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ORIGINAL ARTICLE

The Contextual Factors Associated with Co-occurring Substance and Problematic Internet Use in Adolescence: a Network Approach

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Abstract

This study assessed the association between substance use (alcohol and tobacco) and problematic Internet use (PIU) in a sample of Brazilian adolescents. A stratified and probabilistic sample was used to recruit 869 adolescents (M_{AGE} = 13.3; SD_{AGE} = 2.10) living in a city in the southeast of Brazil. Participants completed a sociodemographic questionnaire, the Internet Addiction Test (IAT), and the Drug Use Screening Inventory (DUSI). To estimate the influence of different variables on substance use and PIU, we conducted a network analysis (NA) from four centrality levels. The results indicated an association between substance use and PIU, in particular with tobacco. The NA indicated that the time spent on the Internet had the greatest influence on alcohol consumption, while among smokers, income and anxiety were associated with the highest centrality levels. These findings help clarify the complex relationship between substance and problematic Internet use among adolescents.

Keywords Adolescence · Problematic Internet use · Tobacco · Alcohol

Introduction

Psychoactive substance use represents a severe public health problem in many countries. A study evaluating the global burden of disease (GBD) between 1990 and 2016 showed significant increases in the GBD for several psychoactive substances on different continents. Main increases were observed in the consumption of alcohol (44%) and other drugs (56.9%) (Degenhardt & GBD 2016 Alcohol and Drug Use Collaborators, 2018). Furthermore, the GBD was significantly higher among

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low and middle-income countries. Particularly in Brazil, there was an increase in the GBD for alcohol, particularly among males (12%) (Marinho et al., 2018).

Substance-related disorders (SRD) are among the main public health problems in many countries due to their high prevalence in the general population, mainly among young people. In a report published by the World Health Organization, approximately three million premature deaths are due to excessive alcohol consumption, with one-third of deaths occurring in individuals aged 15–29 years (WHO, 2018). These findings align with epidemiological data that indicates rapid growth in SRD among young people (Drope & Schluger, 2018). This increase is significantly higher in low- and middle-income countries with poor prevention programs and specialized assistance.

The losses generated by SRD are significant, especially among youths (Bedendo et al., 2013, 2017). Several authors have reported that adolescents with SRD experience significantly more significant losses than adults in areas such as family, criminal offenses, problems with studying, and violent acts (Carvalho et al., 2017). In addition, adolescents have neurobiological and psychosocial differences that may increase the vulnerability of both SRD and other behavioral addictions (Bedi et al., 2021). Some authors also observed that dysregulation of dopamine reward pathways is more common among those adolescents exposed to reward stimuli than adults (Kim et al., 2011, 2020), and the fact that adolescents do not have a fully developed frontal cortex (i.e., executive functioning) may increase vulnerabilities to multiple addictions (Bedi et al., 2021). These findings indicate the possibility of a cross-addiction, in which specific neurochemical pathways are activated from environmental cues for both chemical (substance use) and behavioral stimuli (gambling, video games, smartphones, Internet, among others).

There is an increase in problematic Internet use (PIU) prevalence, especially in countries with high levels of connectivity (Andrade et al., 2020a, 2021a, b; Masaeli & Farhadi, 2021). Because of technological advances, it is easier to engage in many daily tasks associated with more extended Internet and smartphone use as they provide more types of entertainment that can act as reinforcing stimuli (Marín-Díaz et al., 2020). Although PIU is not considered a specific pathology in mental disorder manuals, several studies suggest similarities between the clinical symptoms of PIU and SRD (Berdin & Saules, 2019; Durkee et al., 2016; Lanthier-Labonté et al., 2020; Morioka et al., 2017; Razjouyan et al., 2018; Savolainen et al., 2020; Vázquez-Nava et al., 2020; Vranken et al., 2020). For example, neural areas are activated similarly to SRD and PIU stimuli (Kim et al., 2011). Other studies have also identified that problematic Internet users present alterations in the neural regions commonly associated with the clinical symptoms of SRDs, such as changes in impulsivity levels (Li et al., 2019), motivation (Brand et al., 2019), and cognitive control (Cudo et al., 2020). In addition, some studies have observed lower baseline levels of dopamine release and lower density of dopaminergic D2 receptors (Kim et al., 2011) in the ventral striatum in users with PIU, like those found in individuals with SRD (Nall et al., 2021).

Several clinical studies have been conducted to identify a possible association between SRD and PIU. In a study with 73,000 adolescents, smokers had almost three times the greater chance of developing PIU (Lee et al., 2013). In a study with more than 100,000 Japanese adolescents, a significant association was observed between SRD and PIU, with more than 55% of adolescents with PIU smoking more than 21 cigarettes daily (Morioka et al., 2016). In an innovative study, Berdin and Saules (2019) sought to identify behavioral and emotional problems in individuals

who used the Internet while drinking alcoholic beverages. More than 60% of these people reported regret in some online behavior due to consuming alcohol, compared to only 30% of participants who accessed the Internet without consuming alcohol. In another study (Rücker et al, 2015), adolescents with PIU were more likely to consume tobacco (adjusted odds ratio (aOR) = 2.05), alcohol (aOR = 1.72), marijuana (aOR = 1.94), or other illegal substances (aOR = 2.73).

These findings indicate that addictions may share both clinical and behavioral symptoms, such as the feeling of anxiety due to deprivation of the reinforcing stimulus (drugs, Internet, games, smartphones, etc.). The search for behaviors that lead to the feeling of pleasure reduces time on other tasks unrelated to addictive behavior and increases the amount of time spent on addiction-related behaviors (Jin Jeong et al., 2020). Individuals with SRD and PIU also report more significant emotional problems than the general population and lower quality of life in various domains (Swendsen et al., 2010; Wartberg et al., 2016). In a 10-year longitudinal study with more than 5000 participants, those with a previous mental disorder (mainly anxiety or mood disorders) had a greater probability of experimental substance use and increased intensity of use (Swendsen et al., 2010). The authors also identified that those with mental disorders and who had already used alcohol or tobacco had a significantly higher risk of excessively consuming these substances. More recently, some authors have reported that individuals with severe levels of depression and stress are three times more likely to present PIU, and those with anxiety had an increased probability of 2.79 (Andrade et al., 2020a).

