–16) (ABEP, 2018).

To allow pairing of individuals' questionnaires at different times while protecting their anonymity and confidentiality, students provided a code generated in such a way that they were the only ones who could decode it. Each code comprised seven letters and one number created from their personal information, such as first name, last name, date of birth, mother's name, father's name, and maternal grandmother's name (Galanti et al., 2007). This code was matched across surveys using the Levenshtein algorithm, which can identify similarities between a set of characteristics (Levenshtein, 1965). This matching procedure was previously conducted in drug prevention program evaluations in Europe (Faggiano et al., 2010) and Brazil (Sanchez et al., 2018).

Statistical Analyses

We used the LTA, a longitudinal extension of latent class analysis, to evaluate the effectiveness of PROERD on the probabilities of transition in drug use profiles over time. A robust maximum likelihood (MLR) estimator computed standard errors with the Huber–White “sandwich” estimator efficiently dealing with nonindependence of the participants, because students were nested within schools (Asparouhov, 2006). Moreover, under the full information maximum likelihood and assumption of a missing at random mechanism, we dealt with missing data in accord with the intent-to-treat paradigm.

Different analytical steps were involved in conducting LTA. First, we conducted latent class analysis for each time point, and the extraction of latent classes ceased when the inclusion of a class yielded little additional information. The best latent class solution for each time point was selected based on the goodness-of-fit criterion, considering the parsimony and interpretability of the classes, based on previous literature using Brazilian data (Valente et al., 2018). In addition to the statistical

indices presented below, the best solution and number of latent classes were considered the most consistent statistical and conceptual distinctions among the groups.

The following fit indices were used to determine the best solution statistically: the Akaike information criterion, Bayesian information criterion (BIC), sample size-adjusted Bayesian information criterion (SSABIC), and Vuong–Lo–Mendell–Rubin test. Entropy was used to assess how well discriminated the latent classes underlying the best solution were, where values close to 1 indicated clear and precise classifications.

In sequence, we evaluated the measurement invariance of the best-class solution over time. Measurement invariance helps to stabilize the model, classes, and their definitions over time. We tested and compared two model restrictions: a non-invariance model (i.e., all the thresholds freely estimated across time and within the same latent class) and full invariance (i.e., all the thresholds held constant across time within the same latent class). We conducted difference testing using the log-likelihood method to assess whether the imposed restrictions attenuated the model. All analyses were conducted using Mplus version 8.5 (Muthén & Muthén, 2017), and outputs are available upon request.

Results

Attrition

We didn't find a significant difference when comparing the attrition between groups (i.e., intervention and control). Regarding demographic variables, age differed between the students who were followed at 9 months and those who were lost at follow-up. Among the fifth-grade students, the prevalence of binge drinking was 0.83% among the followed students, and it was 2.3% among the lost students ($p=0.017$). Among the seventh-grade students, the prevalence of alcohol use was 35.41% among the followed students and 44.74% among the lost students ($p<0.001$). Thus, students who missed the nine-month follow-up showed a significantly higher prevalence of the use of certain substances at baseline. For more information regarding attrition analysis, please see Sanchez et al. (2021).

A total of 2,152 fifth-grade students were expected to be found in the schools at baseline; however of those, 1,727 (80.3%) students answered the baseline questionnaire, and 1,334 of those answered the follow-up questionnaire 9 months after baseline (77.2%). Regarding the seventh-grade students, a total of 2,890 were expected to be found in that grade at participating schools; of those, 2,303 (79.7%) students answered the baseline questionnaire, and 1,739 also answered the follow-up questionnaire 9 months after baseline (75.5%), as presented in Fig. 1. Adolescents lost in the nine-month follow-up were 22.76% among the fifth graders and 24.49% among the seventh graders.

