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Adolescent addictions and risky behaviors: implications for health

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Adolescent addictions and risky behaviors: implications for health

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Table of contents

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Editorial: Adolescent addictions and risky behaviors: implications for health

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Editorial on the Research Topic
Adolescent addictions and risky behaviors: implications for health

Adolescence is a transitional stage marked by significant cognitive and emotional development, accompanied by crucial psychosocial transitions. During this period the initiation of substance use and engagement in risky behaviours reach its peak (1).

In relation to the use of alcohol, tobacco and cannabis, Villanueva-Blasco et al. have explored the relationship between these substances and various factors associated with the school environment, establishing indirect connections with behavioural problems. The results reveal that behavioural problems are positively correlated with alcohol and the problems associated with its ingestion, while cannabis consumption showed an inverse correlation with these problems. Likewise, a positive association was found between tobacco and cannabis use. Structural equation modelling demonstrated that the perception of the school environment exerts an influence on adolescent behaviour, with the sense of challenge experienced by young people in their school environment directly correlating with the presence of behavioural problems. Additionally, problem behaviour was predicted using alcohol, tobacco and cannabis, as well as excessive alcohol consumption.

In line with this Research Topic, a systematic review examining longitudinal studies on the effect of social networks on adolescent cannabis use has been published by (Torrejón-Guirado et al.). The results suggest that social networks are essential for understanding the impact of cannabis consumption and the mechanisms of peer influence, demonstrating that cannabis use among friends is associated with a higher frequency and intensity of use. Furthermore, the review indicates an increase in consumption when adolescents do not feel close to their schoolmates, friends, or local community environment.

Consequently, studies underscore the significance of environmental influences on the onset of substance use. A study conducted among Chinese adolescents who consume alcohol (Liu et al.) revealed that those with peers who drink are 11.1% more likely to consume alcohol than those without such peers, with this probability being higher among males. A positive correlation has been identified between the presence of siblings and an

increased likelihood of alcohol consumption. The absence of parental care has been shown to amplify the impact of peer influence on alcohol use. It is imperative for educational institutions to prioritize the dissemination of preventive education in contexts where young individuals may be more susceptible to peer influences, with the aim of preventing the initiation of substance use (Liu et al., Dadras).

Regarding tobacco use, there is a notable gap in the literature regarding the factors associated with the stages of behaviour change in the Transtheoretical Model that are applicable to smoking cessation among adolescents (Dadras). Consequently, Dadras address this in their study of Indonesian youth, emphasizing the significance of promoting cessation messages, knowledge, and individual attitudes toward quitting at each stage. This is particularly salient when formulating interventions that tackle age-specific barriers, gender disparities, cultural influences, environmental factors, and prevailing attitudes toward smoking. The influence of parents and teachers is critical, having parents who smoke and observing teachers smoking increases the likelihood that adolescents will enter the contemplation and action phases of quitting, respectively. Exposure to cigarette advertisements on television, social media, and at social events, as well as receiving free or discounted cigarettes, has been associated with an increased likelihood of being in both the contemplation and action stages of smoking cessation. Early initiation of cigarette smoking has been associated with an increased likelihood of individuals entering the contemplation and action phases of quitting. Moreover, beginning regular smoking at an early age is linked to a higher risk of developing nicotine dependence and a lower probability of attempting to quit. A systematic review with meta-analysis has demonstrated a cross-sectional relationship between chronic smoking and neurocognitive impairments in adolescents and young adults, notably revealing an association between chronic tobacco use and impaired impulsivity in this population (Elatfy et al.).

Risky behaviours and non-substance addictions must be considered, as problematic internet use has been shown to significantly impact an individual's physical, mental, and social well-being (2). The study by Demirdöğen et al. highlights that problematic internet use is preceded by negative coping strategies, high levels of escapism, functional impairment, and excessive network usage exceeding seven hours per day. Additionally, escapism levels were found to be higher among youths exhibiting problematic internet use. In this context, research suggests that for adolescents with borderline personality disorder, transdiagnostic online integrative treatment may serve as an effective approach to reducing symptoms of risky behaviours and internet addiction (Mohamadpour and Mohammadi).

In this context, Internet Gaming Disorder (IGD) has been defined as a behavioural addiction characterized by excessive and compulsive video game use (3). Research indicates that adolescents diagnosed with IGD exhibit alterations in resting-state functional connectivity, which are linked to heightened impulsivity and increased disorder severity (Zhao et al.). A qualitative approach is essential when studying this demographic, as gaming addiction may be influenced by cultural factors, early exposure, social networks, and peer pressure (Mazaherizadeh et al.). The concept of "life crafting" has emerged to describe how gaming shapes young individuals' identities and career aspirations (Mazaherizadeh et al.). Notably, clinically significant age-related disparities have been identified among individuals seeking treatment for gaming disorder. Younger treatment seekers tend to progress more rapidly toward problematic gambling compared to adults (Hofstedt and Gordh). In this study, both age groups exhibited similar levels of psychiatric symptoms, including Attention Deficit Hyperactivity Disorder, Autism Spectrum Disorders, and problem gambling. However, among younger individuals, problematic gambling develops approximately seven years after their initial exposure to gambling, whereas in adults, this progression took around eleven years. These findings suggest a correlation between younger age at treatment-seeking and a faster escalation to gaming disorder.

The manuscripts included in this Research Topic represent a significant step forward in the comprehensive understanding of substance use and addictive behaviours among adolescents. The findings contribute to the essential progress needed to assess the current context and develop interventions aimed at preventing initiation or promoting cessation of use. These results provide valuable insights into the contemporary landscape, facilitating the design of effective intervention strategies. Emphasis is placed on the importance of identifying evidence-based approaches to addressing risk situations. To achieve this, the collaboration of multidisciplinary teams is crucial, ensuring a holistic and integrated approach that encompasses both prevention and treatment.

Author contributions

MCM-F: Conceptualization, Writing – original draft, Writing – review & editing. PS: Writing – original draft, Writing – review & editing. EF-M: Writing – original draft, Writing – review & editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The influence of peer's social networks on adolescent's cannabis use: a systematic review of longitudinal studies

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Aim: A systematic review was performed to summarize the key findings of the peer influence on cannabis use through Social Network Analysis (SNA) studies and identify limitations and gaps with the purpose of informing future research and practice. Longitudinal studies were included since they provide robust information about social relationships change over time.

Background: Adolescents' cannabis use is a global problem, which has awakened an interest in its determinants such as social influences. Research has shown the importance of these influences on cannabis uptake and use. SNA is an useful relational approach to examine socialization mechanisms related to the onset of cannabis use in adolescents.

Method: A search was conducted in PyscINFO, PubMed, Scopus and Web of Science for longitudinal articles published until February 2023, to examine cannabis use and peer's social networks. We focus on peers' influence of peers on cannabis use. Additionally, information about effect of cannabis use for peer selection was collected.

Results: The results of the included studies ($n = 8$) showed that friends' cannabis use was most often/strongly associated with cannabis use. There was also an increase of cannabis use when the adolescent did not feel close to the school's peers, had a higher proportion of friendships relative to the total number of ties in the neighborhood, had a central position, did not belong to any group but had ties to members of two or more groups, had cannabis user friends (especially in early ages), and lived in a neighborhood where cannabis was used.

Conclusion: Cannabis use is mainly related to friends' use. Yet, future studies are warranted to control for relevant selection effects to further knowledge on network effects on cannabis use, improving the design, and improving the modeling of the network. This systematic review may inform about the critical aspects of preventing cannabis use among adolescents, taking into consideration their complex social environment.

KEYWORDS

peer influence, adolescents, cannabis, social network analysis, friendship

1 Introduction

Cannabis is the third most consumed drug among adolescents (1, 2). According to the World Drug Report issued in 2021 (2), 13.8 million of adolescents aged between 15 and 16 years old used cannabis worldwide. This figure is equivalent to 5.6% of the global population and exceeds the prevalence rate among the general population (3). Furthermore, the European report on drugs (2021) declared cannabis to be the most established drug used in Europe, finding that 15.4% of young people had consumed cannabis in the previous year (1). It is also important to note that cannabis has become a legal drug in many high-income countries in recent decades (4). This legalization of cannabis has led to a 3.8% increase in recreational use in those states (5).

The onset age of cannabis use is around 15 years old (1, 2). Adolescents are particularly vulnerable to cannabis use because their brain is still developing (6). Some consequences of cannabis use are short-term, such as cognition and coordination problems, toxicity or traffic injuries, but also long-term, such as mental disorders, addiction, suicide risk, and cardiovascular or pulmonary diseases (6–8). These consequences, furthermore, can affect the social and family sphere, leading to, for instance, school dropout and family/friend's problems (e.g., breach of family rules, physical and psychological violence, deterioration, or loss of relationships) (7–9). Moreover, adolescents are sensitive to joining and remaining in peer groups. Peers are individuals who share similar ages and interests, and tend to belong to a similar social group. Adolescents are highly influenced by peers since they try to resolve disagreements by adopting peers' behaviors (10).

The importance of peer influence on adolescent's recreational cannabis use has been demonstrated in a substantial body of research (11–13). For instance, peers close to adolescents exert a stronger influence on adolescent cannabis use than peers less close to adolescents (12). Additionally, well-stablished socio-cognitive theories discuss the importance of peer influences on risk behaviors (11–13). A first type of peer influence concerns social modelling. This factor, proposed by Bandura in his Social Cognitive theory (14), implies that behaviors of others such as cannabis use can be adopted by merely observing their behavior (15, 16). When such a behavior is reinforced, this behavior is more likely to become adopted (14). This process may occur unconsciously. Furthermore, occupied social position within a peer group can also play a significant role in how adolescents are influenced toward cannabis use. Adolescents may see high-status peers or more popular peers (usually cannabis users) as role models, in order to improve their own social standing into the group (13). Another type of social influence concerns social norms, a construct originally proposed by Fishbein and Ajzen in the theory of Reasoned Action (17). Norms of other people have shown to influence other persons behavior, including cannabis use such as previous studies have shown regarding adolescent peer's social norms favoring cannabis use (10, 11). Furthermore, during adolescence, it is expected that youth may not reject the cannabis use offers because they want to fit in with their peers (11). An even more explicit type of social influence concerns direct peer pressure from others (18, 19). These three types of social influence can operate and can have unique contributions (20–23).

The traditional theoretical concepts about social influences did not look to the complex constellation of peer's influence processes that can modulate the social modelling, norms or pressure (e.g., the influence of social structure of the friendships or the interactions between the adolescents within a social network). Taking such a social network approach implies the use of Social Network Analysis (SNA). SNA is focusing on examining the social structure and interactions among social actors within a social network (24). A network is comprised of nodes (i.e., individuals/actors) and the ties/relationships between those nodes. SNA assumes that social actors and the network they are embedded in are interdependent (25). SNA also makes it possible to control correctly for possible selection and confounding effects while examining peer influence processes, for instance, regarding the cannabis use. Besides, adolescent's cannabis use can also become similar to their peers because they select each other based on similar cannabis use behavior or due to peers jointly being influenced by an external source (i.e., both watching a movie in which actors use cannabis) (26, 27). This also adds value in regard to previous approaches in cannabis prevention field. Several studies have now applied SNA to examine peer network influences in adolescent cannabis use (28, 29). So it is now timely and relevant to review and summarize their findings.

Longitudinal studies may provide important insights into dynamic social relationships, since they address temporality (30). They consider the dynamics of social phenomena as being the result of a time-process, where observations are made at different time points. Reviewing longitudinal studies is needed in order to understand dynamic relationships between individuals and peer groups patterns regarding cannabis use, and broader patterns of social change over time (31). Thus, this review included only longitudinal studies in order to tracking the influence of peers on cannabis use over time (causal relationship), reducing the bias inherent in cross-sectional studies, and facilitating future comprehensive experimental research.

The goal of this study is to systematically synthesize the scientific literature on longitudinal applications of social network approach to study peer influences on adolescent recreational cannabis use. The research question was: do peer networks characteristics influence in recreational cannabis use in adolescents between 12 and 21 years? This review will summarize the key characteristics and findings of peer influences on recreational cannabis use and identify limitations and gaps in the literature, with the purpose of informing future research and practice. Additionally, measures for selection effects on cannabis use will be also included.

2 Methods

2.1 Search strategy and retrieval system

For conducting and communicating this systematic review, the recommendations of PRISMA 2020 statement were followed (32). The protocol was pre-registered in PROSPERO (33). Eligible studies were identified in October 2021 and the search was updated in February 2023 by conducting an in-depth literature search on electronic databases used (peer-reviewed): PsycINFO, Scopus, PubMed and Web of Science. The search strategy used a combination of Boolean connections and search terms relevant to key concepts used in this review: social network, cannabis use and adolescent. As example, the specific search strategy in the PubMed database was:

((Network[tiab]AND friend*[tiab]) OR relation*[tiab] OR peer*[tiab] OR social*[tiab] OR media*[tiab] OR acquaintance*[tiab] OR team*[tiab] OR mate*[tiab] OR partner*[tiab] OR leisure[tiab] OR hobby[tiab] OR school[tiab] OR highschool[tiab] OR university[tiab] OR junior high* OR senior high*[tiab] OR colleague*[tiab]) AND ("Adolescent"[Mesh] OR "Young Adult"[Mesh] OR adolescen*[tiab] OR teen*[tiab] OR young*[tiab] OR youth*[tiab] OR puber*[tiab] OR minor*[tiab] OR juvenil*[tiab] OR student*[tiab] OR pupil*[tiab]) AND ("Marijuana Use"[Mesh] OR "Marijuana Smoking"[Mesh] OR "Cannabis"[Mesh] OR cannabi*[tiab] OR blunt*[tiab] OR marijuana*[tiab] OR marihuana*[tiab])*

Additionally, we searched reference lists from each study (backward) and articles that cite back to a specific article (forward), for additional articles. No restrictions were placed on the language and the time window of search.

2.2 Study selection criteria

2.2.1 Inclusion criteria

- Study design: longitudinal empirical studies.
- Study subject, target population: adolescents (between 12 and 21 years old). Although organizations as the World Health Organization or American Academy of Pediatric usually define the adolescence as the period of 10–21 years, adolescents from 12 years were chosen because cannabis is a substance which use starts late (34, 35). In case there were studies where they include our age's rank but also older ages, we will only take the data from our target population, if it is possible.
- Statistical method: Social Network Analysis (SNA) descriptive analysis and/or statistical models for social networks.

2.2.2 Exclusion criteria

- Medicinal cannabis use and patients.
- Intervention studies.
- No collection of complete social network data (i.e., no information on social actors and the ties among them, collection of individual data or only dyad and triad level data).
- Simulation studies that focused on varying intervention parameters.
- Exclusive use of conventional statistical method (e.g., regression) rather than SNA in data analysis.

2.3 Data extraction and preparation

The process was developed in the following phases: firstly, after deleting the duplicates, a screening of articles based on title and summary following the inclusion / exclusion criteria was done. The second screening was through the reading of full texts, to which methodological evaluation was also done. This process was done independently by two authors (MCTG and MABJ), who also independently checked results to evaluate inclusion and exclusion criteria. Discrepancies between these two authors were discussed and a final determination decided by a third author (LM). Data were extracted by a structured form. The following variables were considered: instrument, article ID, publication year, country, design, sample, type of network, social network measures, SNA performed, type of software used to conduct the SNA, and main findings.

2.4 Data synthesis

The studies were heterogeneous in the types of measures used, and it was therefore more appropriate to follow a narrative data synthesis strategy. The review was focused on variables related to peer social network influences and not on other types of network ties (such as family, social kin or broader social contacts).

All included *peer network influence effects on cannabis use* were extracted from each included manuscript. They were classified in three groups: (1) *Endogenous network influence effects on cannabis use* (the influence of the network structure and interactions itself without considering other variables such as the network' behavior or personal characteristics), (2) *Cannabis-related network influence effects on cannabis use* (the influence of the network considering the cannabis use of actors in the network) and, (3) *Other risk behavior related network effects on cannabis use* (e.g., alcohol drinking, or personal characteristics). Interaction effects between peer network influence effects were also extracted (e.g., popularity x density).

A few examples of *endogenous network influence effects on cannabis use* are the effect of number of nominated friends (Outdegree); the effect of number of incoming friendship ties/ relationships (Indegree/popularity); the effect of being in a central position within the network (centrality).