In sum, preliminary studies suggest a potential link between SRD and PIU, particularly among adolescents. However, there is a need for further research in this domain. For example, in a recent systematic review, the authors failed to identify a consistent association between PIU and the use of alcohol and marijuana among young people (Lanthier-Labonté et al., 2020). It should be noted that the number of studies assessing the relationship between SRD and PIU was rather small, which indicates the need for further research. In addition, no study has been conducted in Brazil to assess a possible association between SRD and PIU. The present study aimed to examine the possible association between PIU and substance use (alcohol and tobacco) in Brazilian adolescents. Additionally, we aimed to identify the possible influence of emotional problems (depression, anxiety, and stress) in the relationship between SRD and PIU. Based on previous research, we hypothesized that (i) there would be a significant association between PIU and substance use, (ii) adolescents who used alcohol and tobacco problematically would have a higher frequency of behaviors related to the use of digital media (time spent using the Internet, sending and receiving messages, among others), and (iii) quality of life and emotional problems would present higher levels of centrality (influence) on the use of substances and the Internet using network analysis.

Methods

This is an exploratory cross-sectional study using stratified and probabilistic sampling. The study was conducted with adolescent students from five schools randomly chosen from a pool of all schools in a municipality in the state of São Paulo, Brazil.

Sample

The inclusion criteria were as follows: (i) adolescents must have studied at one of the five schools selected for the study, (ii) they must have accessed the Internet at least once a day from any device (smartphone, computer, or tablet), (iii) participants must have provided a signed informed consent, and (iv) parents must have agreed with their child participating in the study provided a signed assent form. From an initial total of 1837 students, adolescents who had not consumed alcohol or tobacco in the last month and those classified by the DUSI instrument as risk-free users were excluded ($n = 968$). The final sample consisted of 869 adolescents aged 9 to 17 years ($M = 13.3$; $SD = 2.10$), with 322 consuming only alcohol (experimental or misuse), 150 consuming only tobacco (experimental or misuse), and 397 consuming both alcohol and tobacco according to the DUSI instrument.

Instruments

Sociodemographic Questionnaire

The questionnaire collected information about age, sex, education, income, and specific questions about Internet and smartphone use (time of use, number of messages sent and received, most accessed social networks, etc.).

Internet Addiction Test

The IAT was used to assess Internet use patterns. The IAT consists of 20 Likert items ranged from 0 (Never) to 5 (Always), with scores ranging from 0 to 100 points. Scores above 50 points indicate PIU. In Brazil, the IAT has been validated (Conti et al., 2012) with satisfactory internal consistency ($\alpha = 0.87$).

Drug Use Screening Inventory

The DUSI was designed for adolescents with 15 specific dichotomous questions (yes/no) that assess problems associated with the use of various classes of drugs (De Micheli & Formigoni, 2002). The consumption of alcohol and tobacco refers to the last month, and participants were classified into three possible groups according to the number of affirmative responses: nonusers (no score on the instrument), experimental users (2 affirmative answers in substance use), and abusers (3 to 7 affirmative responses in substance use). As previously described in "Methods," participants with no DUSI scores were excluded from this study. According to previous studies (Nascimento & De Micheli, 2015), we classified "experimental users" as individuals who used a substance 1 or 2 times in the last month and "abusive users" as those who consumed a substance up to 9 times a month. De Micheli and Formigoni (2002) validated the DUSI in Brazil and demonstrated high internal consistency ($\alpha = 0.86$).

Depression, Anxiety, and Stress Scale-21

The Depression, Anxiety, and Stress Scale-21 (DASS-21) assesses the prevalence and intensity of depression, anxiety, and stress symptoms with seven questions for each domain. In Brazil, the DASS-21 was adapted and validated for adolescents by Patias et al. (2016). Adolescents may be classified into clinical and non-clinical groups based on their scores for each domain. The authors found high internal consistency for all assessed measures (depression, $\alpha = 0.90$; anxiety, $\alpha = 0.83$; stress $\alpha = 0.86$).

Data Analysis

Raw data (continuous variables) were transformed into *z*-score (standardized), and data with three or more standard deviations were removed from the analysis. The Student's *t*-test was used for independent samples, and nominal or categorical variables were analyzed using Fisher's exact or the chi-square test (χ^2).

We used a graphic exploratory technique, network analysis (NA), to estimate the grouping of different variables associated with sociodemographic and emotional measures and their influence on alcohol and tobacco consumption with PIU and other variables. The differences between boys and girls were also analyzed. This procedure enabled the analysis of the level of influence (centrality) of each variable in the system and estimated whether this process occurs directly or indirectly. NA is increasingly used to study mental disorders through direct or indirect interaction between symptoms (Spritzer et al., 2022; Andrade et al., 2021c; Borsboom, 2017).

The network items (nodes) connect using edges (partial correlations), with the green and red edges representing positive and negative correlations. Thicker edges indicate stronger correlations (Oliveira Pinheiro et al., 2020). The influence of variables on the system was assessed based on four centrality criteria: (i) the number of connections that a node has with the others (betweenness centrality); (ii) the strength of these connections (degree centrality); (iii) the mean weight of the correlations of each item with the others (closeness centrality); (iv) the weighted measure of the item's influence in the system as if it were excluded from the network (expected influence). The analyses were performed using the open-source software JASP®, with a significance level set at 0.05.

Results

Regarding the participants' sociodemographic characteristics (Table 1), girls had a lower rate of experimental use of alcohol and cigarettes than boys. However, no differences were found in alcohol and cigarette use patterns in terms of income, race, and type of Internet access (smartphone, computer, or tablet).