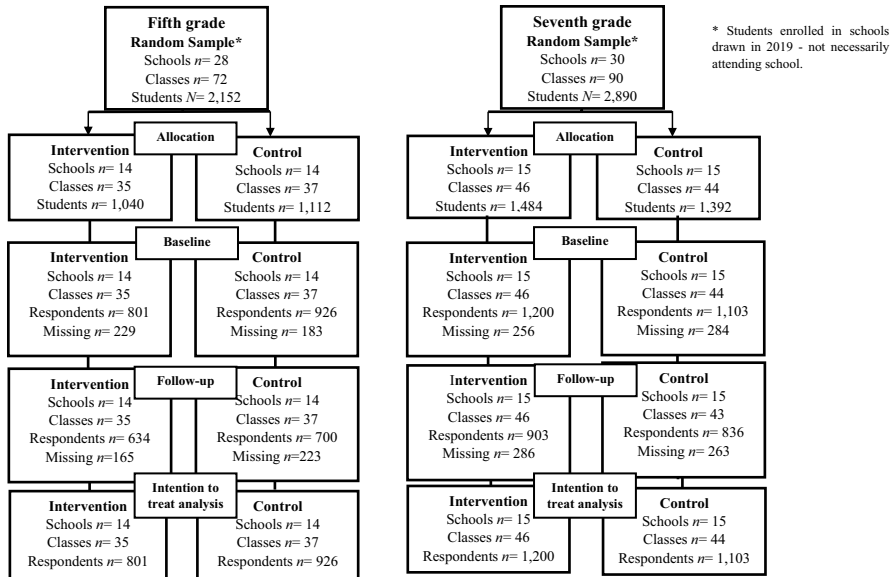


Fig. 1 Flowchart of the randomized controlled trial to assess the effect of the drug use prevention PRO-ERD program among fifth and seventh grade students

Class Enumeration

Table 1 shows the distribution of the fifth- and seventh-grade students according to sociodemographic variables, drug use (alcohol, binge drinking, tobacco, marijuana, and inhalants), and allocation group in the cluster randomized controlled trial of the PROERD program, according to baseline measurements.

Table 2 shows the latent class enumeration for both grades, pre-and-post-PRO-ERD interventions. For the fifth grade, the two-class solution offered the best fit (i.e., BIC and SSABIC increased in three-class solutions) in terms of probability of drug users within each class in the pre-and post-assessment datasets, and prevalence of each class. In contrast, for the seventh grade, the three-class solution showed the best fit (i.e., BIC and SSABIC increased in the four-class solution).

Table 3 describes the probabilities of drug use within each class for each occasion and per grade. Among the fifth graders, we discovered two distinct profiles of drug use across time. The largest group was classified as the “abstainers/low users” (baseline = 98.4%; follow-up = 99.1%), and it exhibited low probabilities of drug use. The second class was the “alcohol users/binge drinkers” (baseline = 1.6%; follow-up = 0.9%), formed largely by adolescents who reported a 100% probability of alcohol drinking, a probability of binge drinking higher than 69%, and lower probabilities (i.e., around 13%–19%) of consumption of other drugs. For the seventh-grade students, we found three profiles of drug use: “abstainers/low users” (92.9%–89.9%), who exhibited very low probabilities of drug use; “alcohol users/binge drinkers” (6.2%–8.3%) with high probabilities to endorse alcohol use and

Table 1 Distribution of the fifth- and seventh-grade students according to sociodemographic data, drug use, and allocation group in the PROERD study, according to baseline. Brazil, 2019

	Total		Missing		Intervention		Control	
	n	%	n	%	n	%	n	%
<i>Fifth-grade students (N = 1,727)</i>								
<i>Sex</i>								
Male	882	51.07	0	0	432	53.93	450	48.60
Female	845	48.93	0	0	369	46.07	476	51.40
<i>Age (mean ± SD)</i>	10.12 ± 0.65	18	1.04	10.10 ± 0.68	10.14 ± 0.61			
<i>SES^a</i>			427	24.72				
A	117	9.00			49	7.94	68	9.96
B	447	34.38			224	36.30	223	32.65
C	646	49.69			309	50.08	337	49.34
D-E	90	6.92			35	5.67	55	8.05
<i>Past year substance use</i>								
Alcohol	164	9.53	6	0.35	82	10.30	82	8.86
Binge drinking	20	1.16	6	0.35	9	1.13	11	1.19
Tobacco	12	0.70	5	0.29	6	0.75	6	0.65
Marijuana	4	0.23	6	0.35	1	0.13	3	0.33
<i>Seventh-grade students (N = 2,303)</i>								
<i>Sex</i>								
Male	1,187	51.54	0	0	621	51.75	566	51.31
Female	1,116	48.46	0	0	579	48.25	537	48.69
<i>Age (mean ± SD)</i>	12.28 ± 0.72	15	0.65	12.28 ± 0.74	12.27 ± 0.71			
<i>SES^a</i>			25	1.09				
A	130	5.71			74	6.25	56	5.12
B	773	33.93			416	35.14	357	32.63
C	1,222	53.64			629	53.13	593	54.20
D-E	153	6.72			65	5.49	88	8.04
<i>Past year substance use</i>								
Alcohol	458	19.96	8	0.35	237	19.82	221	20.11
Binge drinking	132	5.77	7	0.30	71	5.95	61	5.58
Tobacco	36	1.57	8	0.35	20	1.67	16	1.46
Marijuana	41	1.79	8	0.35	22	1.84	19	1.73
Inhalants	57	2.49	11	0.48	31	2.60	26	2.37