Examples of *cannabis-related network influence effects on cannabis use* are the effect of cannabis use of someone's friends (friends' cannabis use); the effect of number of steps it takes for someone to reach the nearest cannabis user in the network considered friends and friend's friends (distance to nearest cannabis users considered friends and friend's friends).

Examples of *other risk behavior related network effects on cannabis use* are the effect of smoking behavior of someone's friends (friends' smoking behavior); the effect of the age of someone's friends (friends' age).

Additionally, for those studies that controlled for selection effects, *cannabis use related selection effects* were extracted (being the outcome the selection of peers instead of the cannabis use). Examples of cannabis use related selection effects are the effect of own cannabis use on selecting an actor as a friend (cannabis use Ego); the effect of cannabis use of another actor on selecting that actor as a friend (cannabis use alter); the effect of having similar cannabis use to another actor on selecting that actor as a friend (cannabis use similarity).

2.5 Study quality assessment

Two reviewers (MCTG and MABJ) independently assessed risk of bias for all studies that met eligibility criteria, using the National Institutes of Health's Quality Assessment Tool for Observational Cohort, Case–Control Studies, Systematic reviews and Meta-Analyses (36). The assessment tool rates each study based on 14 criteria. For each criterion, a score of one was assigned if 'yes' was the response,

whereas a score of zero was assigned otherwise (i.e., an answer of 'no,' 'not applicable,' 'not reported' or 'cannot determine'). The study-specific global score could range from 0 to 14. Discrepancies between MCTG and MABJ were discussed, and a final determination was decided by a third author (LM).

3 Results

3.1 Study selection

As depicted in the flow diagram (Figure 1), the initial search yielded 3,261 scientific articles. Adding the articles identified through backward and forward searching, a total of 4,196 articles were found.

During the review process, many studies that had used the traditional regression-based approach to study the influence of peers on cannabis use were found, that is that they estimated peer effect without developing a complete network.

The main reasons for exclusion were that articles focused on medicinal cannabis use, patients, did not use statistical models for social networks such as SNA, did not include a whole or complete social network, were not longitudinal, or did not meet the age criterion (12–21 years). Finally, 8 articles were included for review (37–44).

3.2 Study quality assessment

Table 1 reports the specific scoring rubric used for assessing each study's methodological quality. All included studies had a high-quality level according to the used tool. Each study clearly defined their research question, their target population, their design, and their analytic methods. However, there were three studies that did not control for the most important confounder in peer influence research, namely selection effects, implying that the estimations of these effects may be bias (40, 43, 44). Thus, their results were treated with caution.

3.3 Basic characteristics of the included studies

Table 2 summarizes the characteristics of the eight longitudinal studies that met the inclusion criteria. The reviewed studies had been published in six journals that mainly emphasized adolescence. Three of the eight studies had common authors (39, 42, 43). Every study had been conducted in the USA and used at least three data measurement points. The included studies were published between 2006 and 2018. Six of the eight studies used data from the Add Health study (The National Longitudinal Study of Adolescent to Adult Health) (37–42), one study used data from the PROSPER study (Promoting School-Community-University Partnerships to Enhance Resilience) (43), and one had collected its own school network data (44). The sample size ranged from 1,373 to 9,500 participants, and mostly examined adolescents aged 15–16 years old. To focus on friendship ties among students within the same school, each school was defined as a separate social network, and most of the included studies had created a specific model for each school group (37, 39, 41, 42, 44).

Table 2 also reports the outcome measures, social network characteristics, and statistical models used. Cannabis use in the last 3 months was the outcome of one study (44), cannabis use in the last month was the outcome of the remaining seven studies (37–43).

In all studies, social network data were constructed based on nominations within school grades, provided by respondents via survey data. The studies differed in the type of nominations and the maximum allowed number of nominations. Regarding the number and the type of allowed nominations, six studies asked respondents to nominate ten of their best friends (five females and five males) (37–42), one study asked to nominate two best friends

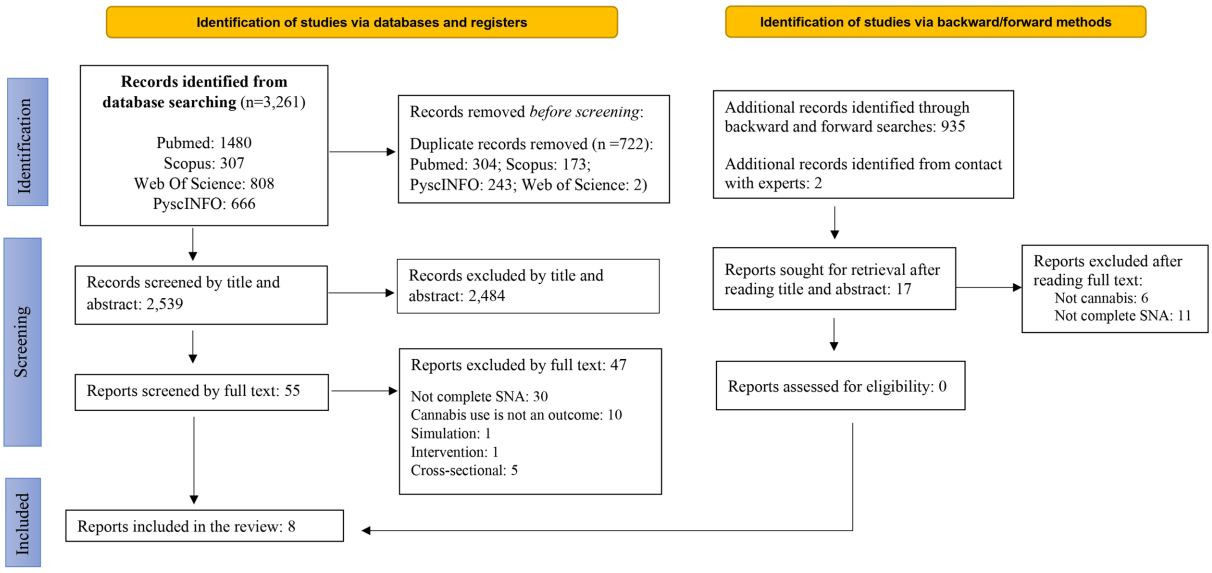

FIGURE 1
PRISMA 2020 flow diagram for new systematic reviews of reviewed studies.

TABLE 1 Summary of the criteria used for assessing each study's methodological quality[36].

	Wang et al. (2018) (37)	Schaefer (2018) (38)	De la Haye et al. (2015) (39)	Vogel et al. (2015) (40)	Tucker et al. (2014) (41)	De la Haye et al. (2013) (42)	Osgood et al (2014) (43)	Ennett et al. (2006) (44)
1. Was the research question or objective in this paper clearly stated?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2. Was the study population clearly specified and defined?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3. Was the participation rate of eligible persons at least 50%?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study pre-specified and applied uniformly to all participants?	Not reported	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5. Was a sample size justification, power description or variance and effect estimates provided?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
10. Was the exposure(s) assessed more than once over time?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
12. Were the outcome assessors blinded to the exposure status of participants?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
13. Was loss to follow-up after baseline 20% or less?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?	Yes	Yes	Yes	No*	Yes	Yes	No*	No*
Sum Score	13/14	14/14	14/14	13/14	14/14	14/14	13/14	13/14

*No control for selection effects.

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TABLE 2 Characteristics of the longitudinal included studies.

Data source (country)	Authors (year)	Study details	Outcome	Type of network(s): (friendship ties, family ties, best friend ties, etc)	Social network measure(s) (Peer influence effects on cannabis use and peer selection effects related to cannabis use)	Social network analysis, software and built models
Add Health (USA)	Wang et al. (2018) (37)	3 waves *n* = 3,128 Aged 12–17 48% female	Cannabis last month into 3 levels: 0 = "never," 1 = "1–10times," 2 = "more than 10 times"	2 school friendship networks Friendship ties: nominations of maximum 5 male best friends and 5 female best friends, within the same school (not necessarily the same grade).	Peer Influence effects on cannabis use: • Indegree (own popularity; received friendship nominations) • Peer influence cannabis use • Number of friends who smoked • Number of friends who drank Peer Selection effects on cannabis use: Similarity of cannabis use	SNA (SABM)/R Siena For each school, three-wave SAB model was built. Each model had three behaviour functions, each modelling the dynamic of one behaviour: alcohol use, tobacco use and cannabis use. In this review, we just focused on cannabis. In the behavior equations, peer influence effects were measured as the sum of negative absolute difference between ego's and alters' behavior averaged by ego's out-degree. In the network equation, they included endogenous network effects (e.g., reciprocity) and homophily selection effects for each substance use behavior as well as additional covariates.
	Schaefer (2018) (38)	3 waves *n* = 1,373 Mean age: 15.56 48.87% female	Cannabis last month was recoded into dichotomous measure (1 = yes cannabis use, 0 = no cannabis use)	2 school friendship networks Friendship ties: nominations of maximum 5 male best friends and 5 female best friends, within the same school (not necessarily the same grade).	Peer Influence effects on cannabis use: • Friend's cannabis use (i.e., average similarity of cannabis use, that is, adolescent's preference to have similar cannabis use than their friends, where the total influence of the friends is the same regardless of the number of friends) Peer Selection effects on cannabis use: • Ego's cannabis use • Alter's cannabis use • Similarity cannabis use • Ego's cannabis use x R alter • R ego x alter's cannabis use • *R refers to ego's risk factors	SNA (SAOM)/ R Siena Four R Siena models were built for both schools. The difference between the models is that each model provided an illustration of the SAOM for one risk factor of cannabis use. Risk factors are: M1 = Family Connectedness, M2 = School belonging, M3 = Grade point average (GPA), M4 = Religiosity and M5 = Self-control. Changes in the friendship network were modelled with two functions: a rate function that determines which actor is given the chance to change a tie, and a friend selection function that determines which change a chosen actor makes. Change in a given behavior was modeled with two functions: a rate function to specify how often individuals are given the chance to change their behavior, and a behavior function that includes predictors of behavior change. They used a multigroup method to estimate one pooled model for the two schools.

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10.3389/fpsyt.2023.1306439

TABLE 2 (Continued)

Data source (country)	Authors (year)	Study details	Outcome	Type of network(s): (friendship ties, family ties, best friend ties, etc)	Social network measure(s) (Peer influence effects on cannabis use and peer selection effects related to cannabis use)	Social network analysis, software and built models
	De la Haye et al. (2015) (39)	3 waves *n* = 1,612 Mean age: 16.4 48.87% female	A dichotomous measure of lifetime of cannabis use was computed at each wave where 1 = ever used cannabis, with changes from 0 to 1 in history of use between waves capturing cannabis initiation.	16 school friendship networks Friendship tie: nominations of maximum 5 male best friends and 5 female best friends, within the same school grade.	Peer Influence effects on cannabis use: • Friends lifetime cannabis use Peer Selection effects on cannabis use: • Any history of cannabis use and current cannabis use of ego • Any history of cannabis use and current cannabis use of alter • Same history or same current cannabis use	SNA (SABM)/R siena 4.0 For each school, various R Siena models were built. Baseline models (M1) included effects of history of cannabis use and covariates, but not risk factors, in predicting the friendship network and history of cannabis use. Phase 2 models (M2) added effects of current (last month) cannabis use on friendship choices. Phase 3 models tested for effects of each of the risk factors on friendship choices. Phase 3 included all parameters from M2 model, + the three new effects (ego, alter, similar) of the risk factor on friendship selection, and the effect of the risk factor on change in history of cannabis use (i.e., cannabis initiation). Final models (M3) included risk factors that were found to significantly predict friendship choices and/or history of marijuana use in phase 3 alongside parameters included in M1 and M2. Therefore, M1 = friendship network and history of cannabis use dynamics; M2 = friendship network, history of cannabis use, and current cannabis use dynamics; M3 = friendship network, cannabis use, and risk factor dynamics. Only significant effects on friendships or cannabis initiation, independent of other risk factors, were retained in M3.
	Vogel et al. (2015) (40)	3 waves *n* = 7,754 Mean age: 15.2 55% female	Cannabis last month was used as dichotomous measure (1 = yes cannabis use, 0 = no cannabis use)	109 school friendship networks Friendship tie: nominations of maximum 5 male best friends and 5 female best friends, within the same school grade.	Peer Influence effects on cannabis use: • Own popularity (indegree; number of friendship nominations an individual received on the friendship roster) • Peer substance use (alcohol and tobacco) • Network centrality (the number of ties the respondent has weighted by the number of ties of those to whom he/she sends and received nominations) • Popularity x density; popularity x school connectedness; popularity x school drug use (*drug use is referred to alcohol and tobacco*)	Multilevel logistic regression models on Stata/ preconstructed measures from secondary data that can be found on the Add health website. Three hierarchical logistic regression models were performed: model 1 included the main effects of the socio-demographic characteristics, individual risk factors, and peer-network characteristics on self-reported cannabis use. Second model introduced the school level covariates (network density, connectedness, and normative drug culture) and model 3 included three interactions of school context (popularity x density, popularity x connectedness, popularity x school drug use).

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10.3389/fpsyt.2023.1306439

TABLE 2 (Continued)

Data source (country)	Authors (year)	Study details	Outcome	Type of network(s): (friendship ties, family ties, best friend ties, etc)	Social network measure(s) (Peer influence effects on cannabis use and peer selection effects related to cannabis use)	Social network analysis, software and built models
	Tucker et al. (2014) (41)	3 waves *n* = 1,612 Mean age: 16.4 47.3% female	Cannabis last month into 4 levels: 0 = none, 1 = 1–3 times, 2 = 4–11 times, 3 = 12–32 times, and 4 = 33 times or more.	2 schools friendship networks Friendship tie: nominations of maximum 5 male best friends and 5 female best friends, within the same school grade.	Peer Influence effects on cannabis use: *These effects were measured through interactions (e.g., friend's cannabis use x reciprocity).* • Friends' cannabis use • Reciprocity (both participants nominated each other as a friend) • Friend popularity (friend indegree: the total number of friendship nominations received by a nominated friend) • Popularity difference of respondent (the difference in number of friend nominations received, i.e., indegree) Peer Selection effects on cannabis use: • Ego's cannabis use • Alter's cannabis use • Squared alter cannabis use • Same cannabis use	SNA - SABM/R Siena For each school, 3 R Siena models were build. The only difference between the 3 models is that each one of the models included one specific interaction with peer influence, either friends' cannabis use (influence) × Friendship reciprocity (model 1-M1), Friends' cannabis use (influence) × friend popularity (model 2-M2) or Friends' cannabis use (influence) × popularity difference (model 3-M3).
	De la Haye et al. (2013) (42)	3 waves *n* = 1,612 Mean age: 16.4	Cannabis last month into 4 levels: 0 = none, 1 = 1–3 times, 2 = 4–11 times, 3 = 12–32 times, and 4 = 33 times or more. They also created a dichotomous measure of lifetime use at each wave (where 1 = had ever used cannabis, with changes from 0 to 1 in lifetime use between waves capturing initiation)	2 school friendship networks Friendship tie: nominations of maximum 5 male best friends and 5 female best friends, within the same school grade and out-school friends, but finally they only included friends were also survey respondents	Peer Influence effects on cannabis use: • Friends' cannabis use (last month/lifetime) Peer Selection effects on cannabis use: • Ego's cannabis use • Alter's cannabis use • Squared alter cannabis use (on last month) • Same cannabis use	SNA, SABM/R Siena Two R Siena models were estimated to examine associations of adolescent friendships with (1) cannabis initiation, and (2) frequency of past month cannabis use. Each model includes effects predicting the evolution of the friendship network (friend selection effects) and effects predicting cannabis use (cannabis effects). For cannabis initiation, friend influence was tested with two effects: the effect of having friends who had ever used cannabis in their lifetime, and the effect of having friends who had used cannabis in the past month.
PROSPER (Promoting School-Community-University Partnerships to Enhance Resilience) (USA)	Osgood et al. (2014) (43)	5 waves *n* = 9,500 Mean age: 6th through 9th grades 51.5% female	Cannabis last month into 5 levels: from 1 = "Not at all" to 5 = "More than once a week."	27 school friendship networks	Peer Influence Effects: • Indegree (own popularity; friendship nominations an individual received, i.e., number of other students who named the respondent)	Multi-level logistic regression model/a routine programmed themselves (SAS)

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10.3389/fpsyt.2023.1306439

TABLE 2 (Continued)

Data source (country)	Authors (year)	Study details	Outcome	Type of network(s): (friendship ties, family ties, best friend ties, etc)	Social network measure(s) (Peer influence effects on cannabis use and peer selection effects related to cannabis use)	Social network analysis, software and built models
				Friendship tie: nominations of maximum 2 best friends and 5 additional friends from their current school grade. 368 school grade cohort friendship networks.	• "Group members" were distinguished as (1) core member vs. (2) peripheral members of the group (meaning that removing a single friendship link would be sufficient to separate them from the main portion of the group), while "non-group members" are (1) isolates (who did not send or receive friendship nominations to anyone else in the grade network or who shared ties with one person who was disconnected from the rest of the network, forming an isolated dyad), (2) liaison (who had ties to members of two or more groups) and (3) other non-members (students who were not defined as members of a group, a liaison, or an isolate). All participants are core group members except those labelled as peripheral group members, liaison and isolate. Core member was treated as the reference to test the others. • Friend's cannabis use • Outdegree (number of friendship nominations an individual made) • Reach (reach of an adolescent to others in the networks through pathways of ties)	A three-level logistic regression was performed. Five waves of data (level 1) as nested within individual respondents (level 2-stable individual differences in substance use), who are in nested within the school district cohorts that define the social networks (level 3-unexplained differences among social networks in rates of substance use). For the group detection they used a variant of Moody's CROWDs routine, which is similar in form to other algorithms designed to search for groups by maximizing modularity scores.
Context of Adolescent Substance Use Study (USA)	Ennett et al. (2006) (44)	5 waves $n = 5,104$ Mean age: sixth (35.9%), seventh (33.1%), and eighth (31.0%) graders 65.5% female	Cannabis last 3 months: from 0 to 10 or more times. *Because responses were skewed toward never and infrequent use, a binary variable was formed for each that contrasted adolescents who reported any days/times of use in the last 3 months with those who reported none.	26 separate networks from 13 schools. Friendship tie: nominations of maximum 5 best friend within the same school grade.	Peer influence effects: Social embeddedness: • Reciprocity • Neighborhood density (number of friendship ties present among friends/alters divided by the total number of possible ties) • Out nominations (out-degree)	Three-level hierarchical generalized linear models/SAS IML was used to calculate all measures except two: betweenness centrality and Bonacich power centrality, which were calculated by UCINET (Version 6).