Table 2 presents Internet use characteristics and between-group comparisons of the experimental and abusive use of alcohol. Participants with a higher consumption pattern of alcohol (abusive group) had a more significant duration of Internet use, time on cell phones, number of times they checked their cell phone, and time on WhatsApp compared to participants in the experimental or risk-free group.

For tobacco, there was a higher frequency of Internet time and total daily hours spent on the smartphone in the abusive group concerning the other groups (Table 3). Also, participants who abused nicotine had higher IAT scores and a higher frequency of all symptoms assessed by the IAT than the other participants.

Figure 1 presents the NA related to alcohol use in girls (Fig. 1A) and boys (Fig. 1B). The data indicated that the use of alcohol (node 21) is directly related to the time spent on the Internet (positive correlation) and the frequency of checking cell phones in both boys and girls. However, the strength of these correlations was greater among girls. On the other hand, the score of the IAT instrument (node 20) was not

Table 1 Descriptive analysis of sociodemographic characteristics according to the patterns of substance use (alcohol and tobacco)

Variable	Substance use											
	Alcohol						Tobacco					
	Experimental use		Misuse				Experimental use		Misuse			
	N	%	*N*	%	χ^2	*p*	*N*	%	*N*	%	χ^2	*p*
Gender					**9.88**	**					**4.79**	*
Male	418	67.3	50	51.0			275	59.3	39	46.4		
Female	203	32.7	48	49.0			189	40.7	45	53.6		
Race					**0.10**	**0.94**					**2.45**	**0.29**
White	185	60.3	39	60.9			139	62.3	21	65.6		
Mixed race	89	29.0	19	29.7			57	25.6	10	31.3		
Black	33	10.7	6	9.40			27	12.1	1	3.10		
Economic class					**1.36**	**0.71**					**6.21**	**0.10**
A	30	4.80	3	3.10			14	3.0	5	6.00		
B	240	38.6	34	35.1			163	35.1	38	45.8		
C	311	50.1	54	55.7			253	54.5	35	42.2		
D–E	40	6.40	6	6.20			34	7.3	5	6.00		
Mainly Internet access					**1.66**	**0.43**					**5.97**	**0.06**
Smartphone	555	89.7	89	90.8			411	88.8	78	92.8		
Computer	54	8.70	6	6.10			42	9.00	2	2.40		
Tablet	10	1.60	3	3.10			10	2.20	4	4.80		

N = number of participants; % = frequency of participants; χ^2 = chi-square test; *p* = significance level. *$p < 0.05$; **$p < 0.01$

Table 2 Internet usage pattern according to the patterns of substance use-alcohol

	Substance use					
	Alcohol	*N*	*M*	*SD*	*T*	*p*
Time spent on smartphone (h)	Misuse	88	7.19	3.66	7.55	***
	Experimental	608	5.03	2.30		
Time spent on Internet (h)	Misuse	72	5.76	2.07	3.70	***
	Experimental	591	4.85	1.94		
Number of smartphone checks daily	Misuse	88	17.22	12.99	−2.30	*
	Experimental	597	20.54	12.58		
Every how many minutes check the smartphone (min)	Misuse	89	19.96	18.86	0.36	0.71
	Experimental	584	19.29	15.53		
Number of calls received daily	Misuse	93	2.31	1.67	0.66	0.50
	Experimental	606	2.19	1.58		
Number of calls made daily	Misuse	92	1.55	1.62	1.19	0.23
	Experimental	611	1.38	1.22		
Number of messages sent daily	Misuse	82	123.39	158.77	0.18	0.85
	Experimental	558	120.10	144.97		
Number of messages received daily	Misuse	84	320.73	380.77	2.95	**
	Experimental	569	213.69	297.79		
Time spent on WhatsApp daily	Misuse	86	97.02	113.08	2.89	**
	Experimental	565	68.06	81.76		
IAT instrument						
Total score	Misuse	98	61.52	29.97	−0.14	0.88
	Experimental	618	61.99	30.57		
Salience	Misuse	98	15.05	7.82	−0.19	0.84
	Experimental	618	15.22	7.97		
Excessive use	Misuse	98	15.22	7.80	−0.03	0.97
	Experimental	618	15.26	7.95		
Neglecting work	Misuse	98	9.05	4.70	−0.15	0.87
	Experimental	618	9.13	4.81		
Anticipation	Misuse	98	6.05	3.12	−0.21	0.82
	Experimental	618	6.13	3.21		
Lack of control	Misuse	98	10.04	3.64	−0.13	0.89
	Experimental	618	10.09	3.70		
Neglecting social life	Misuse	98	6.10	3.12	−0.03	0.97
	Experimental	618	6.11	3.20		

N = number of participants; *M* = mean; *SD* = standard deviation; *T* = *T* test values; *p* = significance level. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

directly connected with alcohol use among all participants. Time spent on the Internet was one of the variables with the most significant influence on the system as it presented the highest levels of centrality based on the criteria used (Fig. 1C).

Regarding the use of tobacco (Fig. 2), the graphs indicated a direct correlation between the score on the IAT instrument (node 20) and the use of tobacco (node 21) in both girls