^a Chi-Square Test and student's *t* test^b Socioeconomic classification according to Associação Brasileira de Empresas de Pesquisa

Table 2 Goodness-of-fit statistics for the number of latent classes of drug use over the past year among the fifth- and seventh-grade students participating in the PROERD study

Grade	Timeline	Class	Free parameter	H0	Factor Correction	AIC	BIC	SSABIC	VLMR- LRT	LMR-LR	Entropy
Fifth grade	Baseline	Class 1	4	- 750.244	1.136	1508.49	1530.30	1517.59			
		Class 2	9	- 685.588	0.995	1389.18	1438.25	1409.66	<0.001	<0.001	0.924
		Class 3	14	- 680.289	1.022	1388.58	1464.92	1420.44	0.453	0.049	0.951
	Class 4	Degrees of freedom for this model are negative									
Seventh grade	Baseline	Class 1	4	- 472.170	1.178	952.34	973.12	960.41			
		Class 2	9	- 441.477	1.024	900.95	947.71	919.12	0.002	0.002	0.953
		Class 3	14	- 436.483	0.959	900.96	973.70	929.23	0.019	0.021	0.971
	Class 4	Degrees of freedom for this model are negative									
Fifth grade	Baseline	Class 1	5	- 2309.973	1.561	4629.95	4658.65	4679.49			
		Class 2	11	- 1936.114	1.296	3894.23	3957.37	3922.42	<0.001	<0.001	0.932
		Class 3	17	- 1920.210	1.171	3874.42	3971.99	3917.98	0.055	0.059	0.928
	Class 4	23	- 1912.513	1.098	3871.03	4003.04	3929.97	0.061	0.064	0.873	
	Class 5	29	- 1911.097	1.031	3880.19	4046.65	3954.51	0.507	0.510	0.911	
	Class 6	Degrees of freedom for this model are negative									
Seventh grade	Baseline	Class 1	5	- 2139.783	1.162	4289.57	4316.87	4300.98			
		Class 2	11	- 1814.762	1.071	3651.52	3711.58	3676.64	<0.001	<0.001	0.899
		Class 3	17	- 1801.578	1.052	3637.16	3729.97	3675.97	0.093	0.098	0.908
	Class 4	23	- 1795.556	1.061	3637.11	3762.69	3689.62	0.264	0.270	0.840	
	Class 5	29	- 1792.535	1.023	3542.07	3801.41	3709.28	0.181	0.185	0.947	
Class 6	Degrees of freedom for this model are negative										

Abbreviations: AIC = Akaike Information Criteria; BIC = Bayesian Information Criteria; ssABIC = sample size adjusted BIC; VLMR-LRT = Voong-Lo-Mendell-Rubin; Likelihood Ratio LRT Test; LMR-LR adjusted test = Lo-Mendell-Rubin Adjusted LRT Test

Table 3 Weighted probabilities over the past year of the occurrence of alcohol use, binge drinking, tobacco use, inhalant use, and marijuana use according to the model of the three latent classes among the fifth- and seventh-grade students participating in PROERD study

Outcomes Probability of drug use		Baseline		Post-Intervention			
		Abstainers/ Low users	Alcohol user/ Binge drinkers	Abstainers/ Low users	Alcohol user/ Binge drinkers		
Fifth grade	Alcohol use	0.130	100	0.063	0.868		
	Binge drinking	0	0.720	0	0.262		
	Tobacco	0.003	0.162	0.002	0.325		
	Marijuana	0.003	0.194	0	0.086		
	% ^a	98.37%	1.63%	99.10%	0.90%		
	<i>n</i> ^a	1697	28	1321	12		
Outcomes Probability of drug use		Abstain- ers/Low users	Polydrug users	Alcohol user/ Binge drinkers	Abstain- ers/Low users	Polydrug users	Alcohol user/Binge drinkers
Seventh- grade	Alcohol use	0.116	0.937	1	0.166	0.929	1
	Binge drinking	0	0.721	0.588	0	0.572	0.677
	Tobacco	0.003	0.513	0.087	0.004	0.432	0.127
	Marijuana	0.002	1	0.062	0.004	0.719	0
	Inhalants	0.011	0.541	0.103	0.012	0.364	0.139
	% ^a	92.86%	0.96%	6.18%	89.92%	1.74%	8.34%
	<i>n</i> ^a	2134	22	142	1562	30	145

^aBased on final class counts and proportions for the latent classes based on their most likely latent class membership

binge drinking; and “polydrug users” (0.1% – 1.7%) who exhibited the highest probabilities of using all five drugs.