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10.3389/fpsyt.2023.1306439

TABLE 2 (Continued)

Data source (country)	Authors (year)	Study details	Outcome	Type of network(s): (friendship ties, family ties, best friend ties, etc)	Social network measure(s) (Peer influence effects on cannabis use and peer selection effects related to cannabis use)	Social network analysis, software and built models
					Social position: (1) Group member (who shared most of their friendship ties with each other and where the removal of one member of the group would not cause the group to be disconnected, (2) Isolate (one or no friendship ties) and (3) Bridge (those with friendship ties to adolescents who were members of different groups, but who were not themselves members of any group) *The three social positions were measured by two dummy-coded variables with group member as the reference Social status: • Normed indegree (own popularity, measured by number of friendship nominations received by ego divided by the number of possible friendship nominations) • Reach centrality (incoming ties only) • Betweenness centrality (the possibility to the adolescent can control flows of information or norms by serving as a gatekeeper between peers, and can connect peers from different parts of the network who are not directly connected to each other) • Bonacich power centrality (centrality of the friends with whom ego is linked) Social proximity to cannabis users: • Best friend cannabis user (having a best friend who reported recent use) • No. neighborhood cannabis users • Distance to cannabis user (low coding for nearest user friends or nearest user friend's friends)	A three-level hierarchical generalized linear model was performed. The three levels were time nested within adolescents nested within networks. Data were arranged in a cohort sequential design with adolescent age. For each network variable, they presented the exponentiated b coefficient predicting the starting point of cannabis use at the different ages (i.e., the age 11 odds ratio). They included the main effect of the network variable and the interaction between the network variable and age. Moody's CROWDS algorithm for identifying peer groups was also used to measure adolescents' group position in the network as a group member, bridge, or isolate.

*Means relevant clarifications.

10.3389/fpsyt.2023.1306439

and five additional friends (42), and the last one asked to nominate a maximum of five best friends (44). The last studies did not make a distinction by gender. Regarding the social network methods used, five studies applied stochastic actor-based/orientated models (SABM/SAOM) via R Siena (37–39, 41, 42), one of them used network measures that was already provided on Add Health (39), one used their own network analysis routine (43), and the last one calculated network measures in UCINET that were later treated as variables in three-level hierarchical generalized linear models (44).

3.4 Key findings regarding peer network influence effects on cannabis use

The main objectives of the study and key findings about peer network influences on adolescent cannabis use are presented in Table 3. Furthermore, the definitions of the included effects (Supplementary Table S1) and a more concise overview of the significance of all included peer influence (Supplementary Table S2) are available in the supplementary materials.

3.4.1 Endogenous network influence effects on cannabis use

The most examined effect was own popularity (37, 40, 43, 44). Two of the studies did not find a significant effect (37, 43), while two others found a significant positive effect indicating that the more incoming ties one had, the more cannabis they used (40, 44). One study examined the effect of their own popularity on cannabis use in three different age groups (44), and found that when age increase, the effect of their own popularity decreases. Finally, one study examined whether the effect of own popularity on cannabis use could be moderated by density, school level's alcohol and tobacco use, and school connectedness (40). Only the interaction with school connectedness was statistically significant, indicating that the effect of own popularity on cannabis use was less strong for schools where students felt happy and close to the people at school (40).

Outdegree, neighborhood density, and reciprocity were jointly examined in one study (44). Although adolescents nominating a higher number of friends (high outdegree) had a significantly higher risk of cannabis use, being nested in denser network neighborhoods protected against cannabis use. Reciprocity did not appear to significantly influence cannabis use (44). However, in this study, possible selection effects were not modelled.

Three studies examined the effect of being in a central position within the network on cannabis use (40, 43, 44). Although different centrality measures were modelled, most centrality effects were not significant (40, 44). Only reach centrality significantly influenced cannabis use in two studies (43, 44). This indicates that adolescents that are closer to all other actors in the network, have a higher tendency to use cannabis in comparison with those who are less close to others. Unfortunately, none of the studies controlling for selection included centrality effects in their models. The same applies for group position effects that were also only examined in two studies not controlling for selection effects (43, 44). Only being a liaison compared to being a core member significantly increased cannabis use (42). These two studies which included influence effects related to the adolescent's position in the network created different dummy variables to make the comparison (43, 44). The first study distinguished between one cohesive group (core and peripheral members), multiple groups (liaisons), or no group (isolates and other non-members). They were represented through a set of dummy variables that contrast all other positions to core members (43). The second study measured adolescents' position in the network as a group member, bridge, or isolate. They were measured by two dummy-coded variables with group member as the reference (44). See Supplementary material for more information.

3.4.2 Cannabis-related network influence effects on cannabis use

The cannabis use of friends was included in six studies (37–39, 41–43). Three of them showed a positive significant influence of friends' cannabis use on adolescent cannabis use (37, 38, 43), while one study showed no significant results (41). The two remaining studies (39, 42) showed mixed results, and one of them had two different outcomes that gave different results (42).

In the first study, adolescent' lifetime cannabis use was significant influenced by friend's lifetime cannabis use only at one school (39). In the second study, adolescent's lifetime cannabis use was not statistically significantly influenced by friend's lifetime cannabis use. Yet, it was significantly influenced by friend's last month cannabis use at one school but not the other (42). Additionally, no significant results of friend's cannabis use were found for adolescent's last month cannabis use (42).

Only one study modelled the specific effect of social proximity with a cannabis user, where not having a best friend cannabis user, having fewer neighborhood cannabis users, and being at a greater distance to the nearest user among friends and friends' friends, led to less adolescent cannabis use (44). The influence of best friend's use was greatest at early adolescence (44).

One study found that the higher mean of friends' cannabis users, the more adolescent's cannabis use (43). This study also examined whether the effect of friends' cannabis use could be moderated by the number of friends. The effect of the average of friends' users is stronger on own cannabis use in case of lower number of friends, possibly due to the fact that adding a single friend is more consequential for adolescents with fewer friends than for those with many friends (43). Another study examined whether friends' cannabis use could be moderated by reciprocity, friends' popularity and popularity difference in two schools (41). The interaction with reciprocity was significant only in one school. In this, the effect of friend's cannabis use on adolescent' cannabis use was stronger for adolescents who tended to adopt the cannabis use behaviors of their mutual friends. The interaction with friend popularity was significant also in one of both schools, where adolescents were likely to adopt the cannabis use behaviors of their more popular friends (41).

3.4.3 Other effects of network-related risk behavior related network effects On cannabis use

One study found that adolescents were more likely to use cannabis if their peers used alcohol or tobacco (40). Yet, another study found that the number of friends who smoke and drink at school was not statistically significant with cannabis use (37).

TABLE 3 Aim and major findings related to peer influence and selection effects on adolescent's cannabis use.

Data Source	Authors (year)	Objective	Synthesis of results: Major findings related to the social network analyses
Add Health	Wang et al. (2018) (37)	To examine the co-evolution of adolescent friendship network ties and whether there was interdependence in usage of cigarettes, alcohol, and cannabis	Peer influence effects on cannabis use: School 1: • In-degree (own popularity) ($\beta = 0.03$, $p > 0.05$) • Cannabis use peer influence (**$\beta = 1.43$, $p < 0.01$**) • Number of friends who smoked ($\beta = 0.02$, $p > 0.05$) • Number of friends who drank ($\beta = -0.04$, $p > 0.05$) School 2: • In-degree (own popularity) ($\beta = 0.02$, $p > 0.05$) • Cannabis use peer influence (**$\beta = 1.32$, $p < 0.001$**) • Number of friends who smoked ($\beta = 0.03$, $p > 0.05$) • Number of friends who drank ($\beta = -0.04$, $p > 0.05$) Peer selection effects on cannabis use: School 1: • Similarity cannabis use:**$\beta = 0.27$, $p < 0.001$**. School 2: • Similarity cannabis use on school 2:**$\beta = 0.22$, $p < 0.01$**.
	Schaefer (2018) (38)	The aim was in the systematic network selection processes that lead adolescents into friendships with substance-using peers	Peer influence effects on cannabis use: • Friend's cannabis use (average similarity): M1(**$\beta = 2.122$, $p < 0.001$**); M2(**$\beta = 2.029$, $p < 0.01$**); M3(**$\beta = 1.887$, $p < 0.05$**); M4(**$\beta = 2.338$, $p < 0.001$**); M5(**$\beta = 2.184$, $p < 0.001$**) Peer selection effects on cannabis use: • Cannabis ego: M1 ($\beta = -0.24$, $p > 0.05$); M2 ($\beta = -0.48$, $p > 0.05$); M3 ($\beta = -0.048$, $p > 0.05$); M4 ($\beta = -0.029$, $p > 0.05$); M5 ($\beta = -0.107$, $p > 0.05$). • Cannabis alter: M1 ($\beta = 0.20$, $p > 0.05$); M2 ($\beta = 0.163$, $p > 0.05$); M3 ($\beta = 0.207$, $p > 0.05$); M4 ($\beta = 0.143$, $p > 0.05$); M5 ($\beta = 0.12$, $p > 0.05$). • Cannabis similarity: M1 (**$\beta = 0.395$, $p < 0.01$**); M2 (**$\beta = 0.268$, $p < 0.05$**); M3 (**$\beta = 0.321$, $p < 0.05$**); M4 (**$\beta = 0.395$, $p < 0.001$**); M5 ($\beta = 0.267$, $p > 0.05$). • Ego's cannabis use x R alter: M1 ($\beta = -0.108$, $p > 0.05$); M2 (**$\beta = -0.512$, $p < 0.05$**); M3 ($\beta = -0.132$, $p > 0.05$); M4 ($\beta = -0.337$, $p < 0.1$); M5 ($\beta = -0.291$, $p > 0.05$). • R ego x alter's cannabis use: M1 ($\beta = 0.199$, $p > 0.05$); M2 ($\beta = -0.269$, $p > 0.05$); M3 ($\beta = 0.046$, $p > 0.05$); M4 ($\beta = 0.384$, $p < 0.1$); M5 ($\beta = -0.567$, $p < 0.1$).

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10.3389/fpsyt.2023.1306439

TABLE 3 (Continued)

Data Source	Authors (year)	Objective	Synthesis of results: Major findings related to the social network analyses
	De la Haye et al. (2015) (39)	The current study tests whether the observed tendency for adolescents to select friends with similar histories of marijuana use (42) is explained by friends' selection on other risk factors associated with substance use	Peer influence effects on cannabis use: School 1: • Friends' lifetime cannabis use: M1: (**PE = 0.52, p < 0.01**); M2: (**PE = 0.52, p < 0.01**); M3: (**PE = 0.50, p < 0.01**) School 2: • Friends' lifetime cannabis use: M1: (PE = 0.24, $p > 0.05$); M2: (PE = 0.24, $p > 0.05$); M3: (PE = 0.10, $p > 0.05$) Peer selection effects on cannabis use: School 1: • Any history of cannabis use ego: M1 (PE = −0.16, $p > 0.05$); M2 (PE = −0.05, $p > 0.05$); M3 (PE = 0.00, $p > 0.05$) • Any history of cannabis use alter: M1 (PE = −0.10, $p > 0.05$); M2 (PE = −0.10, $p > 0.05$); M3 (PE = 0.01, $p > 0.05$) • Same history of cannabis use: M1 (**PE = 0.27, p < 0.01**); M2(**PE = 0.20, p < 0.05**); M3 (**PE = 0.18, p < 0.05**) • Current cannabis use ego: M2 (PE = −0.12, $p > 0.05$); M3 (PE = −0.08, $p > 0.05$) • Current cannabis use alter: M2 (PE = 0.06, $p > 0.05$); M3 (PE = 0.11, $p > 0.05$) • Same current cannabis use: M2 (**PE = 0.17, p < 0.01**); M3 (**PE = 0.16, p < 0.01**) School 2: • Any history of cannabis use ego: M1 (**PE = −0.27, p < 0.01**); M2 (**PE = −0.23, p < 0.05**); M3 (PE = −0.23, $p > 0.05$) • Any history of cannabis use alter: M1 (PE = 0.14, $p > 0.05$); M2 (PE = 0.15, $p > 0.05$) M3 (PE = 0.12, $p > 0.05$) • Same history of cannabis use: M1 (**PE = 0.32, p < 0.01**); M2 (**PE = 0.33, p < 0.01**); M3 (**PE = 0.30, p < 0.01**) • Current cannabis use ego: M2 (PE = −0.06, $p > 0.05$) • Current cannabis use alter: M2 (PE = −0.06, $p > 0.05$); M3 (PE = 0.12, $p > 0.05$) • Same current cannabis use: M2 (PE = −0.02, $p > 0.05$)
	Vogel et al. (2015) (40)	To examine the moderating influence of school connectedness, school drug culture, and global network density on the association between peer network status and cannabis use.	Peer influence effects on cannabis use: • Own popularity: M1 (**β = 0.04, OR = 1.04, CI95% = 1.02, 1.07, p < 0.05**), M2 (**β = 0.04, OR = 1.04, CI95% = 1.01, 1.07, p < 0.05**); M3 (**β = 0.04, OR = 1.04, CI95% = 1.02, 1.07, p < 0.05**) • Peer substance use (alcohol and tobacco): M1 (**β = 0.64, OR = 1.90, CI95% = 1.70, 2.13, p < 0.001**), M2 (**β = 0.64, OR = 1.90, CI95% = 1.70, 2.12, p < 0.001**); M3 (**β = 0.64, OR = 1.90, CI95% = 1.70, 2.12, p < 0.001**) • Network centrality: M1 ($\beta = -0.10$, OR = 0.90, CI95% = 0.78, 1.04, $p > 0.05$), M2 ($\beta = -0.09$, OR = 0.91, CI95% = 0.79, 1.05, $p > 0.05$); M3 ($\beta = -0.10$, OR = 0.91, CI95% = 0.79, 1.04, $p > 0.05$) • Own popularity x density: M3 ($\beta = <0.00$, OR = 0.99, CI95% = 0.97, 1.02, $p > 0.05$) • Own popularity x school connectedness: M3 (**β = −0.05, OR = 0.95, CI95% = 0.91, 0.98, p < 0.05**) • · Own popularity x school drug use (alcohol & tobacco): M3 ($\beta = <0.00$, OR = 0.99, CI95% = 0.99, 1.01, $p > 0.05$)

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10.3389/fpsyt.2023.1306439

TABLE 3 (Continued)