Table 3 Internet usage pattern according to patterns of substance use-tobacco

	Substance use					
	Tobacco	*N*	*M*	*SD*	*T*	*p*
Time spent on smartphone (h)	Misuse	80	5.94	2.36	4.2	***
	Experimental	460	4.87	2.03		
Time spent on Internet (h)	Misuse	75	5.55	1.56	3.72	***
	Experimental	451	4.75	1.73		
Number of smartphone checks daily	Misuse	80	19.19	11.85	−0.24	0.80
	Experimental	452	19.54	11.91		
Every how many minutes check the smartphone	Misuse	79	17.54	15.92	−1.31	0.18
	Experimental	435	20.11	15.89		
Number of calls received daily	Misuse	83	2.48	1.73	1.77	0.07
	Experimental	458	2.15	1.55		
Number of calls made daily	Misuse	83	1.54	1.43	1.64	0.10
	Experimental	458	1.30	1.18		
Number of messages sent daily	Misuse	77	98.73	137.39	−1.30	0.19
	Experimental	401	122.02	144.59		
Number of messages received daily	Misuse	80	179.41	293.77	−0.66	0.50
	Experimental	423	202.85	289.42		
Time spent on WhatsApp daily	Misuse	78	79.67	94.20	0.13	0.89
	Experimental	416	78.16	91.10		
IAT instrument						
Total score	Misuse	84	70.10	27.91	2.44	*
	Experimental	462	61.27	30.93		
Salience	Misuse	84	17.39	7.21	2.47	*
	Experimental	462	15.07	8.03		
Excessive use	Misuse	84	17.42	7.23	2.47	*
	Experimental	462	15.10	8.01		
Neglecting work	Misuse	84	10.33	4.45	2.24	*
	Experimental	462	9.06	4.81		
Anticipation	Misuse	84	7.00	2.90	2.58	*
	Experimental	462	6.03	3.22		
Lack of control	Misuse	84	11.06	3.41	2.47	*
	Experimental	462	9.98	3.73		
Neglecting social life	Misuse	84	6.89	2.96	2.29	*
	Experimental	462	6.03	3.22		

N = number of participants; *M* = mean; *SD* = standard deviation; *T* = *T* test values; *p* = significance level. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

(Fig. 2A) and boys (Fig. 2B). Among girls, tobacco consumption was directly associated with the time spent on the Internet and the age of the participants. In the latter case, the older the age, the greater the frequency of consumption. On the other hand, a strong correlation between Internet use and tobacco consumption in boys was not identified. We also found a negative correlation between tobacco use and the frequency that boys check their smartphones. Concerning tobacco consumption, the variables most influenced the network (Fig. 2C) for both boys and girls were the participants' income and anxiety levels.

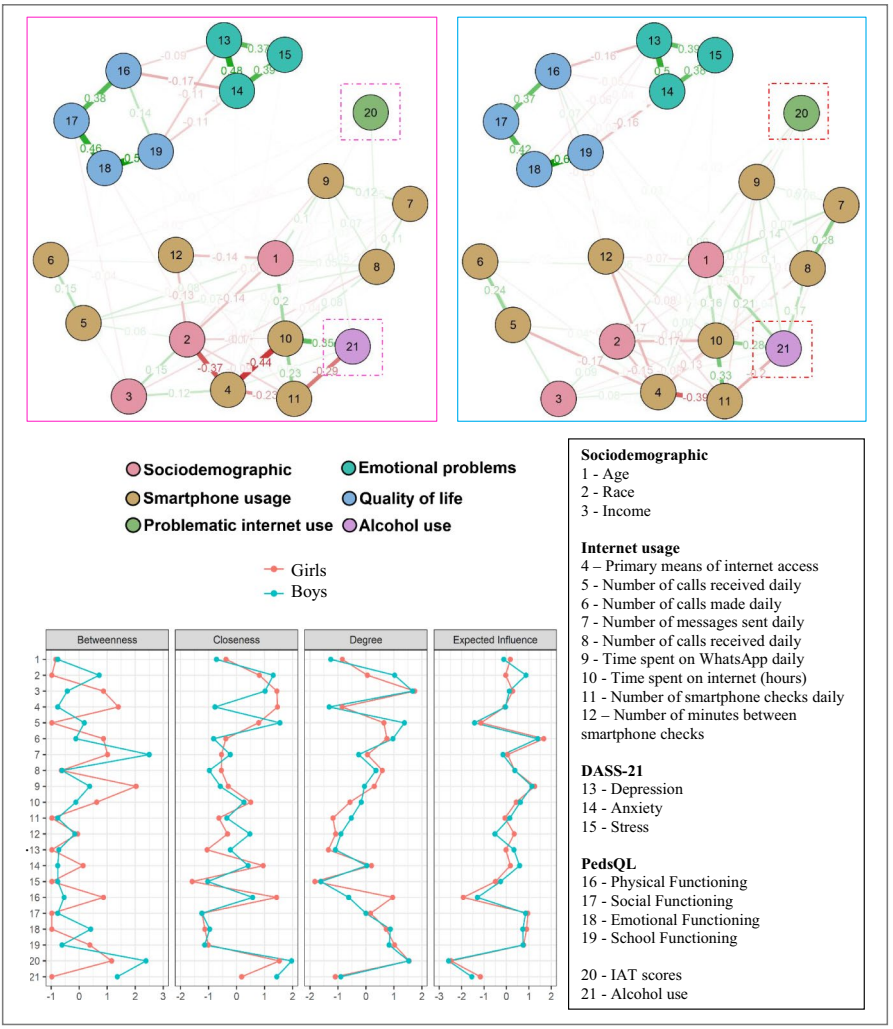

Fig. 1 Gaussian graphical model to detect the connections for substance use-alcohol (purple node) regarding sociodemographic (pink nodes), Internet usage (brown nodes), DASS-21 scores (green water nodes), PedsQL scores (blue nodes), and IAT total scores (green node) with smartphone use behaviors (blue nodes), SAS-SV (yellow nodes), and IAT scores (purple nodes) between girls (pink box) and boys (blue box). The last image reprtesents the network centrality measures of the variables between boys (blue line) and girls (red line). The more relevant nodes of the study (alcohol use and internet addiction) have been highlighted with a dotted square for better visualization

Discussion

In this study, we tested a possible association between substance-related disorder (alcohol and tobacco) and PIU among adolescents. Using the NA approach, we also sought to identify whether alcohol and tobacco consumption were directly associated with PIU. To the best of our knowledge, this is the first study to assess the association