The intermediate group, with respect to consuming alcohol and binge drinking, was qualitatively different among the fifth relative to the seventh graders. Among the fifth graders, the probabilities of using other drugs (i.e., tobacco, marijuana, and inhalants) were higher than the probabilities observed among older students (seventh graders).

Invariance Testing

For both grades, the log likelihood test was not statistically significant, indicating that the added constraints (i.e., holding all threshold parameters equal across time for each class) did not worsen the model (fifth grade: $\chi^2_{(8)} = 8.2332$, $p = 0.411$, seventh grade: $\chi^2_{(15)} = 20.019$, $p = 0.171$).

LTA/ Program Effectiveness

For students in both grades, we found no evidence that the transition probabilities differed between the intervention and control groups (fifth-grade $Wald_{(1)}=2.226$, $p=0.1357$; seventh-grade $Wald_{(4)}=2.866$, $p=0.5806$). For example, among fifth graders, the probability that an individual who was an abstainer/low user at baseline remained in this class after the follow-up was 0.979 for the control group and 0.997 for the intervention group, an exceedingly small difference of 1.8%, which was not statistically significant. Among seventh graders, even though the probabilities were higher than in fifth grade, the probability that an individual who was an abstainer/low user at baseline and remained as such after the follow-up was 0.868 for the control group and 0.856 for the intervention group, which again was not statistically significant.

The probability of staying in the same drug class at follow-up was the highest observed (as specified along the diagonal axis in Table 4), with the only exception being among fifth-grade participants in the control group, where the probability that those who were alcohol users/binge drinkers at baseline and then moved to abstainers/low users was 54%, which corresponded to only 0.06% of the participants. For the PROERD intervention group, the probability of transitioning from alcohol users/binge drinkers at baseline to abstainers/low users was 44.8%; this pattern was also observed in a minority of cases, corresponding to 0.02% of the participants. These differences were not statistically significant. The off-diagonal values shown in Table 4 describe the transition behavior between the classes over time. It should be noted that starting in one class and moving to the other had the lowest probability of occurrence, and that the transitions were not statistically significant. For example, among the seventh-grade students, those who were alcohol users/binge drinkers at baseline and became abstainers/low users at follow-up (probability of 27.3% in the control group and 18.9% in the intervention group, with a difference of 8.4% in the probability) did not demonstrate a statistically significant transition.

Discussion

This randomized controlled trial evaluated the effectiveness of the most widely disseminated drug prevention program in Brazilian schools (PROERD), implemented through two curricula in the fifth and seventh grades, both of which were adapted from the North American program DARE-kiR. The strength of this study was its assessment of the impact of a drug use prevention program through a pattern-centered approach (LTA). Using this approach, we grouped participating students into categories or clusters based on their use of a variety of substances at baseline, and then tested the effects of the intervention on any changes noted over time in their membership in these categories. We found no evidence for the effects of the intervention on the probabilities of transition across drug use profiles when comparing the intervention to the control groups in either of the PROERD curricula targeting fifth and seventh graders.

Table 4 Probability of transition between classes from baseline to nine months in the control and intervention (PROERD) groups

	Control group		Follow-up		PROERD	Follow-up		
	Baseline	Abstainer/ Low users	Alcohol user/ Binge drinkers	Abstainer/ Low users		Alcohol user/ Binge drinkers	Abstainer/ Low users	Alcohol user/ Binge drinkers
Fifth grade	Baseline	Abstainer/ Low users	0.021	0.979	Baseline	Abstainer/ Low users	0.997	0.003
		Alcohol user/ Binge drinkers	0.460	0.540		Alcohol user/ Binge drinkers	0.448	0.552
Seventh grade	Baseline	Abstainer/ Low users	0.022	0.868	Baseline	Abstainer/ Low users	0.124	0.019
		Alcohol user/ Binge drinking	0.089	0.273		Alcohol user/ Binge drinking	0.749	0.062
		Polydrug users	0.819	0.181		Polydrug users	0	0.819