Data Source	Authors (year)	Objective	Synthesis of results: Major findings related to the social network analyses
	Tucker et al. (2014) (41)	To examine whether structural features of friendships moderate friends' influence on adolescent cannabis use over time.	Peer Influence effects on cannabis use: School 1: • Friends' cannabis use: M1: not significant*; M2: not significant*; M3: PE = 0.85, $p = 0.069$. • Friends' cannabis use (influence) × friendship reciprocity M1:**PE = 1.14, p = 0.028** • Friends' cannabis use (influence) × friend popularity M2: PE = 0.12, $p = 0.189$ • Friends' cannabis use (influence) × popularity difference M3: PE = −0.02, $p = 0.500$ School 2: • Friends' cannabis use: M1: not significant*; M2: not significant*; M3: PE = 0.53, $p = 0.109$ • Friends' cannabis use (influence) × friendship reciprocity M1: PE = 0.51, $p = 0.254$ • Friends' cannabis use (influence) × friend popularity M2:**PE = 0.15, p = 0.041** • Friends' cannabis use (influence) × popularity difference M3: PE = 0.01, $p = 0.709$ Note: reciprocity, friend popularity and popularity difference were not measured individually: they were measured in interactions. Peer Selection effects on cannabis use: School 1 • Ego's cannabis use M1: PE = −0.01, $p = 0.860$; M2: PE = −0.01, $p = 0.905$; M3: PE = −0.02, $p = 0.909$ • Alter's cannabis use M1: PE = −0.19, $p = 0.652$; M2: PE = −0.27, $p = 0.684$; M3: PE = −0.26, $p = 0.873$ • Squared alter cannabis use M1: PE = 0.14, $p = 0.314$; M2: PE = 0.16, $p = 0.444$; M3: PE = 0.16, $p = 0.764$ • Similar/same cannabis use M1:**PE = 1.53, p = 0.003;** M2:**PE = 1.49,p = 0.000**; M3:**PE = 1.49,p = 0.004** School 2 • Ego's cannabis use PE = 0.10, $p = 0.102$; M2: PE = 0.09, $p = 0.103$; M3: PE = 0.09, $p = 0.049$ • Alter's cannabis use**PE = 0.49,p = 0.040**; M2: PE = 0.37, $p = 0.064$; M3: PE = 0.39, $p = 0.071$ • Squared alter cannabis use PE = 0.41, $p = 0.195$; M2: PE = −0.09, $p = 0.267$; M3: PE = −0.10, $p = 0.282$ • Similar/same cannabis use**PE = 1.03,p = 0.000**; M2:**PE = 1.04,p = 0.000**; M3:**PE = 1.02,p = 0.000**
	De la Haye et al. (2013) (42)	(A) To determine the extent to which friendship networks influence cannabis use (influence effects) and cannabis use influences friendship selection (selection effects). (B) to assess if a multiplicative model of risk explains differences in cannabis-based selection and influence.	Peer Influence effects on cannabis use: On lifetime (M1) School 1: • Friends' cannabis use lifetime: not significant* • Friends' cannabis use last month:**PE = 1.31,p = 0.001** School 2 • Friends' cannabis use lifetime: not significant* • Friends' cannabis use last month: PE = 0.61, $p = 0.116$ On last month (M2) School 1 • Friend's cannabis use: PE = 0.63, $p = 0.126$ • School 2 • Friend's cannabis use: PE = 0.51, $p = 0.125$ Peer Selection effects on cannabis use: On lifetime (M1)

(Continued)

10.3389/fpsyt.2023.1306439

TABLE 3 (Continued)

Data Source	Authors (year)	Objective	Synthesis of results: Major findings related to the social network analyses
			School 1 • Ego's cannabis use:**PE = −0.15,p = 0.049** • Alter's cannabis use: PE = −0.10, $p = 0.099$ • Same cannabis use: **PE = 0.27,p = 000** School 2 • Ego's cannabis use (lifetime):**PE = −0.14,p = 0.032** • Alter's cannabis use (lifetime): PE = 0.11, $p = 0.104$ • Same cannabis use (lifetime):**PE = 0.43,p = 0.000** On last month (M2) School 1 • Ego's cannabis use: PE = −0.02, $p = 0.822$ • Alter's cannabis use: PE = −0.25, $p = 0.558$ • Squared alter cannabis use: PE = 0.16, $p = 0.268$ • Same cannabis use:**PE = 1.49,p = 0.000** School 2 • Ego's cannabis use: PE = 0.10, $p = 0.069$ • Alter's cannabis use: PE = 0.39, $p = 0.238$ • Squared alter cannabis use (past month): PE = −0.09, $p = 0.459$ • Same cannabis use:**PE = 1.02,p = 000**
	Osgood et al. (2014) (43)	To examine the association of substance use with the types of positions adolescents hold in cohesive peer groups within the friendship networks of their schools' grade-cohort.	Peer Influence effects on cannabis use: • Indegree (own popularity): (Coef = 0.013, $p > 0.05$). • Friendship group position (core member as the reference group): Peripheral member (Coef = 0.112, $p > 0.05$). Isolate (Coef = 0.142, $p > 0.05$). Liaison (**Coef = 0.312, p < 0.01**). Non-member (Coef = 0.155, $p > 0.05$). • Friend's cannabis use: Friends' mean use (**Coef = 3.763, p < 0.01**). Friends' mean use × total simple number of friends (**Coef = 2.408, p < 0.01**). • Out-degree: (**Coef = −0.125, p < 0.01**). • Reach: (**Coef = 0.008, p < 0.01**).

(Continued)

10.3389/fpsyt.2023.1306439

TABLE 3 (Continued)

Data Source	Authors (year)	Objective	Synthesis of results: Major findings related to the social network analyses
Context of Adolescent Substance Use Study	Ennett et al. (2006) (44)	To examine the peer context of adolescent substance use, social network analysis was used to measure three domains of attributes of peer networks: social embeddedness, social status, and social proximity to substance users.	Peer influence effects on cannabis use: Social embeddedness: • Reciprocity: ages 11 (OR = 0.55, $p > 0.05$); ages 13: (OR = 0.75, $p > 0.05$); ages 15: (OR = 1.01, $p > 0.05$). • Neighbourhood density: ages 11 (OR = 0.49, $p > 0.05$); ages 13: (OR = 0.24, $p > 0.05$); ages 15: (**OR = 0.12, p < 0.001**). • Out nominations (out-degree): ages 11 (OR = 1.28, $p > 0.05$); ages 13: (**OR = 1.26, p < 0.05**); ages 15: (**OR = 1.25, p < 0.01**). Social position (group member is the reference group): Isolate: ages 11 (OR = 1.11, $p > 0.05$); ages 13: (OR = 0.96, $p > 0.05$); ages 15: (OR = 0.83, $p > 0.05$). Bridge: ages 11 (OR = 1.00, $p > 0.05$); ages 13: (OR = 0.98, $p > 0.05$); ages 15: (OR = 0.96, $p > 0.05$). Social Status: • Normed indegree: ages 11 (**OR = 1.66, p < 0.05**); ages 13: (**OR = 1.35, p < 0.001**); ages 15: (OR = 1.09, $p > 0.05$) • Reach centrality: ages 11 (**OR = 1.05, p < 0.05**); ages 13: (**OR = 1.04,p < 0.001**); ages 15: (**OR = 1.02, p < 0.05**) • Betweenness centrality: ages 11 (OR = 1.07, $p > 0.05$); ages 13: (OR = 1.06, $p > 0.05$); ages 15: (OR = 1.06, $p > 0.05$) • Bonacich power centrality: ages 11 (OR = 1.00, $p > 0.05$); ages 13: (OR = 1.01, $p > 0.05$); ages 15: (**OR = 1.03,p < 0.01**). Social proximity to cannabis users: • Best friend cannabis user: ages 11 (**OR = 23.34, p < 0.001**); ages 13: (**OR = 7.82, p < 0.001**); ages 15: (**OR = 2.62, p < 0.01**). • No. neighbourhood cannabis users: ages 11 (**OR = 7.39, p < 0.001**); ages 13: (**OR = 3.77, p < 0.001**); ages 15: (**OR = 1.93, p < 0.001**) • Distance to cannabis user: ages 11 (**OR = 0.25, p < 0.001**); ages 13: (**OR = 0.41,p < 0.001**); ages 15: (**OR = 0.66, p < 0.001**).

* Authors did not provide the exact value. R, risk factors of 4 attributes: family connectedness, school belonging, grade point average (GPA), religiosity and self-control. PE, parameter estimate; OR, odds ratio. See last column from Table 2 for understanding which models are M1, M2, M3 in each article. Significant of bold values.

10.3389/fpsyt.2023.1306439

3.5 Findings regarding cannabis use related selection effects

There were five SIENA studies that incorporated a co-evolution approach, in which peer influence was controlled for selection effects. Furthermore, they incorporated alternative network and behavior change mechanisms to avoid misdiagnosis of selection or influence effects when another social process is operating. In all five studies, adolescents had the significant tendency to select friends based on similarities in cannabis use behavior, regardless of the outcome (lifetime cannabis use or last month use) and regardless of which operationalization was used for the selection effects in the estimation procedure (37–39, 41, 42). Additionally, cannabis users tended to make fewer friends (39, 42).

4 Discussion

This review is the first to longitudinally examine the influence of peer social networks on cannabis use, taking a social network approach. During the review process, the methodological quality of the included studies was critically evaluated, considering the high quality of those studies that controlled for selection effects (37–39, 41, 42). This review found multiple outcomes that sometimes result in different results, such as, for instance, some studies controlling for selection effects and others not.

The most often found effect was the positive influence of friend cannabis use on adolescent cannabis use, meaning that adolescents are more likely to use cannabis if their close friends use cannabis. Yet, different operationalizations were used for assessing the influence of friends' cannabis use. Other studies not included in this review, have also shown that the influence of peers is an important factor in cannabis use (11, 21, 22, 45). Although these studies did not take a network approach, they showed that adolescents are influenced by the perceived cannabis use of friends (modeling) (21, 22, 39), norms regarding cannabis use among Friends (11, 21, 22), and that they may experience pressure to conform to the behavior of their cannabis' consuming Friends (22). Based on these studies and our results in the present review, we can conclude that it is important to consider the influences of peers in cannabis prevention efforts.

Although the own popularity was explored by four studies (43, 46–48), results were inconclusive. Those studies, that showed significant positive effects, unfortunately did not control for selection effects (46, 48). The one study that controlled for selection did not find significant effects of popularity (37). Hence, the development of more longitudinal studies controlling for selection effects is needed to study the effects of popularity and possible interactions with popularity on cannabis use.

Regarding the effects of social position on cannabis use, only one study suggested that an adolescent who takes a liaison position in the network could be a potential diffusion agent of behaviors towards cannabis use (43). There is very little evidence to draw any conclusions about the effect of social position on cannabis use. In other research, no association was found between social network position and cannabis use (46). More research is needed to analyze how social positions are related to cannabis use. If different social positions do influence cannabis use, prevention efforts need to consider them as they can possibly interfere in intervention process by empowering (e.g., when multiple non-cannabis users are in a bridge position) or diminishing (e.g., when multiple cannabis users are in a bridge position) intervention effects.

It is also relevant to further explore the changes in peer influence effects over time. One included study showed that age seems to act as a moderator of the peer influence and selection effects on cannabis use (44). For instance, the influence of best friend's use was greatest at early adolescence, when they are most vulnerable to peer influence. Previous research has shown that at early adolescence, peers become the reference and the main source of support, and adolescents are concerned about the need to feel accepted by those around them (14, 23, 46). This feeling faded when adolescents were older (44, 46, 49).

Our findings showed a large diversity in effects, indicating that more research is needed to clarify peer influence processes on cannabis use. The use of stochastic actor-orientated modelling (SAOM) implies the use of a complete network, as well as leads to a specific and better approach to study peer influence effects controlling for selection effects (47, 50). Data about peer influence on substance use applying SAOM have been published in the last decade, especially for alcohol and tobacco (47, 50). A similar approach is recommended for studying cannabis use.

Some limitations are evident in this review. First, the number of included studies is low, most of them belonged to the Add Health study, and the peer influence are measured differently. Although Add Health is a highly powerful study in terms of social networks, additional research, through other validated surveys, examining social networks in other communities is needed to be able to identify common patterns regarding social networks. Second, the instrument used to assess the methodological quality of this literature does not include questions to assess the control of selection effects, neither the number of adolescents on the network nor its changes over time (i.e., the number of joining and leaving participants in the network). It would be recommended to develop a standard tool to assess the methodological quality of SNA studies.

Despite these limitations, this systematic review supported earlier findings suggesting the role of peer influence on cannabis use among adolescents. An unique point of this review is the specificity and adequacy of the study selection criteria, for instance, including only longitudinal studies and completed social networks.

4.1 Implications for future research and practice

Identifying the effect of peer influence on cannabis use is crucial in order to improve the social approach of the traditional socio-cognitive models, as well as prevention and early intervention programs (11–13, 20–23). Once more research would include a broad range of effect in a correct longitudinal design, it could start to translate these peer network influence effects into tools to help intervention programs to become more effective, taking advantage of the composition of the network. Then, it will be of great value to direct prevention efforts towards peer groups that are at risk of cannabis use.

Future research should conduct more longitudinal studies, controlling for selection effects, improving the modelling of the network (i.e., using a complete network), and with more effects of peer influence effects. For instance, studying the role of own popularity and friend popularity, and the influence of the number of alcohol and tobacco friend's users on cannabis use. It would be recommended that studies control for selection effects. Moreover, as indicated by previous literature (48, 51), it is important to examine more data about the frequency of cannabis use and patterns according to gender and ethnicity, since these could be different in these populations. Additionally, although a growing body of evidence indicates that school environments have a strong influence on adolescent cannabis use (51), future studies could aim to have a broader scope of the network around adolescents, including, for example, out-of-school networks.

It is also important to include direct observations of interactions between targets and peers in order to better understand how peers affect each other and how this influence works overtime. There is already an European intervention trial with social network data for smoking cigarettes (52, 53). Yet, SNA was not yet used within cannabis use prevention, probably due to the lack of adequate SNA studies to support the use of SNA in such programs. Moreover, the European Monitoring Centre for Drugs and Drug Addition has recognized in 2021 the importance of social responses to cannabis-related problems (54). It might be relevant to include the SNA in this type of standards. Finally, further studies may also focus on the impact of the legalization of recreational cannabis use on peer network influence, considering that most of the included articles were conducted before the legalization of marijuana in the USA. The legalization could potentially amplify the positive perception of cannabis use within peer groups.

5 Conclusion

To develop effective cannabis prevention programs, it is essential to comprehend the impact of social networks on cannabis use behavior. This systematic review underscores the significance of peer influences on adolescent cannabis use. This review provides a summary of longitudinal findings from scientific evidence regarding peer influence on cannabis use, utilizing the social network approach, and confirming the importance of peer influences on adolescent cannabis use. Different operationalization of the influence of friends' cannabis use was the most significant peer influence effect on adolescent's cannabis use. Regrettably, disparities in reporting other peer influence effects hinder optimal comparisons, making it advisable to identify the best methods for measurement in the future (e.g., through consensus meetings or Delphi studies). Therefore, more extensive, and improved research is warranted. Additional studies that control for relevant selection effects are necessary to advance our understanding of these network effects on cannabis use, with an emphasis on expanding the range of network influence effects considered.

Author contributions

MCTG: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Writing – original draft. MABJ: Data curation, Formal analysis, Investigation, Methodology, Supervision, Writing – review & editing. MLS: Conceptualization, Funding acquisition, Resources, Supervision, Writing – review & editing. HV: Conceptualization, Supervision, Writing – review & editing. LM: Conceptualization, Formal analysis, Investigation, Methodology, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2023.1306439/full#supplementary-material

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The impact of the peer effect on adolescent drinking behavior: instrumental-variable evidence from China

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Background: Governments around the world have taken measures to limit adolescent drinking, however, rates are still alarmingly high. However, most of these measures ignore the peer effect of drinking among adolescents. Previous studies have not sufficiently considered the reciprocal relationship between adolescent alcohol consumption and peer alcohol consumption, which may lead to an overestimation of the peer effect and mask underlying issues. Good instrumental variables are powerful but rare tools to address these issues.

Objective: This paper aims to correctly estimate the peer effect of drinking on adolescent drinking behavior in China.