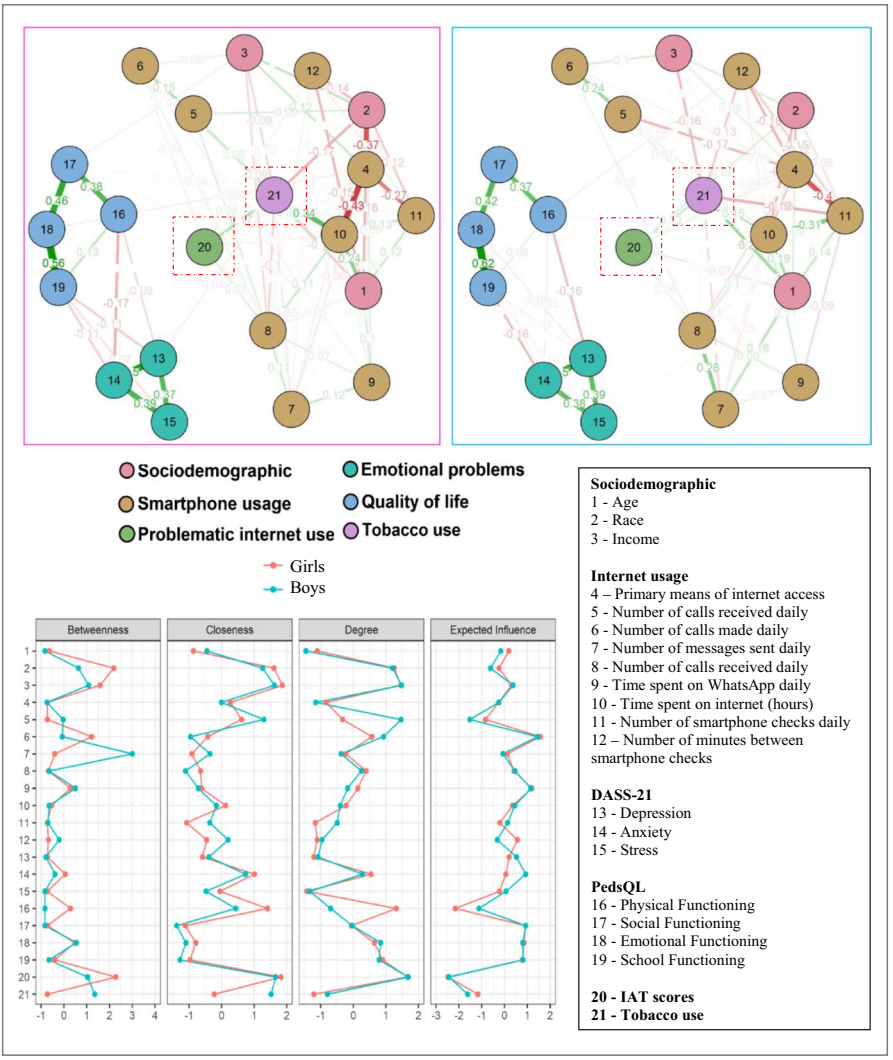

Fig. 2 Gaussian graphical model to detect the connections for substance use-tobacco (purple node) regarding sociodemographic (pink nodes), Internet usage (brown nodes), DASS-21 scores (green water nodes), PedsQL scores (blue nodes), and IAT total scores (green node) with smartphone use behaviors (blue nodes), SAS-SV (yellow nodes), and IAT scores (purple nodes) between girls (pink box) and boys (blue box). The last image reprtesents the network centrality measures of the variables between boys (blue line) and girls (red line). The more relevant nodes of the study (alcohol use and internet addiction) have been highlighted with a dotted square for better visualization

between substance use and the Internet, by means of NA approach. Our main findings indicated an association between substance use and PIU. However, this association was more robust among smokers. The NA also indicated that time spent on the Internet had the most significant influence (centrality) on alcohol use, while income and anxiety had the highest centrality levels among smokers. These findings align with previous findings

reported in the literature (Andrade et al., 2020b; Cruz et al., 2018; Swendsen et al., 2010). Notably, participants who abused alcohol used smartphones and the Internet more and used WhatsApp for more extended periods than the experimental group. These findings indicate that the association between alcohol and Internet use may be more specific to the use of smartphones and not the Internet itself. In a study conducted with young Belgians, there was a strong association between alcohol use and access to digital media (Vranken et al., 2020). Also, the authors detected a strong positive correlation between binge drinking and access to Snapchat and WhatsApp. In another study conducted in countries on different continents, alcohol abuse was associated with different digital media services and Facebook and Instagram were the digital media most associated with alcohol abuse among individuals in Spain, Finland, and South Korea (Savolainen et al., 2020).

These findings are relevant as they indicate that social media may maintain or increase the pattern of substance use in different ways. For instance, viewing advertisements for substances (such as alcohol and tobacco) can increase the probability of consumption (Hoffman et al., 2014). Platforms with more dynamic interactions (WhatsApp and Facebook) may increase the consumption risk due to the exchange of instant group messages and viewing content related to the topic under discussion, such as substances. In a study conducted with Mexican adolescent smokers, 32% of participants who used WhatsApp and Facebook daily reported that tobacco consumption was influenced by digital networks (Vázquez-Nava et al., 2020).

In our findings, the prevalence of adolescents with PIU was significantly higher among smokers, and there were no differences in this prevalence among drinkers. The NA indicated that tobacco use was directly related to PIU. Although our findings are in line with some studies in the literature (Lee et al., 2013; Morioka et al., 2016, 2017; Razjouyan et al., 2018), these results should be interpreted with caution for a few reasons. First, the problematic use of smartphones and the Internet are not synonymous, and relevant clinical and behavioral differences may be associated differently with each type of substance (De-Sola Gutiérrez et al., 2016). Second, tobacco is a substance commonly consumed at any time and can be associated with individuals' daily routine such as work and study, thus increasing the likelihood of using cigarettes while on the Internet (Liu et al., 2019; Rücker et al., 2015).