The lack of effect of both PROERD curricula in preventing substance use is problematic because the program has been widely implemented in Brazilian schools. This implementation has required a large public investment in Brazil, including financial and human resources. Our findings align with those of previous studies that also found null effects of the program on the prevention of each drug assessed using a more traditional approach (Sanchez et al., 2021). Another study that analyzed the effect of PROERD on secondary outcomes found iatrogenic results, insofar as the seventh-grade curriculum appeared to increase students' intention to use cigarettes in the future and the likelihood that they were accept marijuana were it offered; and the fifth-grade curriculum appeared to slightly reduce decision-making skills (Valente & Sanchez, 2021).

The pattern of transition or stability among drug use classes was similar over time in the intervention and control groups, which suggests that PROERD is not effective in retaining students in the abstainers/low user profile or transitioning students from the drug use profiles to the abstainers/low user profile, when compared to the control groups. Although no results on the effectiveness of DARE-kiR have been published, to the best of our knowledge, other kiR versions (non-DARE and not implemented by police officers) have demonstrated positive preventive results for seventh-grade students, such as the reduction in the report of lifetime alcohol use (Gosin et al., 2003), discontinuation of alcohol use (Kulis et al., 2007), and a 30% reduction in the use of marijuana and tobacco (Kulis et al., 2007). Our findings thus contradict those of previous studies regarding the effectiveness of kiR. However, we should mention that all previous kiR evaluations focused on the program's effects regarding each type of drug considered separately; our approach differed insofar as we considered the underlying heterogeneity of drug use among the adolescents we studied.

We attribute the lack of effects found to DARE-kiR's failure to culturally adapt the curriculum prior to implementation in Brazil's schools. All evidence points to the importance of conducting a rigorous cultural adaptation process when implementing evidence-based interventions in a new context (Barrera et al., 2017). It is even more critical among programs such as kiR, which are classified as cultural grounding interventions, which suggests that prevention messages should be informed by a careful consideration of the culture of the target population (Colby et al., 2013). Corroborating our hypothesis, all previous kiR studies have provided evidence that cultural adaptation of the curriculum is associated with more effective results (Hecht et al., 2018; Holleran Steiker et al., 2014; Kulis et al., 2005, 2017). In addition, we highlight a significant difference in educational development among Brazilian and North American students. Considering reading performance, which measures the capacity to understand, use, and reflect on written texts, Brazil is ranked 59th, compared with the United States at the 24th position (PISA, 2016). We consider reading and writing skills as vital to the realization of kiR's objectives, since the intervention is guided by a student handbook offering several activities that depend on the students' ability to read the instructions, reflect on them, and write down their thoughts.

kiR is defined as a culturally grounded program, which means that preventive messages should be responsive to culture of the target population (Hecht & Krieger, 2006). The lessons are based on examples that need to be fully adapted to the

adolescents' experience, including the videos that constitute the essential elements of the sessions. These adaptations should be conducted before disseminating the program, and with the active participation of adolescents and other members of the community, as described by kiR developers (Marsiglia & Booth, 2015). Thus, the lack of cultural adaptation of the program arouses concern and reinforces the importance of evaluating the program's effects on Brazilian students.

The lack of cultural adaptation may also impact the program's implementation fidelity because its instructors may need to adjust the content of the lessons to ensure that the students identify with the examples presented (Castro et al., 2004). Considering that the greater the fidelity of program implementation, the better the results for the outcomes studied (Flay et al., 2005), we suggest that further studies evaluate the fidelity of implementation of the program and how its police officers adapt it.

Among the fifth-grade students, we identified two classes of drug use profiles: "alcohol users/binge drinkers" and "abstainers/low users." To the best of our knowledge, this is the first study that has described the latent profiles of drug use among fifth-grade students (Tomczyk et al., 2016). These results corroborate previous findings that the vast majority of the fifth-grade students have not experimented with any drug before the age of 10 (Carlini et al., 2010). Among the seventh-grade students, we identified three classes of drug use profiles: "abstainers/low users," "alcohol users/binge drinkers," and "polydrug users." These findings are consistent with a recent study of a population of Brazilian adolescents of a similar age (Valente et al., 2017) and a systematic review that reported similar results from international studies (Tomczyk et al., 2016). However, we should highlight the fact that, among the seventh graders, the proportion of students who belonged to abstainers/low users (92.86% at baseline) was higher than that reported by previous studies on North American students of the same age (Chung et al., 2013; Snyder & Smith, 2015).