Methods: Owing to the detailed information of household background in the dataset of our survey, we were able to use the drinking behaviors of peers' fathers and their beliefs about the health risks of alcohol as instrumental variables, which are more powerful than school-average instrumental variables. We collected data from the 2017 Health and Nutrition Panel survey, which surveyed 10,772 primary school students from 59 urban migrant and 60 rural public schools.

Results: The instrumental variable method estimation revealed that peer drinking significantly influences adolescent drinking behavior, with adolescents who have peers who drink alcohol being 10.5% points (2 stage least square, i.e., 2SLS, full sample estimation) more likely to engage in drinking compared to those without such peers. Furthermore, the effect differs significantly between migrant and rural adolescents.

Conclusion: The study found that parental care plays a significant role in the degree of peer effect, with the absence of parental care being a key factor in the presence of the peer effect.

KEYWORDS

peer effect, adolescent addiction, drinking behavior, instrumental variable, China

1 Introduction

Adolescent drinking is on the rise (1). In a study by Hibell et al. (2), 15–16-year-old students in 35 European countries reported that approximately 90% (range: 66–95%) of youth have tried alcoholic beverages at least once. Recent data from the World Health Organization has shown that 41.2% of 15–19-year-olds drink alcohol in China (3). According to a meta study, among

Chinese adolescents, the prevalence rates for lifetime drinking, past month drinking, and binge drinking are 51, 24, and 9%, respectively (4).

Underage drinking can have profound negative consequences for underage drinkers, as well as their families, their communities, and society as a whole (5). According to a 2014 estimate by the WHO, 5.1% of the global burden of disease and injury can be attributed to alcohol consumption (6). Alcohol consumption can cause more than 200 illnesses and injuries (3), and can increase risk for type 2 diabetes, coronary artery disease, arrhythmias, and stroke among adolescents who consume alcohol early in life (7). Additionally, studies have shown that partaking in harmful drinking behavior at a young age increases one's risk of serious mental illness and excessive drinking in adulthood (8). Problematic drinking behavior can also lead to a range of social problems such as violence, crime, and suicide (9, 10). Moreover, data from the 2004 WHO Global Burden of Disease Study indicates that alcohol consumption itself is a major risk factor for decreasing disability-adjusted life years among people aged 10–24 years (11).

Given the risks, governments around the world have taken various measures to limit teenage drinking. Rates of adolescent alcohol have varied across country contexts due to the different cultural practices, laws, and policies. Countries, such as the United States, that emphasize zero-tolerance policies seek to encourage adolescent abstinence from alcohol and drug use (12). In order to do so, the United States has issued laws and regulations that restrict teenage drinking behavior (5). Similarly, China established Article 67 of the Law on Protection of Minors, which stipulates that those who sell tobacco or alcohol to minors, or fail to set up conspicuous signs not to sell tobacco or alcohol to minors, shall be ordered to make corrections by the competent authorities and given administrative punishment. It indicates that although selling tabaco and alcohol to minors is still non-criminal, those who violates this administrative regulatory will face with penalties or sanctions range from fines and warnings to the suspension of certain privileges. Experts and scholars recommend intervention in adolescent drinking behavior from the aspects of retail availability (13, 14), social availability (15), pricing (16–18), and drinking and driving (19–21). Nevertheless, underage drinking rates remain alarmingly high, particularly among youth aged 18–20 years, causing preventable health and safety consequences (5). A meta-analysis of drinking behavior among Chinese adolescents, showed that 15.3–44.7% of secondary school students drank alcohol (22).

Adolescent drinking behavior has been shown to be related to social and economic factors. Adolescents with downward socioeconomic mobility during childhood are more likely to drink alcohol (23), and studies have shown that cultural orientation influences adolescent drinking behavior in developing countries (24). Among the many socioeconomic factors that influence adolescent drinking, family is considered to be an important social factors affecting the occurrence and transformation of underage drinking problems (25). First, compared to living with parents, living with other family members is associated with a wide variety of problematic behaviors in adolescents (26). Additionally, Barrett and Turner found family structure was associated with adolescent drinking behaviors (26). Further, a Chilean study found that parental drinking was one of the main causes of teenage drinking (27). In the study of gender heterogeneity, Bobakova et al. found that females appear to be sensitive to parental monitoring in regard to drunkenness, while males are not (28). In China, family structure has been shown to have a similar impact on adolescents' drinking behaviors, with parents' drinking behaviors reported as having the greatest impact (29).

Although family also has an important influence on adolescent drinking behavior, adolescents spend less time with their parents and more time with their peers (30). Clark and Lohéac and Evans et al. found that there is a close relationship between the behavior of adolescents and the behavior of their peers (31, 32). Thus, peer drinking is widely viewed to have a significant influence on adolescent alcohol use as well (33). Peer alcohol consumption and expectations of alcohol remained the most important predictors of alcohol problems among Spanish adolescents (31). When controlling for other background characteristics, peer influence was the most significant factor affecting adolescent drinking (32, 34). Further, Chuang et al. found that the neighborhood context constitutes the setting in which peer influences on adolescent behaviors occur (35). Barrett and Turner and Gommans et al. also found that the popularity composition of one's peer group and the relative difference in popularity between an adolescent and their peers is also associated with adolescent drinking (26, 36). Tyler et al. also found that peer drinking lead to higher levels of alcohol abuse among adolescents aged 14–16 (37). Lee et al. also found that having peers who consume alcohol may increase adolescents' future drinking behaviors by up to 80% (34).

Peer effect has long been viewed as crucial element to students' human capital accumulation (38). Despite so, for researchers, a point of view that it may be a potent influence on bad behaviors, specially, the alcohol use, can be date back to Bauman and Ennett's study in 1996 (39) and even before. There is a great deal of research regarding the peer effect on adolescent drinking, but there are still some shortcomings. Adolescents can and do select peers with similar drinking habits (40). They tend to acquire friends who are similar to them, and they also appear to acquire new friends who are similar to their old friends (41). Previous studies do not pay attention to the endogenous problem of mutual causation between adolescents' and their peers' drinking during model regression. In this study, we have raised the basic question of whether the peer-teen drinking correlation is due to selection or causation.

Some relative attempts are cross-lagged panel models (42–44) and survival model (45). However, a better approach that is often used in economic researches is the instrumental variable (IV) method. It does not rely on the assumption that lagged behaviors are not correlated with each other. But, a good IV requires additional information that only affect the peer's drinking behavior and consequently difficult to be found. Fortunately, with the detailed information of parents, we have the chance to detect a good IV. Specifically, in order to overcome the endogeneity of peer influence on adolescent drinking, we took "whether the peer's father is drinking" and "whether the peer himself/herself believes that drinking alcohol is unhealthy" as instrumental variables to investigate the peer effect on adolescent drinking. These are more powerful than commonly used school-averaged instrumental variables and the reasons are detailed in the "Validity of the instrumental variables" section. In the context of Chinese culture, parental drinking significantly affects adolescent drinking behavior (46), as there is a correlation between a father's drinking behavior and the drinking behavior of their child (47). But peer's father's drinking would not affect their own drinking behavior. Therefore, peers' fathers' drinking is regarded as a good instrumental variable of peer drinking.

2 Materials and methods

2.1 Type of this study

This study is a cross-sectional observational study that uses instrumental variable methods to estimate the peer effect of drinking on adolescent drinking behavior in China. The study uses data from the 2017 Health and Nutrition Panel survey (HNPS), which covers 10,772 primary school students from four provinces in China. The study uses the drinking behaviors of peers' fathers and their beliefs about the health risks of alcohol as instrumental variables, which are more powerful and valid than commonly used school-average variables. The study also examines the heterogeneity of the peer effect across different groups of adolescents, such as migrant and rural, left-behind and non-left-behind, and parents' migrant work.

2.2 Data

2.2.1 Sampling

The data in this study were obtained from the 2017 Health and Nutrition Panel survey (HNPS), which originates from a project conducted by College of Economics and Management at the China Agricultural University. The HNPS adopted a stratified sampling method to draw approximately 10,772 students from 238 classes of third- and fourth-years (ages of 8 and 10-years) at 119 primary schools across 4 provinces. We used the data from HNPS for three reasons. First, it is a large-scale primary school education survey for China. Second, the survey collected detailed information about the characteristics of students, as well as their families. Third, the HNPS includes students with rural household registrations in both urban and rural areas. Among them, the students in urban were considered as migrant students, while the students in rural include left-behind children and non-left behind children. With rapid urbanization and industrialization of China, many rural residents have migrated to urban areas for work, increasing the proportion of left-behind children in rural villages. Therefore, we can identify if there is a difference between the types of students in terms of the peer effect.

The HNPS employed a multi-faceted methodology that involved the survey of students, collection of data on alcohol consumption, and the administration of standard mathematics tests and health assessments. The sampling procedure was comprised of three distinct phases. First, during the period from May 15th, 2017 to June 15th, 2017, the HNPS data included students with rural registered residences in Beijing (northern China), Suzhou (eastern China), Henan (central China), and Anhui (central China) provinces. Henan is the province that sends the most migrant workers to Beijing, while Anhui province is the largest source of immigrants to Suzhou and one of the largest sources of immigrants to Shanghai (44). Then, the researchers approached the local bureau of education to obtain a comprehensive list of primary schools in these counties (excluding schools located in the county seat as they were predominantly attended by urban children and were not covered by the nutrition improving program neither), from which six schools were randomly selected per county, resulting in a total of 60 schools. Finally, one class from grade 3 and grade 4 was randomly selected from each school to conduct the surveys and tests. Finally, after dropping those who did not finish all the relative questionnaires (parents' and students') and tests, a total of 60 classes (1,931 students) in Beijing, 58 classes (3,239 students) in Suzhou, 60 classes (3,456 students) in Henan, and 60 classes (2,934 students) in Anhui. Overall, there were 5,718 third-graders and 5,842 fourth-graders were included in the sample. Due to a little sort of the children are "isolated," who has not a friend at school, all samples could not be matched with corresponding peers. Therefore, we only used 10,772 samples who have friend at school.

It is worth noting that the students' parents are informed and have given written consent to the survey. They were informed that the data was collected only for scientific research and will be analyzed only anonymously. The ethnical approval is provided by China Agricultural University Institutional Review Board. Only researchers who are authorized the College of Economic and Management, China Agricultural University can have access to the data.

2.2.2 Data collection

All HNPS participants were asked to answer a series of questions in order to generate variables to measure individual and family characteristics for each student, as well as to collected personal and family information from students and ask who their close friends are in the same class. We collected information on each student's gender, age, and number of siblings, as well as whether the student participated in preschool. We also collected information regarding the ages and education levels of the students' fathers and mothers and whether their father consumed alcohol or smoked tobacco. The durability assets of family were also measured. Students' drinking statuses were obtained by asking them whether they drank alcohol. The identity of students' peers was determined by asking them what the name of their best friend was. This was matched with the corresponding peer survey. Throughout the paper, when referring to peers, we are referring to the best friend that each student provided in their answer.

Brunborg et al. found that adolescent alcohol consumption was closely related to disposable income, however, income information is not available from the HNPS because it is filled out by students, not parents (45). Despite this, the HNPS can provide information on the main assets owned by a student's household. The survey asks students about seven main assets, including a refrigerator, television, microwave oven, induction cooker, air conditioner, washing machine and computer. Based on this information, and using the method proposed by Filmer and Pritchett (47), we conducted a principal component analysis (PCA) to create a variable that measures household durable assets to generate a proxy for household wealth. If a household owned a durable asset, it was recorded as 1, otherwise it was recorded as 0. We applied PCA method on these dummy variables to calculate the scoring factor that captures the "relative household asset condition comparing to the other local households." The descriptive statistic of this variable is shown in Table 1 (Household assets). Notice that it is the relative value, rather than the absolute value of this variable contains the information we want.

2.3 Sample characteristics

After processing and selecting variables, 10,772 student samples were obtained. The explained variable was Drink (whether the student drinks alcohol), and the core explanatory variable was $Drink_{peer}$ (whether the student's peer drinks alcohol). The control variables were Gender, Age, Preschool (whether the student attended preschool),

TABLE 1 Variables and summary statistics for the student sample.

Variable	Definition	Obs.	Mean	SD
Drink	Dummy, 1 = drinks, 0 = not,	10,772	0.265	–
$Drink_{peer}$	Dummy, 1 = peer drinks, 0 = not,	10,772	0.272	–
Father drinks	Dummy, 1 = father drinks, 0 = not,	10,772	0.749	–
Aware	Dummy, 1 = drinking harmful to health, 0 = not	10,772	0.698	–
Gender dummy	Dummy, 1 = boy, 0 = girl	10,772	0.520	–
Age	Age measured by month	10,772	126.9	10.74
Preschool	Dummy, 1 = attended preschool, 0 = not	10,772	0.932	–
Number of siblings	The number of siblings	10,772	0.468	0.636
Local dummy	Dummy, 1 = rural, 0 = migrant	10,772	0.567	–
Father's age	Age of father	10,772	37.55	1.534
Mother's age	Age of mother	10,772	35.95	1.281
Father's education	Educational years of father	10,772	9.010	2.660
Mother's education	Educational years of mother	10,772	8.424	3.301
Household assets	Household durable asset index	10,772	0.000	1.470

Data source: author's survey.

Number of siblings, Local dummy (rural or migrant), Father's age, Mother's age, Father's education, Mother's education, and Household assets.

Table 1 reports the individual and family characteristics of the sample. Overall, the drinking behaviors of students were similar to those of their peers. Most students had a certain understanding of the harm of drinking. In our sample, parents were usually young, low level of education, and generally have only one child.

2.4 Statistical relationship of interest

The purpose of this study was to estimate the influence of peers on students' drinking behaviors. The Ordinary Least Squares (OLS) model estimates are as follows:

$$drink_i = \beta_0 + \beta_1 drink_{peer,i} + \beta_2 M_i + \beta_3 N_i + \delta_i + \varepsilon_i \quad (1)$$

Where, $drink_i$ refers to whether the student (i) has the behavior of drinking, and $drink_{peer,i}$ refers to whether the student's peer has the behavior of drinking. In addition, M_i represents a series of characteristic variables at the individual level (for the student), such as gender, age, whether they attended preschool, and number of siblings. N_i represents a series of characteristic variables at the household level, such as parents' ages, parents' educational years, and household durable assets. δ_i is included to control for differences between schools. ε_i is the error term.

2.5 Validity of the instrumental variables

Given the mutual influence of students and their peers' drinking behaviors, which means they affect each other, the OLS estimates may be biased. To address this endogeneity issue, this study selected the drinking behavior of students' peers' fathers and their perception of the harm of drinking as IVs.

Traditionally, two criteria have been used to assess the quality of instrumental variables (IVs): exogeneity and validity. First, there is a strong correlation between the drinking behaviors of students' peers' fathers and the drinking behaviors of the students' peers. However, peers' fathers' drinking behaviors have no influence on the students' own drinking behaviors. Second, there is a high correlation between peers' understanding of the harm of drinking and their own drinking behavior. However, peers' understanding of the harm of drinking has no impact on adolescents' drinking behaviors. Therefore, the IVs we have selected are both exogenous and valid.

Previous studies often use school-averaged variables as IVs, which can lead to correlations with unobservable variables within schools, thereby compromising exogeneity. However, incorporating school fixed-effects to account for unobservable variables within schools may render the use of school-averaged IVs infeasible. This is due to the collinearity between these variables and fixed-effects, making them essentially a linear combination of fixed-effects and thus unable to be used simultaneously. Our IVs avoid such problem since peers' fathers' behaviors various between each student and are less likely to be correlated with unobserved factors of schools.

In addition, two students may become friends because they displayed similar behaviors before becoming friends, that is, their behavior is not the result of the influence of a good friend. Therefore, there may be a self-selection problem in drinking alcohol. To mitigate this, we added the question "Why is he/she your best friend?" to the questionnaire. According to the students' answers, 71% chose to become friends with their peers because of their "good personality," while few chose friends who had similar drinking habits. Therefore, we were able to ignore the endogeneity of self-selection.