Regarding emotional problems, the NA indicated that anxiety was associated with the highest levels of centrality for substance use, especially tobacco. Additionally, this influence was even more robust among girls. Our data confirm previous studies showing that higher anxiety levels are linked with SRD and the use of digital media (Berdin & Saules, 2019; Durkee et al., 2016; Lanthier-Labonté et al., 2020; Wartberg et al., 2016). Anxiety disorders are significantly higher among females (Fawcett et al., 2020), and tobacco use has significantly increased among girls in several countries (GBD 2016 Alcohol and Drug Use Collaborators, 2018; Drope & Schluger, 2018) which may help to explain the present findings.

Some limitations of our study must be considered. First, we conducted an exploratory study with a transversal collect data, which it was not possible to establish causal relationships or assess the mediating or moderating factors of emotional problems in Internet use. Second, a standardized instrument was not used to assess the problematic smartphone use, which reduces the possibility of identifying specific behaviors of adolescents using the Internet by smartphones. Third, the generalizability of our findings may be limited as participants consisted of adolescents living in a single Brazilian city.

The study also had strengths, including the sample size, the data collection method (probabilistic sampling), and the field that has not yet been studied in Brazil.

Conclusion and Future Directions

The results from this study will contribute for future studies, in which we intend to (i) test the moderating or mediating role of anxiety for Internet use between alcohol and tobacco users through the structural equation modeling technique, (ii) assess the association between Internet use and other substances, and (iii) access the prevalence of the Internet and drug use over time, using new waves of data collection.

In summary, our data indicated an association between substance use, mobile devices, and the Internet, especially among smokers. The NA indicated that tobacco was directly related to PIU, especially among girls, and that anxiety was one of the most influential variables in the system. These findings are relevant as they clarify adolescents' complex relationship between substance use and problematic Internet use.

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Author Contribution M. A. Z. Passos, E. P. Vellozo, and M. S. S. Vitalle were responsible for the study design. Al. L. M. Andrade was responsible to draft the manuscript and data analyses. M. A. Z. Passos, E. P. Vellozo, and T. Shoen were responsible for the data acquisition. S. R. Niskier, M. A. Kulik, T. Shoen, M. A. Z. Passos, E. P. Vellozo, and M. S. S Vitalle cooperated in the technical procedures, interpretation of the data, and preparation of the manuscript. All the authors are responsible for its contents, having revised and approved its final version.

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Declarations

Statement of Human Rights All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. This study was approved by the Ethics Committee of the Federal University of São Paulo (no. 1,833,092, CAAE: 62073316.1.0000.5505) and by the Committee of the Pontifical Catholic University of Campinas (no. 2,383,838, CAAE: 75837417.1.0000.5481).

Informed Consent Informed consent was obtained from all parents of the adolescents. The Term of Assent was obtained from all adolescents.

Conflict of Interest The authors declare no competing interests.

References

Andrade, A. L. M., Enumo, S. R. F., Passos, M. A. Z., Vellozo, E. P., Shoen, T. H., Kulik, M. A., Niskier, S. R., et al. (2021a). Problematic internet use, emotional problems and quality of life among adolescents. *Psico-USF, 26*(1), 41–51. https://doi.org/10.1590/1413-82712021260104

Andrade, A. L. M., Kim, D. J., Scatena, A., Enes, C. C., Enumo, S. R. F., & De Micheli, D. (2021b). Validity and reliability of the Brazilian version of the Smartphone Addiction Scale-Long Version (SAS-LV). *Trends in Psychology, 29*(2), 302–319. https://doi.org/10.1007/s43076-020-00046-y

Andrade, A. L. M., Kim, D. J., Scatena, A., et al. (2021c). Validity and reliability of the Brazilian version of the Smartphone Addiction Scale-Long Version (SAS-LV). *Trends in Psychology., 29*, 302–319. https://doi.org/10.1007/s43076-020-00046-y

Andrade, A. L. M., Scatena, A., Bedendo, A., Enumo, S. R. F., Dellazzana-Zanon, L. L., Prebianchi, H. B., Macgado, W. L., et al. (2020a). Findings on the relationship between Internet addiction and psychological symptoms in Brazilian adults. *International Journal of Psychology, 55*(6), 941–950. https://doi.org/10.1002/ijop.12670

Andrade, A. L. M., Kim, D. J., Caricati, V. V., Martins, G. D. G., Kirihara, I. K., Barbugli, B. C., Enumo, S. R. F., et al. (2020b). Validity and reliability of the Brazilian version of the Smartphone Addiction Scale-Short Version for university students and adult population. *Estudos de Psicologia (Campinas), 37*, e190117. https://doi.org/10.1590/1982-0275202037e190117

Bedendo, A., Andrade, A., Opaleye, E. S., & Noto, A. R. (2017). Binge drinking: A pattern associated with a risk of problems of alcohol use among university students. *Revista Latino-Americana de Enfermagem, 25*, e2925. https://doi.org/10.1590/1518-8345.1891.2925

Bedendo, A., Opaleye, E. S., Andrade, A. L. M., & Noto, A. R. (2013). Heavy episodic drinking and soccer practice among high school students in Brazil: The contextual aspects of this relationship. *BMC Public Health, 13*(1), 247. https://doi.org/10.1186/1471-2458-13-247

Bedi, A., McGlinchey, R. E., Salat, D. H., Currao, A., Fonda, J. R., Milberg, W. P., & Fortier, C. B. (2021). Age of onset of adolescent binge drinking is differentially associated with cortical thickness in post-9/11 adult veterans. *Alcoholism, Clinical and Experimental Research*, e14606. https://doi.org/10.1111/acer.14606

Berdin, A. N., & Saules, K. K. (2019). Combined use of alcohol and the internet: Associated features. *Substance Use & Misuse, 54*(13), 2099–2107. https://doi.org/10.1080/10826084.2019.1630440

Borsboom, D. (2017). A network theory of mental disorders. *World Psychiatry, 16*(1), 5–13. https://doi.org/10.1002/wps.20375