These differences in drug use profiles among the North American and Brazilian populations suggest the importance of conducting curricular cultural adaptation, insofar as many of the program's activities focus on developing drug resistance strategies through students' own stories of resisting offers of substance use (Hecht et al., 2008). Considering that the vast majority of Brazilian fifth- and seventh-grade students belong to the abstainers/low users class and probably had never experienced a situation where they were offered a drug, the program's emphasis on resistance strategies may have raised students' perception of drug use by their peers, which is associated with a potential increase in their own drug use (Elek et al., 2010). Considering that drug use prevalence is lower among younger Brazilian adolescents, we emphasize the need for cultural adaptation of the drug resistance strategy examples to reflect Brazilian adolescents' likely lack of experience with drug offers. We also believe that the grades in which the program is implemented in Brazilian schools should be reviewed so the program activities may be more appropriate for the student's cognitive skills.

Regarding students' movement between groups or categories of substance use over time, among fifth graders we did not find the same pattern as for older adolescents, that is, stability regarding drug use profiles (Baggio et al., 2014; Choi et al., 2017; Valente et al., 2018). In this sample, in the control group, 54% of the fifth graders who were part of the alcohol user/binge drinker group at baseline moved

to the category comprising abstainers/low users at follow-up. The same was true for the intervention group, where 45% of the students in the fifth grade moved in the same direction. Despite the lack of statistical significance for these inter-group differences, this is an interesting finding, showing that such movement is more fluid in younger students and that their drug use seems to be more experimental and unstable.

We also found stability regarding drug use profiles from baseline to 9 months, in which students with the highest probability among transition alternatives remained in the same latent class over time. The seventh graders who were classified as abstainers/low users at baseline were most likely to stay in this class at follow-up, independent of the intervention. This result is congruent with international (Baggio et al., 2014; Choi et al., 2017) and national (Valente et al., 2018) studies. The stability of drug use profiles highlights the possible advantages of selective interventions instead of universal programs. Several studies have highlighted the positive results of selective programs for drug use (Conrod, 2016; Shetgiri et al., 2011), suggesting that drug use profiles should be identified early, and early intervention approaches should target adolescents with risky behaviors (Offord, 2000).

The main limitation of this study has to do with the attrition rate (22.7% among the fifth graders and 24.5% among the seventh graders). Considering that the lost students differed regarding the outcome measure, this may introduce some bias in the analysis; however, this is expected in drug use prevention programs. Losses during follow-up are a common limitation in longitudinal studies (Sanchez et al., 2018), and LTA estimates under full information maximum likelihood offer solutions to these missing data problems. In addition, we highlight the fact that to prevent contamination, the study sample was derived from state schools of São Paulo that did not receive the PROERD in the three years before our study, resulting in a sample of schools located in low-income neighborhoods that were probably more exposed to drug use in comparison than other more wealthy schools not included in our sample (Daniel et al., 2009). Therefore study findings cannot be generalized. When administered in wealthier areas with children from different socioeconomic backgrounds, we do not know the program's effects. Another source of bias was the absence of a measure of implementation fidelity.

The LTA approach identified two drug use profiles among the fifth graders and three among the seventh graders in our sample of Brazilian students. Despite the established benefits of applying LTA to the field of drug behavior, there is a lack of studies critiquing this approach to evaluate the subgroup effectiveness of drug prevention programs. Considering the heterogeneity of adolescent drug use, future studies should explore the impact of interventions on transitions in drug use profiles. Transition probabilities in drug use profiles seemed to be different among the fifth- and seventh-grade students we assessed; however, none was influenced by the intervention. In terms of local policy, this intervention's null effects suggest that the PROERD program's components should be culturally adapted according to the Brazilian adolescents' drug use profiles before further implementation in Brazil.

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Declarations

Conflicts of interest The authors are now the Editor-in-Chief, Managing Editor, and Statistical Editor of the *Journal of Prevention*. However, this manuscript was submitted early in 2021, before they took these posts. The submission was handled by the Editor-in-Chief at that time, Dr. Chirs Ringwalt. All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

Ethics approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study was registered in the Brazilian Ministry of Health Register of Clinical Trials (REBEC), under protocol number 6q23nk. The study protocol was approved by the Universidade Federal de São Paulo's Research Ethics Committee (n:1327/2018).

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