Specifically, we estimate the following equations:

$$drink_{peer,i} = \alpha_0 + \alpha_1 Fdrink_{peer,i} + \alpha_2 aware_{peer,i} + \alpha_3 M + \alpha_4 N + \alpha_5 \delta_i + v_i \quad (2)$$

$$drink_i = \beta_0 + \beta_1 \widehat{drink_{peer,i}} + \beta_2 M_i + \beta_3 N_i + \beta_4 \delta_i + \varepsilon_i \quad (3)$$

This is called two stage least square (2SLS) method in the econometric terminology. We used peers' fathers' drinking behaviors and peers' perceptions regarding harm from drinking as IVs, and conducted an overidentification test in equation (2). Here, $drink_{peer}$ indicates whether peers drink alcohol and $Fdrink_{peer}$ indicates whether the peers' fathers drink alcohol. Peers' perceptions of the dangers of alcohol consumption are represented by $aware_{peer}$. In equations (3), Mi represents a series of characteristic variables at the individual level of students, such as gender, age, school attendance, number of siblings and other indicators. N_i represents a series of characteristic variables at the family level, such as parents' ages, parents' educational year, and household durable assets.

With data and methods prepared, we use STATA 17 software to estimate all the parameters that we are interested in.

3 Results

3.1 OLS and IV estimation

Based on the OLS estimation, this study investigated the relationship between peer drinking and adolescent drinking behavior. In Table 2, the dependent variable was adolescent drinking. Columns (2) and (3) are the stepwise regression results after adding students' individual characteristics and family characteristics to the OLS model. The OLS estimation results show that adolescents who had peers who drank alcohol were 11.1% more likely to drink alcohol than those who had peers who did not. After adding individual characteristics and family characteristics into the model, the drinking probability of adolescents who had peers who drank alcohol was increased by 7.1% points in comparison to those who had peers who did not, and its promoting effect was still significant.

In terms of individual control variables, male student drinking probability was 13.1% points higher than that of female student. Since the samples were students of third- and fourth-years, there was a small age gap between the sample students, so the students' ages (months) did not appear to influence their drinking behaviors. The number of siblings had appeared to have a significant positive impact on their drinking. Siblings influence young children's cognitive skills directly or indirectly (48). Having one additional sibling increased the probability of adolescent drinking by 2.3% points. One possible reason for this is that adolescents with more siblings have less parental care and are more susceptible to peer drinking behavior. The drinking probability of rural adolescents was found to be 48.7% points lower than that of migrant adolescents. One possible reason for this is that migrant adolescents have more opportunities to drink than rural adolescents. Students' fathers' ages appeared to have a significant positive impact on their children's drinking; with each additional year of age, the probability of their child's drinking increased by 3.6% points. Mothers' ages, on the other hand, had a significant negative impact on their children's drinking, with every additional year reducing the probability of their child's drinking by 22.2% points. Students' fathers' years of education had no statistically significant impact on their children's drinking behaviors, while mothers' years of education had a significant negative impact. Increasing, mothers' years of education by 1 year reduced the probability of their children's drinking by 0.4% points. Adolescents whose fathers drank alcohol had a 6.6% points higher probability of drinking than those whose fathers did not drink. The above results show that parents have a significant positive relationship with adolescent drinking behavior. Household durable assets can provide a suitable environment for adolescents to drink, which are positively correlated with teenage drinking behavior.

The endogeneity problems are as follows: (1) There is a mutual influential relationship between adolescent peer drinking and control variables. That is, adolescents often spend time with their peers, and the drinking behaviors of their peers often affect the individual characteristics of adolescents, such as views regarding

TABLE 2 Effects of peer drinking on adolescent drinking behavior.

Variables	(1)	(2)	(3)
	OLS	OLS	OLS
$Drink_{peer}$	0.111***	0.071***	0.071***
	(0.013)	(0.012)	(0.012)
Aware		−0.220***	−0.215***
		(0.017)	(0.017)
Boy		0.139***	0.131***
		(0.011)	(0.011)
Age		−0.000	0.000
		(0.001)	(0.001)
Preschool		−0.020	−0.028
		(0.024)	(0.024)
Number of siblings			0.023**
			(0.010)
Local dummy			−0.487***
			(0.010)
Father's age			0.036***
			(0.005)
Mother's age			−0.222***
			(0.006)
Father's education			−0.001
			(0.002)
Mother's education			−0.004**
			(0.002)
Father drinks			0.066***
			(0.014)
Asset			0.014***
			(0.004)
Constant	0.337***	0.433***	7.451***
	(0.005)	(0.083)	(0.204)
School fixed effects	Yes	Yes	Yes
R-squared	0.021	0.103	0.150
Observations	10,772	10,772	10,772

OLS means ordinary least square. The value of the robust standard errors is reported in parentheses. The definitions for each of the variables are available in Table 1. ***Indicate significance level of 1%. **Indicate significance level of 5%.

alcohol. (2) There may be a reverse causal relationship between adolescent drinking and peer drinking. In other words, teens who drink alcohol tend to form peer relationships more easily. (3) Although the model setting and variable selection have been considered comprehensively in this paper, there may still be missing variables and measurement errors, resulting in estimation bias.

In this paper, the IV method was used to correct possible endogeneity problems. As shown in Table 3, column (1) is the regression result using the IVs. Firstly, in order to test the problem of under-identification, the estimated values of the LM (Lagrange multiplier) statistics in the regression models of columns (1) were calculated to be 494.949 ($p = 0.000$), indicating that there was no under-identification question. Secondly, in order to test whether IVs are weak, we calculated the Cragg-Donald Wald F statistic, which was much higher than the critical value of rejecting the weak IV hypothesis at the 10% statistical level, strongly rejecting the null hypothesis of "IV redundancy." Thirdly, through the Overidentification test of all Instruments, the Hansen J statistic was 0.957, which strongly rejected the hypothesis of endogenous instrumental variables. Therefore, the selection of IVs in this paper had strong explanatory power regarding whether the sample students drank alcohol, and the selection of IVs was deemed appropriate.

In Table 3, the regression results in column (1) show that peer drinking had a positive influence on students' drinking with peers' perceptions of drinking harm and peers' fathers' drinking behaviors as IVs. Adolescents who had peers who drank alcohol were 10.5% points more likely to drink than those who had peers who did not. The above regression results show that peer drinking increased the probability of students drinking. At the same time, the regression results using IVs also showed that family and regional characteristics (e.g., father's drinking behavior and parents' years of education) significantly affect students' drinking behaviors.

In order to test the robustness of the results, the sample was divided into peer fathers who worked outside the home (columns 2 of Table 3) and peer fathers who worked locally (columns 3 of Table 3). In the group of peer fathers who worked outside, the drinking probability of adolescents who had peers who drank alcohol was increased by 12.6% points in comparison to those who had peers who did not. In the other group, the drinking probability of adolescents who had peers who drank alcohol was increased by 9.7% points in comparison to those who had peers who did not. The results showed that the peer effect still had a positive influence on adolescent drinking behavior in the two group regressions, indicating the robustness of the results. A permutation test was used to test the difference in the coefficients between the groups after grouping regression. The empirical p value of this difference was 0.316 under 2SLS model, which is not statistically significant, indicating that there is no significant difference between the regression coefficients of the two groups.

TABLE 3 Instrumental variable analysis of peer effects.

Variables	(1)	(2)	(3)
	2SLS	2SLS	2SLS
	All the samples	Peer fathers who worked outside	Peer fathers who worked locally
$Drink_{peer}$	0.105***	0.126**	0.097*
	(0.040)	(0.062)	(0.053)
Aware	−0.214***	−0.201***	−0.223***
	(0.010)	(0.015)	(0.013)
Boy	0.126***	0.137***	0.115***
	(0.010)	(0.016)	(0.014)
Age	−0.000	0.001*	−0.001*
	(0.000)	(0.001)	(0.000)
Preschool	−0.028*	−0.023	−0.033
	(0.017)	(0.027)	(0.021)
Number of siblings	0.023***	0.032***	0.015*
	(0.007)	(0.010)	(0.009)
Local dummy	−0.477***	−0.355	−0.401
	(0.148)	(0.230)	(0.252)
Father's age	0.032	0.066	−0.001
	(0.046)	(0.066)	(0.064)
Mother's age	−0.214***	−0.226***	−0.112
	(0.052)	(0.062)	(0.112)
Father's education	−0.000	−0.003	0.003
	(0.002)	(0.003)	(0.002)
Mother's education	−0.004***	0.001	−0.008***
	(0.001)	(0.002)	(0.002)
Father drinks	0.066***	0.068***	0.067***
	(0.009)	(0.014)	(0.011)
Asset	0.014***	0.018***	0.010***
	(0.003)	(0.005)	(0.004)
Constant	7.326***	0.126**	4.848
	(2.070)	(0.062)	(4.203)
School fixed effects	Yes	Yes	Yes
Observations	10,772	4,726	6,046
Cragg-Donald Wald F statistic	306.383	126.378	177.466
Hansen J statistic	0.957	1.458	4.994
Permutation test (P-val)		0.316	

2SLS means two stages least square method. The values of the robust standard errors are reported in parentheses. The definitions for each of the variables are available in Table 1. ***Indicate significance level of 1%. **Indicate significance level of 5%. *Indicate significance level of 10%.

3.2 Heterogeneity analysis results

Based on existing literature research, there are individual, regional (49), and family differences (50) in adolescent drinking behavior. In order to identify these differences, we analyzed the heterogeneity for three aspects: migrant or rural, left-behind, or non-left behind, and parents' migrant work.

To overcome potential endogeneity problems, we used the 2SLS (two stage least square) model for regression after the OLS regression (Table 4). Columns (1) and (2) are the OLS and 2SLS models (with

TABLE 4 Results of heterogeneity analysis of peer effect.

Variables	(1)	(2)
	OLS	2SLS
	Migrant (N = 4,659)	
$Drink_{peer}$	0.045***	0.100*
	(0.015)	(0.059)
R-squared	0.137	0.135
Control variables	Yes	Yes
School fixed effects	Yes	Yes
Cragg-Donald Wald F statistic		140.243
Overidentification test (P-val)		0.022
	Rural (N = 6,113)	
$Drink_{peer}$	0.089***	0.114**
	(0.013)	(0.055)
R-squared	0.162	0.161
Control variables	Yes	Yes
School fixed effects	Yes	Yes
Cragg-Donald Wald F statistic		166.031
Overidentification test (P-val)		0.570
Permutation test(P-val)		0.249
	Non-left behind children (N = 1732)	
$Drink_{peer}$	0.067***	0.084
	(0.024)	(0.087)
R-squared	0.219	0.219
Control variables	Yes	Yes
School fixed effects	Yes	Yes
Cragg-Donald Wald F statistic		59.987
Overidentification test (P-val)		0.463
	Left-behind children (N = 4,381)	
$Drink_{peer}$	0.098***	0.130*
	(0.015)	(0.067)
R-squared	0.171	0.118
Control variables	Yes	Yes
School fixed effects	Yes	Yes
Cragg-Donald Wald F statistic		109.553
Overidentification test (P-val)		0.697
Permutation test(P-val)		0.232
	Neither parent is at home (N = 2,901)	
$Drink_{peer}$	0.122***	0.223***
	(0.019)	(0.086)
R-squared	0.193	0.106
Control variables	Yes	Yes
School fixed effects	Yes	Yes
Cragg-Donald Wald F statistic		66.153
Overidentification test (P-val)		0.653
	Father at home (N = 312)	
$Drink_{peer}$	0.137**	0.557**
	(0.061)	(0.258)
R-squared	0.477	0.001
Control variables	Yes	Yes
School fixed effects	Yes	Yes
Cragg-Donald Wald F statistic		5.340
Overidentification test (P-val)		0.320
Permutation test(P-val)		0.151

OLS means ordinary least square. 2SLS means two stages least square. The values of the robust standard errors are reported in parentheses. The definitions for each of the variables are available in Table 1. ***Indicate significance level of 1%. **Indicate significance level of 5%. *Indicate significance level of 10%.

peer drinking and peer perception of harm from drinking as IVs) respectively. In the regression of the 2SLS model, the test results of LM and Cragg Donald Wald F statistics show that there is no insufficient identification or weak IVs, indicating that the selection of instrumental variables is still appropriate. Therefore, the grouped regression coefficients reported below refer to the results of the 2SLS model.

Firstly, we divided the sample into migrant and rural adolescents to investigate differences in regards to the residence of rural students. Overall, the numbers of migrant and rural adolescents drinking alcohol were similar, with the proportion of rural and migrant adolescents drinking being 28.17 and 24.40%, respectively. The results of a migrant-rural heterogeneity analysis show that peer drinking can significantly increase the drinking behavior of migrant and rural adolescents. In the rural students, adolescents who had peers who drank alcohol has a 11.4% point higher probability than those who had peers who did not, and its thrust is significantly higher than that of migrant students. Whether the coefficient difference between the two sub-samples is significant still needs to be tested. A permutation test was used to test the coefficient difference between the groups after the grouping regression. The test results show that there was no significant difference in the peer effect coefficient of drinking among migrant and rural adolescents.

Secondly, in order to analyze the peer effect of drinking behavior of rural adolescents, the students were divided into two groups: non-left behind children (NLBC) and left behind children (LBC). We define left-behind children as children who have at least one of their parents working outside the home. The regression results show that there was no peer effect in NLBC group and a significant peer effect in LBC group. The permutation test was used to test the coefficient difference between the groups after grouping regression. The test results show that the coefficient difference passed the significance level test and there is a significant difference. The results further show that for rural adolescents, the drinking behavior of NLBCs is not affected by peer drinking because they receive care from their parents. On the other hand, the lack of parental care provided to LBCs leads to the significant peer effect on their drinking. Among the LBC, adolescents who had peers who drank alcohol were 13.0% points more likely to drink than those who had peers who did not.

Thirdly, we focused on the difference in peer effects between the LBCs group with all parents out and the LBCs group with fathers at home. In order to further analyze the peer effect of parental care on adolescent drinking behavior, students were divided into two groups: neither parent is at home (NH) and father at home (FH). In the NH and FH groups, peer drinking significantly affected adolescent drinking behavior, and the peer effect coefficient in FH group was more than that in NH group. Without parental care, adolescents are more likely to be influenced by peer drinking, and adolescents who had peers who drank alcohol has a 22.3% point higher probability than those who had peers who did not. However, in the FH group, although the weak instrumental variable test fails due to too few samples, the result is still significant.

4 Discussion

This paper aimed to estimate the peer effect of drinking on adolescent drinking behavior in China, using the drinking behaviors of peers' fathers and their beliefs about the health risks of alcohol as

instrumental variables. The main findings of this paper are as follows:

Firstly, peer drinking significantly influences adolescent drinking behavior, with adolescents who have peers who drink alcohol being 10.5% points (c.f. the coefficient of $Drink_{peer}$ in Table 3, which is 0.105 and is both economically and statistically significant) more likely to engage in drinking compared to those without such peers. This effect is robust to different specifications and subsamples.

Secondly, the peer effect differs significantly between migrant and rural adolescents, left-behind and non-left-behind adolescents, and adolescents with different parental care situations. The peer effect is stronger for rural adolescents, left-behind adolescents, and adolescents whose parents work outside the home.

Finally, parental care plays a significant role in the degree of peer effect, with the absence of parental care being a key factor in the presence of the peer effect. Parental characteristics, such as age, education, and drinking behavior, also have significant impacts on adolescent drinking behavior.

These findings contribute to the existing literature on adolescent drinking behavior in several ways. First, this paper provides novel and rigorous evidence on the peer effect of drinking on adolescent drinking behavior in China, a country with a large and diverse population of adolescents and a high prevalence of underage drinking. Previous studies on this topic either have only identified the causal effect of peer drinking (51, 52), or have often relied on weak or questionable instrumental variables, such as school-average variables, to address the endogeneity problem. The consequence of omitting the dual-causality problem can lead to biased estimation. For instance, a study estimating the peer effect which overlooks such endogeneity problem yields a 22% effect of alcohol drinking probability increase by peer drinking behavior (53), which is nearly 2 times greater than our result:10.5%. This paper uses more powerful and valid instrumental variables, based on the detailed information of household background in the dataset, to overcome the endogeneity issue and obtain consistent and unbiased estimates of the peer effect.

Second, this paper highlights the importance of parental care in moderating the peer effect and influencing adolescent drinking behavior. Previous studies highlighted the importance of both parental monitoring and peer influence in adolescent alcohol use, with parental monitoring having an indirect effect on drinking behavior through its influence on peer use and tolerance (54). Another research found that adolescents with binge-drinking parents were more likely to increase their own drinking regardless of the level of peer drinking (55). Our study claim that parental care is a crucial factor that affects the development and well-being of adolescents, especially in the context of rapid urbanization and industrialization in China, which have led to large-scale migration and separation of families. This paper shows that parental care can reduce the susceptibility of adolescents to peer influence and protect them from engaging in harmful drinking behavior. Parental characteristics, such as age, education, and drinking behavior, also have significant impacts on adolescent drinking behavior, suggesting that parents can serve as role models and sources of information and guidance for their children.