Brand, M., Wegmann, E., Stark, R., Müller, A., Wölfling, K., Robbins, T. W., & Potenza, M. N. (2019). The Interaction of Person-Affect-Cognition-Execution (I-PACE) model for addictive behaviors: Update, generalization to addictive behaviors beyond internet-use disorders, and specification of the process character of addictive behaviors. *Neuroscience and Biobehavioral Reviews, 104*, 1–10. https://doi.org/10.1016/j.neubiorev.2019.06.032

Carvalho, A. P., Silva, T., Valença, P., Ferreira Santos, C., Colares, V., & Menezes, V. A. (2017). Alcohol consumption and physical violence among adolescents: Which is the predictor? *Ciencia & Saude Coletiva, 22*(12), 4013–4020. https://doi.org/10.1590/1413-812320172212.06172016

Conti, M. A., Jardim, A. P., Hearst, N., Cordas, T. A., Tavares, H., & de Abreu, C. N. (2012). Evaluation of semantic equivalence and internal consistency of a Portuguese version of the Internet Addiction Test (IAT). *Revista de Psiquiatria Clínica, 39*, 106–110. https://doi.org/10.1590/S0101-60832012000300007

Cruz, F. A. D., Scatena, A., Andrade, A. L. M., & De Micheli, D. (2018). Evaluation of Internet addiction and the quality of life of Brazilian adolescents from public and private schools. *Estudos de Psicologia (Campinas), 35*(2), 193–204. https://doi.org/10.1590/1982-02752018000200008

Cudo, A., Torój, M., Demczuk, M., & Francuz, P. (2020). Dysfunction of self-control in Facebook addiction: Impulsivity is the key. *The Psychiatric Quarterly, 91*(1), 91–101. https://doi.org/10.1007/s11126-019-09683-8

GBD 2016 Alcohol and Drug Use Collaborators. (2018). The global burden of disease attributable to alcohol and drug use in 195 countries and territories, 1990–2016: A systematic analysis for the Global Burden of Disease Study 2016. *The Lancet Psychiatry, 5*(12), 987–1012. https://doi.org/10.1016/S2215-0366(18)30337-7

De Micheli, D., & Formigoni, M. L. (2002). Psychometric properties of the Brazilian version of the drug use screening inventory. *Alcoholism, Clinical and Experimental Research, 26*(10), 1523–1528. https://doi.org/10.1097/01.ALC.0000033124.61068.A7

De-Sola Gutiérrez, J., Rodríguez de Fonseca, F., & Rubio, G. (2016). Cell-phone addiction: A review. *Frontiers in Psychiatry, 7*, 175. https://doi.org/10.3389/fpsyt.2016.00175

Drope, J., & Schluger, W. N. (2018). *The tobacco atlas: Sixth edition*. American Cancer Society. Retrieved from: https://tobaccoatlas.org/wp-content/uploads/2018/03/TobaccoAtlas_6thEdition_LoRes_Rev0318.pdf

Durkee, T., Carli, V., Floderus, B., Wasserman, C., Sarchiapone, M., Apter, A., & Cosman, D. (2016). Pathological internet use and risk-behaviors among European adolescents. *International Journal of Environmental Research and Public Health, 13*(3), 294. https://doi.org/10.3390/ijerph13030294

Fawcett, E. J., Power, H., & Fawcett, J. M. (2020). Women are at greater risk of OCD than men: A meta-analytic review of OCD prevalence worldwide. *The Journal of Clinical Psychiatry, 81*(4), 19r13085. https://doi.org/10.4088/JCP.19r13085

Hoffman, E. W., Pinkleton, B. E., Weintraub Austin, E., & Reyes-Velázquez, W. (2014). Exploring college students' use of general and alcohol-related social media and their associations with alcohol-related behaviors. *Journal of American College Health, 62*(5), 328–335. https://doi.org/10.1080/07448481.2014.902837

Kim, S. H., Baik, S. H., Park, C. S., Kim, S. J., Choi, S. W., & Kim, S. E. (2011). Reduced striatal dopamine D2 receptors in people with Internet addiction. *NeuroReport, 22*(8), 407–411. https://doi.org/10.1097/WNR.0b013e328346e16e

Kim, H. S., Hodgins, D. C., Kim, B., & Wild, T. C. (2020). Transdiagnostic or disorder specific? Indicators of substance and behavioral addictions nominated by people with lived experience. *Journal of Clinical Medicine, 9*(2), 334. https://doi.org/10.3390/jcm9020334

Jin Jeong, Y., Suh, B., & Gweon, G. (2020). Is smartphone addiction different from Internet addiction? Comparison of addiction-risk factors among adolescents. *Behaviour & Information Technology, 39*(5), 578–593. https://doi.org/10.1080/0144929X.2019.1604805

Lanthier-Labonté, S., Dufour, M., Milot, D. M., & Loslier, J. (2020). Is problematic Internet use associated with alcohol and cannabis use among youth? A systematic review. *Addictive Behaviors, 106*, 106331. https://doi.org/10.1016/j.addbeh.2020.106331

Lee, Y. S., Han, D. H., Kim, S. M., & Renshaw, P. F. (2013). Substance abuse precedes internet addiction. *Addictive Behaviors, 38*(4), 2022–2025. https://doi.org/10.1016/j.addbeh.2012.12.024

Li, Q., Dai, W., Zhong, Y., Wang, L., Dai, B., & Liu, X. (2019). The mediating role of coping styles on impulsivity, behavioral inhibition/approach system, and internet addiction in adolescents from a gender perspective. *Frontiers in Psychology, 10*, 2402. https://doi.org/10.3389/fpsyg.2019.02402

Liu, S. J., Lan, Y., Wu, L., & Yan, W. S. (2019). Profiles of impulsivity in problematic internet users and cigarette smokers. *Frontiers in Psychology, 10*, 772. https://doi.org/10.3389/fpsyg.2019.00772