This paper also has some limitations, biases, or imprecisions that should be acknowledged and addressed in future research. First, this paper relies on self-reported data on adolescent and peer drinking behavior, which may be subject to measurement errors, reporting biases, or social desirability biases. For example, adolescents may underreport or overreport their own or their peers' drinking behavior due to fear of punishment, peer pressure, or impression management. Future research could use more objective and reliable measures of adolescent and peer drinking behavior, such as biomarkers, administrative records, or direct observations.

Second, this paper uses the best friend reported by the student as the proxy for the peer group, which may not capture the full range and diversity of peer influences that adolescents are exposed to. For example, adolescents may have multiple or changing best friends, or they may be influenced by other peers who are not their best friends, such as classmates, neighbors, or online friends. Future research could use more comprehensive and dynamic measures of peer groups, such as network data, social media data, or longitudinal data, to better understand the structure and evolution of peer relationships and influences.

Third, this paper focuses on the peer effect of drinking on adolescent drinking behavior, but does not examine the potential spillover effects of peer drinking on other outcomes, such as academic performance, mental health, or risky behaviors. Peer drinking may have positive or negative effects on these outcomes, depending on the nature and context of peer interactions and influences. For example, peer drinking may foster social bonding and emotional support, or it may impair cognitive functioning and increase impulsivity and aggression. Future research could explore the broader and longer-term consequences of peer drinking for adolescents and their families, communities, and society. The mechanisms of peer effect, such as social norms, peer pressure, parental monitoring, or parental communication can be further investigated.

5 Conclusion

This paper finds a significant peer effect on adolescent drinking behavior. Peer drinking significantly promotes adolescent drinking behavior. And the absence of parental care is increasing the peer effect.

As schools are a large part of society, especially for adolescents, schools should strengthen education and create a good environment for their students. Our results show that adolescent drinking is significantly influenced by their peers. School culture can directly affect peers. Therefore, the role of schools in educating people should be strengthened. Schools should hold moral education classes regularly to inculcate good drinking habits among adolescents. Regarding to the importance of parental care, among rural students, more attention should be paid to left-behind children, especially families in which both parents go out to work.

Schools should pay attention to left-behind children in rural areas, and establish a linkage mechanism between guardians and schools. Our results show that left-behind children in rural areas are more susceptible to peer behavior due to lack of parental care. Schools shall organize regular parent-teacher meetings to provide timely feedback to parents on the performance of adolescents in school. For parents who go out to work, schools should communicate regularly with parents through WeChat groups and phone calls. In terms of guardianship of left-behind children, schools, therefore, should collect feedback in a timely manner and establish a communication mechanism with guardians.

For the future studies, we mainly recommend researchers follow the following directions:

Firstly, expand the sample size and scope. The paper uses data from only four provinces in China, which may not be representative of the whole country. A larger and more diverse sample could increase the external validity and generalizability of the findings.

Secondly, use longitudinal data and dynamic models. The paper relies on cross-sectional data and static models, which may not capture the temporal and causal relationships between peer drinking, parental care, and adolescent drinking behavior. Longitudinal data and dynamic models could allow for tracking the changes and impacts of these variables over time.

Finally, explore the mechanisms and channels of peer and parental influences. The paper does not examine the underlying mechanisms and channels through which peer and parental influences affect adolescent drinking behavior, such as social norms, peer pressure, parental monitoring, or parental communication. Understanding these mechanisms and channels could help design more effective interventions and policies to prevent and reduce underage drinking.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by China Agricultural University Institutional Review Board. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

ML: Conceptualization, Data curation, Formal analysis, Methodology, Software, Visualization, Writing – original draft, Writing – review & editing. W-QZ: Conceptualization, Data curation, Formal analysis, Methodology, Software, Writing – original draft, Writing – review & editing. Q-RZ: Data curation, Investigation, Methodology, Resources, Writing – original draft. YW: Data curation, Investigation, Methodology, Resources, Writing – original draft. S-GL: Project administration, Writing – review & editing, Funding acquisition.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Effectiveness of online integrative trans-diagnostic treatment on internet addiction and high-risk behaviors in female adolescents with borderline personality disorder with comorbid depressive disorder

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Background: Based on research, borderline personality disorder is associated with many behavioral and emotional problems, including Internet addiction and high-risk behaviors. On the other hand, integrative trans-diagnostic treatment, by targeting trans-diagnostic factors in emotional pathology, is considered a suitable treatment for comorbid psychological pathologies. Also, since in adolescence, the opinion of others about oneself is more important, online therapy has the advantage of protecting them from the fear of stigma and shame in the face of others' judgments. Therefore, the aim of the current research was to investigate the effectiveness of online integrative trans-diagnostic treatment on the internet addiction and high-risk behaviors in adolescents with borderline personality disorder.

Methods: The current research was applied and quasi-experimental in a pre-test-post-test manner with a control group. The research sample included 40 female adolescents with borderline personality disorder who were randomly divided into two groups of 20 people, experimental and control groups. The criteria for entering the research included the age range of 12 to 18 years, female, confirmation of the disease by a psychologist, not receiving other psychological treatments in the last 3 months, and having a smartphone to participate in the online group. Substance abuse, any serious mental and physical illness/disorder that interferes with treatment, and failure to attend more than two sessions in therapy sessions were some of the exclusion criteria.The participants were tested on the scales of internet addiction and high-risk behaviors. Then, the treatment plan based on online integrative trans-diagnostic group therapy was presented to the participants of the experimental group online in 9 two-hour sessions. The control group was placed on the waiting list until the completion of the treatment sessions and the post-test implementation, and after the post-test implementation, they received the treatment. Then, their scores were measured, after completing the treatment, and a three-month follow-up period. Descriptive statistics and covariance test were used to analyze the data.

Results: Patients showed a clear improvement in the severity of internet addiction and high-risk behavior symptoms. So that the scores of internet addiction and high-risk behaviors in the experimental group after receiving the treatment, as well as after a three-month follow-up period, were significantly reduced ($p < 0.001$).

Conclusion: These results show that online integrative trans-diagnostic therapy can be an effective treatment option for reducing some symptoms of risky behaviors and internet addiction in adolescents with borderline personality disorder and should be studied further. It is noteworthy that the limitations of this study were the available sampling method, the use of a unisex sample of female patients, and the short-term follow-up period, which makes it difficult to generalize the results.

KEYWORDS

online integrative trans-diagnostic treatment, internet addiction, high-risk behavior, borderline personality disorder, adolescents

Introduction

The topic of discussing the clinical diagnosis of borderline personality disorder (BPD) in adolescents has been around for a while. Nonetheless, there is a lot of focus on this disease right now, and research supports the diagnosis and treatment of BPD in adolescents (1). Adolescent borderline personality disorder (BPD) is now acknowledged as a specific disorder requiring intervention and treatment (2). BPD has an internalized aspect including dissociative identity disorder, paranoid thoughts, and chronic feelings of emptiness. It also has an emotional aspect, i.e., emotional instability, and an externalized aspect including impulsivity, suicide, self-injury behaviors, and unstable interpersonal relationships (3). World Health Organization's extensive studies suggest that cluster B personality disorder patients are seven times more vulnerable to co-occurring mental disorders; so that, it has been estimated recently that 96% of BPD patients experience a type of functional or behavioral disorder in a period of their life (1, 4, 5).

The researches that have been conducted so far support the idea that some personality traits, such as borderline personality traits, are prominent in addictive behaviors, including Internet addiction (6) and various underlying and fundamental factors are common between these two disorders, among which impulsivity can be mentioned (7). Research has shown that people with borderline personality disorder use internet addiction as a way to cope with negative mood (8), reduce depressive symptoms (9) and reduce tension (10).

On the other hand, in the complex process of human growth and development, adolescence is more important, and in the meantime, research has shown that biological and social changes during adolescence are one of the prerequisites for the occurrence of various mental disorders including addictive behaviors (11). In this regard, the Adrenarche and Play systems, which are the biological prerequisites of adolescence, can easily interfere with each other and cause a disturbance in the balance of the brain and, as a result, make it more vulnerable to mental disorders (11).

The American Psychiatric Association has defined Internet addiction as a pattern of Internet use that leads to functional impairment and is accompanied by unpleasant internal states over a two-month period. To diagnose it, it has presented seven criteria (at least three criteria during 2 months): tolerance; withdrawal symptoms; The time of using the Internet will last longer than the person initially intends; persistent desire to control behavior; spending considerable time on Internet-related matters; Continued use despite being aware of its negative effects and reducing social, occupational and recreational activities as a result of using the Internet (12). In fact, Internet addiction is an impulse control disorder and a maladaptive pattern of Internet use that leads to significant discomfort or clinical disorder and creates psychological, educational, and occupational problems in a person's life. The prevalence of this is higher in the age group of 15 to 19 years compared to other age groups (13). Recent studies have shown that the prevalence of Internet addiction among young people, in different societies and cultures, has a wide variation between 1.6 and 30%, and the rapid increase in the number of Internet users has also increased the prevalence of Internet addiction (13).

Risky behavior is also another variable that is associated with symptoms of borderline personality disorder. Research has shown that various types of risky behaviors and risk-taking are common in adolescents with borderline personality disorder (14). Risky behaviors can be defined as behaviors that will have unfortunate consequences for the individual, family, and society. Risky behavior is anything which may put ourselves or others at risk of physical, mental, emotional harm or abuse. These behaviors are more prevalent especially in adolescence and youth and include a wide range of behaviors such as theft, improper nutrition, risky sexual relations, dangerous driving and similar behaviors (15).

Considering the comorbidity and common features of borderline personality disorder with Internet addiction and tendency to risky behaviors, it seems necessary to choose a suitable treatment with the aim of controlling the common underlying symptoms between them. Among the psychotherapy approaches, trans-diagnostic treatment offers many advantages, which make it a perfect choice for measuring the improvement of common symptoms (16). The Unified Protocol for Trans-diagnostic Treatment proposed by Barlow et al. addresses a series of common trans-diagnostic factors that play an effective role in emotional disorders (16). Therefore, this protocol is designed and prepared to treat unipolar mood disorder and anxiety disorder patients as well as other emotional disorders, and can compensate the lack of pathology and comorbidity of different emotional disorders (16). Trans-diagnostic treatment is a suitable alternative treatment, where it is not possible to make homogenous groups (17). This unified protocol focuses on three factors, i.e., "cognitions," "body sensations," and "emotional behaviors." These three factors are interrelated dynamically and each one of them plays an important role in an emotional experience (16).

Systematic reviews suggest that the unified trans-diagnostic therapy can contribute to the improvement of mental health, especially

in a wide range of anxiety and depression disorders (17). Generally, effectiveness of this protocol in treatment of emotional disorders has been confirmed by different randomized control trials, which have been reflected in recent systematic reviews (18, 19). Grossman & Ehrenreich-May showed that trans-diagnostic treatment can reduce anxiety and intense emotional moods in adolescents suffering emotional disorders (20). Sandin et al. also showed that this treatment can reduce symptoms of anxiety, depression, anxiety sensitivity, emotional avoidance, phobia disorder, panic disorder, inclusive anxiety, and major depression in adolescents (21).

In mental health clinics, BPD is a common disorder in adolescents, and 10% of patients, nearly 50% of inpatients, and more than 80% of adolescents who have attempted suicide are estimated to suffer this disorder (4). Prevalence of this disorder at medium level is estimated about 9% in boys and about 13% in girls in adolescence ages (22). In addition, recent studies have emphasized that after the corona pandemic, women are more vulnerable to mental disorders and their consequences (23). Generally, different effective face to face treatment methods are available for abnormal behaviors (24). However, in different societies, there are different limitations to access the respective specialists. Such limitations include believing that the treatment is not warranted or effective, stigma, shame, bad experience of previous mental healthcare providers, and financial problems (25). Such factors are more common among the adolescents, who care more about the others' opinion (26). This shows the importance of appropriate control and treatment, especially using online methods, for borderline personality disorder and related symptoms, especially behaviors in the adolescent age group. Accordingly, the present study aims to investigate the effectiveness of the online unified trans-diagnostic treatment approach in reducing internet addiction and high-risk behaviors in adolescents suffering borderline personality disorder.

Purpose of study

The hypotheses of this research include the following:

1. online integrative trans-diagnostic treatment reduces internet addiction in female adolescents suffering borderline personality disorder.
2. online integrative trans-diagnostic treatment reduces high-risk behaviors in female adolescents suffering borderline personality disorder.

Research method

The current research was applied research and quasi-experimental in the pre-test-post-test method with a control group.

Participants

The statistical population in the present study was adolescent girls suffering from borderline personality disorder with comorbid depressive disorder living in Shiraz in 2022–2023, whose disease was diagnosed by a psychiatrist/clinical psychologist. In order to achieve reliable results in experimental designs, the presence of at least 15 people in each group is recommended (27). Therefore, among the statistical population of the research, 40 people were selected as the sample size and using the available sampling method from the statistical population. This method is a non-probability sampling method whose criterion is access to sample people. Available sampling involves the use of participants who are suitable for the research (28). Since the participants of the current study include people with a specific disorder and also, the participants must be willing to participate in therapy sessions, so the best option for initial sampling from the statistical population was to use this method. In the following, in order to be in the conditions of the experimental research, the participants were randomly (using the simple random method and receiving the code) placed in two control and experimental groups.

The criteria for entering the research included the age range of 12 to 18 years, female, confirmation of the disorder by a psychologist, comorbid major depressive disorder with therapist diagnosis, not receiving other psychological treatments during the last 3 months, and having a smartphone in order to participate in the online group. Reluctance to participate in psychotherapy sessions, having psychotic disorders based on psychological examination, substance abuse, mental disability, any serious medical conditions interfering with treatment and absence of more than two sessions in therapy sessions were also the criteria for exiting the study. The flowchart of the participants is presented in Figure 1 at the end of the text.

Procedure

The participants were randomly divided into two groups of 20 people, experimental and control. First, the participants were tested on the borderline personality disorder scales for children and adolescents and the score in the upper quartile of this scale was the final basis for selecting people. Also, they completed the scales of Internet addiction and high-risk behaviors. Control variables in this study included gender, age (12 to 18 years) and having a comorbid depressive disorder. Then, the treatment plan based on online integrative therapy was presented to the experimental group participants in 8 two-hour sessions and the control group was placed on the waiting list until the completion of the treatment sessions and the post-test implementation, and after the post-test implementation, they received the treatment. In order to achieve fidelity to the treatment, a pilot implementation was carried out before the implementation of the research. All treatment steps were carried out completely and accurately, based on the protocol presented in the research. Also, a supervisor who is proficient in this therapeutic approach, continuously monitored the therapist's work process. After completing the treatment sessions of both groups, as well as after a three-month follow-up period, the participants were re-tested and the results were analyzed.