Marín-Díaz, V., Muñoz-González, J. M., & Sampedro-Requena, B. E. (2020). Problematic relationships with smartphones of Spanish and Colombian university students. *International Journal of Environmental Research and Public Health, 17*(15), 5370. https://doi.org/10.3390/ijerph17155370

Marinho, F., GBD 2016 Brazil Collaborators, et al. (2018). Burden of disease in Brazil, 1990–2016: A systematic subnational analysis for the Global Burden of Disease Study 2016. *The Lancet, 392*(10149), 760–775. https://doi.org/10.1016/S0140-6736(18)31221-2

Masaeli, N., & Farhadi, H. (2021). Prevalence of Internet-based addictive behaviors during COVID-19 pandemic: A systematic review. *Journal of Addictive Diseases*, 1–27.https://doi.org/10.1080/10550887.2021.1895962

Morioka, H., Itani, O., Osaki, Y., Higuchi, S., Jike, M., Kaneita, Y., & Ohida, T. (2016). Association between smoking and problematic Internet use among Japanese adolescents: Large-scale nationwide epidemiological study. *Cyberpsychology, Behavior, and Social Networking, 19*(9), 557–561. https://doi.org/10.1089/cyber.2016.0182

Morioka, H., Itani, O., Osaki, Y., Higuchi, S., Jike, M., Kaneita, Y., ... & Ohida, T. (2017). The association between alcohol use and problematic internet use: A large-scale nationwide cross-sectional study of adolescents in Japan. *Journal of Epidemiology*, 27(3), 107-111. https://doi.org/10.1016/j.je.2016.10.004

Nall, R. W., Heinsbroek, J. A., Nentwig, T. B., Kalivas, P. W., & Bobadilla, A. C. (2021). Circuit selectivity in drug versus natural reward seeking behaviors. *Journal of Neurochemistry*. https://doi.org/10.1111/jnc.15297.10.1111/jnc.15297

Nascimento, M. O., & De Micheli, D. (2015). Evaluation of different school-based preventive interventions for reducing the use of psychotropic substances among students: A randomized study. *Ciência & Saúde Coletiva, 20*(8), 2499–2510. https://doi.org/10.1590/1413-81232015208.15152014

Oliveira Pinheiro, B., Monezi Andrade, A. L., Lopes, F. M., Reichert, R. A., de Oliveira, W. A., da Silva, A. M. B., & De Micheli, D. (2020). Association between quality of life and risk behaviors in Brazilian adolescents: An exploratory study. *Journal of Health Psychology, 27*(2), 341–351. https://doi.org/10.1177/1359105320953472

Patias, N. D., Machado, W. D. L., Bandeira, D. R., & Dell'Aglio, D. D. (2016). Depression Anxiety and Stress Scale (DASS-21) - Short Form: Adaptation and validation for Brazilian adolescents. *Psico-USF, 21*(3), 459–469. https://doi.org/10.1590/1413-82712016210302

Razjouyan, K., Hamzenejhad, P., Khademi, M., & Arabgol, F. (2018). Data on the prevalence of addiction to the Internet among individuals with a history of drug abuse. *Data in Brief, 21*, 1216–1219. https://doi.org/10.1016/j.dib.2018.09.052

Rücker, J., Akre, C., Berchtold, A., & Suris, J. C. (2015). Problematic Internet use is associated with substance use in young adolescents. *Acta Paediatrica (Oslo, Norway: 1992), 104*(5), 504–507. https://doi.org/10.1111/apa.12971

Savolainen, I., Oksanen, A., Kaakinen, M., Sirola, A., Miller, B. L., Paek, H. J., & Zych, I. (2020). The association between social media use and hazardous alcohol use among youths: A four-country study. *Alcohol and Alcoholism, 55*(1), 86–95. https://doi.org/10.1093/alcalc/agz088

Spritzer, D. T., Andrade, A. L. M., Xavier, A. Z., da Silva, G. T., Kim, H. S., Kaliszewska-Czeremska, K., Laconi, S., Igarashi, T., Passos, I. C., & Hauck, S. (2022). The self-perception of text message dependence scale (STDS): A Brazilian-Portuguese validation and expansion of its psychometric properties. *Current Psychology*. https://doi.org/10.1007/s12144-022-02957-8

Swendsen, J., Conway, K. P., Degenhardt, L., Glantz, M., Jin, R., Merikangas, K. R., … & Kessler, R. C. (2010). Mental disorders as risk factors for substance use, abuse and dependence: Results from the 10-year follow-up of the National Comorbidity Survey. *Addiction, 105*(6), 1117-1128. https://doi.org/10.1111/j.1360-0443.2010.02902.x

Vázquez-Nava, F., Vázquez-Rodríguez, E. M., Vázquez-Rodríguez, C. F., Ortega Betancourt, N. V., Castillo Ruiz, O., & Rodríguez Castillejos, G. C. (2020). Tobacco smoking by Mexican adolescents who use the WhatsApp and Facebook social networking platforms as a means of communication. *Journal of Substance Use, 25*(5), 545–549. https://doi.org/10.1080/14659891.2020.1738576

Vranken, S., Geusens, F., Meeus, A., & Beullens, K. (2020). The platform is the message? Exploring the relation between different social networking sites and different forms of alcohol use. *Health & New Media Research, 4*(2), 135–168.

Wartberg, L., Brunner, R., Kriston, L., Durkee, T., Parzer, P., Fischer-Waldschmidt, G., & Carli, V. (2016). Psychopathological factors associated with problematic alcohol and problematic Internet use in a sample of adolescents in Germany. *Psychiatry Research, 240*, 272–277. https://doi.org/10.1016/j.psychres.2016.04.057

World Health Organization (WHO). (2018). *Global Status Report on Alcohol and Health*, 2018. Management of substance abuse unit, World Health Organization. Geneva. retrieved from: https://www.who.int/publications/i/item/9789241565639

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