Statistical analysis

Group differences in demographic data were tested with independent samples t-test for continuous variable (age) and chi-square test for nominal variables (socioeconomic status). To

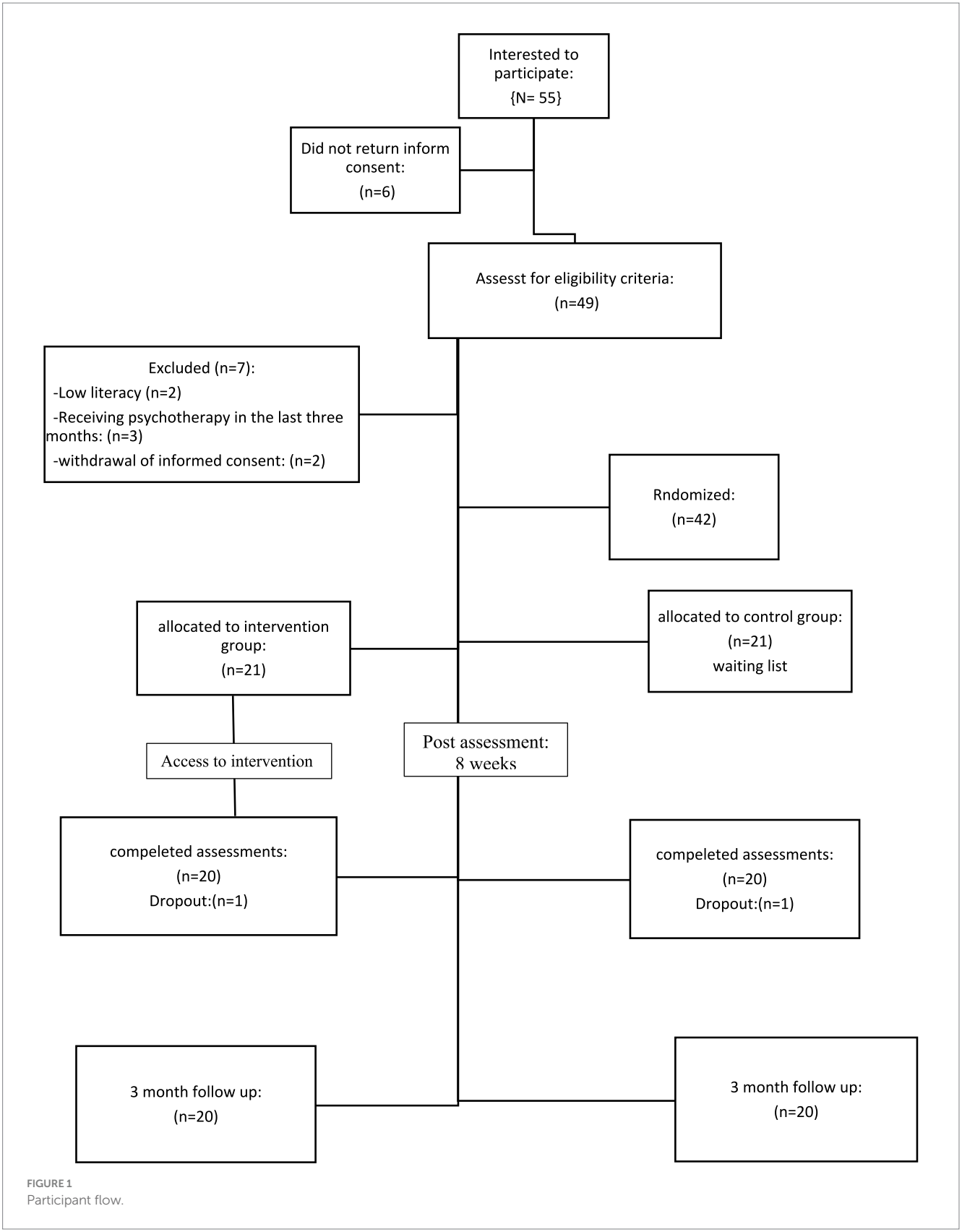

FIGURE 1
Participant flow.

analyze the present results, a linear model was used by predicting the scores after the intervention, controlling the scores before the intervention as a covariate. So, the differences in the results of treatment implementation were evaluated based on one-way analysis of variance (ANCOVA; To compare one dependent variable in two control and experimental groups), considering treatment conditions

as an inter-group factor. This approach includes the use of the covariance structure in the statistical control of hidden confounding variables, using the pre-test effect as the co-variate, and therefore, shows the best information indicators (29).

In order to achieve reliable results in experimental designs, the presence of at least 15 people in each group is recommended (27). Based on this, the current sample size was considered 15 people for each group.The evaluation of intra-group and inter-group changes due to the implementation of the treatment was compared in the control and experimental groups, and the follow-up evaluation was analyzed only for the intervention group and based on the post scores. Within- and betweengroup effect sizes (Cohen's d) were calculated based on estimated means and the pooled standard deviation from the observed means. Richards and Richardson report an averaged effect size of Cohen's d of 0.78 for guided interventions and of 0.36 for unguided interventions (30). Because guidance was used when requested, which could be considered between unguided and fully guided, a medium effect size of 0.50 was aimed. An error level of α 0.05 was also considered as a significance threshold (31). All analyses were performed in SPSS version 25.

Research tools

Borderline personality disorder scale for children and adolescents

This scale is a 24-item self-assessment tool designed to assess borderline personality traits in children aged 12 to 17 years (32). The questions are scored as a five-degree Likert scale, from 1 (never) to 5 (always). The adolescents were asked to score their feelings about themselves and others. Higher scores reflect sever borderline personality symptoms and lower scores reflect minimal symptoms (33). Internal consistency of this scale was 75% (32). Psychometrical specifications of this questionnaire were studied for the first time in Iran by Zargar et al. (34). Validity of this scale was verified using three methods, i.e., Confirmatory Factor Analysis, Concurrent Validity, and Criterion Validity; and reliability of the scale was verified using Cronbach's Alpha Correlation Coefficient. In this study, Cronbach's alpha is reported 0.84 for the overall scale.

Internet addiction scale

The Yang Internet Addiction Questionnaire (IAT) has twenty questions, and the respondent must answer each question on a six-point Likert scale including: never, rarely, sometimes, often, and always, ranging from zero to five. The range of scores of this test is from 0 to 100, with a score of 0 to 39 representing the average user. 40 to 69 indicates mild internet addiction and 70 to 100 indicates severe internet addiction. Also, Cronbach's alpha of this scale in Sweden and Korea is more than 0.9 and in the validity and reliability of this questionnaire in Iran, Cronbach's alpha was 0.88 (35).

Iranian adolescent risk-taking scale (IARS)

This scale was developed by Zadehmohammadi et al. and contains 38 questions that measure 7 subscales. The questions are scored on a 5-point Likert scale from completely disagree (1 point) to completely agree (5 points). The reliability coefficient of this scale using Cronbach's alpha is reported as 0.94, which indicates its good reliability (36).

Integrative trans-diagnostic treatment

Barlow et al.'s trans-diagnostic treatment has a different structure than the well-known cognitive-behavioral treatments. The latest version of this therapeutic approach is based on "therapeutic heading" instead of "therapeutic sessions." Each treatment chapter can take between one and several sessions, and based on the type of disorder, one chapter can take more time than other chapters. The recommended number of sessions, in general, is between 8 and 12 sessions and the suggested time of each session is between 50 and 60 min (16). Table 1 contains the goals and content of the meetings used in this research.

Results

The research sample included 40 female adolescents suffering from borderline personality disorder and depression. The average age of the participants in this research was 15.39 with a standard deviation of 2.14, and they were randomly assigned to two control and experimental groups. Student's t-test was used to measure the equality of two groups. The results showed that there is no significant difference between the two groups in terms of average age ($p = 0.563$; t28 = 0.461). In the present sample, all participants were single and in high school. Also, in order to measure the equality of two groups in socio-economic status, chi-square test was used. The results showed that there is no significant difference between the two groups in terms of this variable (Chi-square test = 1.219; $p = 0.549$). In Table 2, the descriptive statistics of the research variables are presented separately for the control and experimental groups.

In order to implement the research hypotheses, Kolmogorov–Smirnov test was first performed to check the normality of the data and Leven's test was also performed to check the equality of variances. Due to the fact that these two tests were not significant in any of the groups, therefore, the assumption of normality of data and equality of variances was maintained for all variables. Tables 3, 4 show the results of the Leven and Kolmogorov–Smirnov tests.

In examining the first hypothesis, the scores of borderline personality disorder, internet addiction and high-risk behaviors in the post-test were used as dependent variables and group (control, experimental) as independent variables, and their scores in the pre-test were used as covariate variables. Table 5 shows the effectiveness of the treatment on the post-test scores.

As shown in Table 5, there is a significant difference between the groups in the scores of internet addiction and high-risk behaviors in the post-test ($F = 117.02$, $p < 0.001$; $F = 58.416$, $p < 0.001$). This means that the scores of this scale in the post-test in the experimental group are significantly different from the control group and the effectiveness of treatment on these two variables was 68 and 62%, respectively.

Also, the scores of the participants after a three-month follow-up period were measured using the analysis of covariance test, the results of which can be seen in Table 6.

TABLE 1 Integrated meta-diagnostic treatment protocol.

Sessions	The aim of sessions/Content and techniques
Module 1	Increasing motivation to participate in treatment/Enhancing self-efficacy and belief in one's ability to successfully achieve change/ Principles and techniques of motivational interviewing
Module 2	Psychological training and search for emotional experience/Psychological training based on the nature and recognition of emotions, the main components of emotional experience and the concept of learned responses.
Module 3	Emotional awareness training/Learning to identify how to react to emotions and manage positive and negative emotions Mindfulness technique - emotional induction technique - paying attention to the here and now
Module 4	Cognitive assessment and reassessment/The role of cognitive maladaptive automatic evaluations in creating and maintaining emotional experiences, investigating cognitive distortions, methods of correcting maladaptive thinking Discussion technique and cognitive reasoning
Module 5	Emotional avoidance and behaviors caused by emotion/ Emphasis on the behavioral components of emotional experience and familiarity with different patterns of emotional avoidance and how to change the current patterns of emotional responses Discussion technique and psychological training
Module 6	Awareness of physical feelings and their tolerance/Identifying the role of physical feelings in thoughts and behavior and their mutual influence and increasing tolerance towards these feelings Innate exposure technique or visceral exposure
Module 7	Endogenous and situation-based emotional exposure/Providing the logic of dealing with emotion and emotional arousal, Psychoeducational techniques, gradual exposure
Module 8	Prevention of relapse/An overview of treatment concepts and discussion about the improvement and progress of the patient, identification of ways to continue the possible results of the treatment and possible future problems Discussion technique

TABLE 2 Mean and standard deviation of research variables in two experimental and control groups.

Variable	Group	Pre-test		Post-test		Follow up	
		Mean	S.D	Mean	S.D	Mean	S.D
Borderline personality disorder	Experiment	92.69	5.88	84.95	7.65	85.52	10.23
	Control	91.27	6.13	95.89	9.44	94.61	11.16
Internet Addiction	Experimental	111.61	10.74	87.41	14.12	85.32	15.48
	Control	113.52	11.24	114.98	13.56	113.67	16.27
High-Risk behaviors	Experimental	69.76	10.71	58.37	11.96	55.23	9.61
	Control	70.03	10.28	72.19	13.44	76.82	14.28

TABLE 3 Variance equality test.

Test	Variable	*F*	df1	df2	Sig.
Leven	Borderline personality disorder	1.204	4	26	0.310
	Internet addiction	1.382	4	36	0.291
	High-Risk behaviors	1.582	4	36	0.323

As can be seen in Table 6, the effects of treatment on the variables of internet addiction and high-risk behaviors remained after a 3-month follow-up period ($p < 0.001$).

Discussion

The purpose of this study was to investigate the effect of the integrative trans-diagnostic treatment approach on internet addiction and high-risk behaviors in adolescents suffering borderline personality disorder. According to the findings, during ten treatment sessions, internet addiction scores have decreased significantly. The findings obtained in this research are in line with other researches about the effectiveness of this therapeutic approach in reducing various emotional and behavioral disorders (17, 18, 20). Considering the fact that excessive effort to control the emotional experience in a negative cycle can lead to an increase in the initial excitement, more unsuccessful attempts to avoid and, as a result, maintaining the uncomfortable situation, the first skill proposed in this protocol is being aware of and accepting the excitement. Other central topics used

TABLE 4 Normality of the data test.

Test	Variable	*F*	df1	df2	Sig.
Kolmogorov–Smirnov	Borderline personality disorder	0.590	4	36	0.787
	Internet Addiction	0.564	4	36	0.761
	High-Risk behaviors	0.583	4	36	0.789

TABLE 5 The results of the covariance analysis of the difference in the average scores of the post-test in the experimental and control groups.

Variable	The source of variance	df	Mean of squares	*F*	*p*	Effect size
Borderline personality disorder	Group	1	1080.246	12.08	0/108	—
	Error	37	990.168	_		
Internet Addiction	Group	1	564.421	117.02	<0.001*	0.68
	Error	37	32.167	_		
High-risk behaviors	Group	1	376.584	58.416	<0.001*	0.62
	Error	37	37.267	_		

*$p < 0.001$.

TABLE 6 The results of the covariance analysis of the difference in mean follow-up scores in the experimental and control groups with pre-test control.

Variable	df	Mean of squares	*F*	*p*
Internet Addiction	27	587.268	122.397	<0.001*
Risky behaviors	27	395.672	61.025	<0.001*

*$p < 0.001$.

in this therapeutic approach include awareness of thoughts and cognition and helping to increase cognitive flexibility, facing external situations and using alternative strategies, facing bodily sensations and accepting and tolerating them (16). Negative emotions, such as depression, depend on cognition and behavior, and in this approach, regulating the emotions is the fundament of regulating cognitions and behaviors of a person. Additionally, accepting and being aware of emotions, without judging them, is another necessary skill for controlling emotions, which is also discussed in this approach (37).

In this method, management and regulation of emotions are emphasized that people with internet addiction have paid less attention to. On the one hand, Training to deal with negative emotions and cognitive reconstruction has caused a cognitive re-evaluation in adolescents suffering from internet addiction, and on the other hand, by reducing emotional suppression, it has removed the need for this group to express their emotions correctly. The result of this change in emotions and thoughts will be a behavioral change in the adolescent, which has already shown itself in the form of high-risk behavior and Internet addiction.

Another finding of this research indicated a decrease in the score of high-risk behaviors after receiving treatment with an integrative trans-diagnostic approach. This finding is also in line with the research conducted in this field (19, 21). In explaining this finding, it can be said that the integrative meta-diagnostic approach targets emotions and thus helps people to respond to them in a more adaptive way while facing their emotions. Based on this research logic, trans-diagnostic treatments have been designed and used to treat a wide range of disorders. Therefore, active participation in treatment, by trying to reduce subjectively experienced intolerable states, can help reduce the high risk behaviors in all categories of mental disorders. In other words, one of the reasons that can increase mental pressure in a stressful situation is intolerance and non-acceptance of negative emotions. One of the main goals in this therapeutic approach is to accept emotions and negative events as a part of human life. This type of treatment focuses on the adaptive and effective nature of emotions in general and without identifying a specific disorder, and therefore, it has shown supportive results in similar disorders. In addition, the main common points mentioned in emotional disorders include research evidence related to the high degree of concordance and diagnostic overlap and the generalization of therapeutic responses in these disorders (16). According to Barlow's approach, primary emotions have an adaptive nature, but these secondary reactions along with judgment to these emotions make them unbearable and maintain the negative cycle of emotions. Reactions that are critical and judgmental and based on information that is not relevant to the present (16). By targeting people's emotions and helping people to regulate their emotions, this therapy helps people learn to increase their tolerance for emotions, especially negative emotions, which is actually the underlying problem in people who engage in high-risk behaviors (38). Furthermore, another explanation that can be stated in this direction is the emphasis of integrated trans-diagnostic treatment on learning new and more adaptive behaviors in response to emotions, which actually, by teaching self-control of thoughts, reduces the person's involvement in the negative cycle of self-harm in response to the excitement of the experience, and replacing them with more adaptive behaviors.

This awareness about positive abilities and teaching how to use these abilities correctly can ultimately increase the flexibility of adolescents in choosing efficient and appropriate activities and solutions in stressful situations. In fact, the adolescent's power of

choice in doing different activities changes from focusing on negative activities to paying attention to abilities that have been hidden until now. By simply replacing positive behaviors and capabilities, this can reduce attention to risky and harmful activities and, as a result, increase the adaptation of adolescents in stressful situations. On the other hand, paying attention to self-confidence and self-esteem in adolescents increases their daring skills, and on this basis, adolescents can stand stronger against the temptation of their friends and peers in dangerous situations. Therefore, this treatment approach, from several different dimensions, can come into action and help the adolescent to reduce high-risk behaviors and internet addiction as a behavioral disorder.

In addition, empirical evidence and strong theoretical foundations indicate common factors in the fields of symptomology, psychological, physiological and social etiology in various emotional disorders. Also, the high comorbidity in mental disorders creates significant problems for conceptualization and treatment and challenges the treatment, including the difficulty of conducting therapeutic exercises, evaluating progress, and focusing on a problem at a particular time. In addition, evidence-based treatments often have common elements such as cognitive restructuring, which leads to repetition with different treatment goals (39). These common factors show the need to pay attention to treatment with a trans-diagnostic approach, especially in comorbid disorders (16).

Conclusion

In general, as mentioned, in borderline personality disorder, different emotional, cognitive and behavioral dimensions are involved (3). The focus of this research was on some of the behavioral disorders related to this group, including Internet addiction and high-risk behaviors in female adolescents. Overall, integrative meta-diagnostic treatment has been able to help improve behavioral symptoms in adolescents with borderline personality disorder by affecting symptoms of internet addiction and high-risk behaviors. Therefore, the current research has shown that the intervention based on the integrative trans-diagnostic approach can effectively help regulate emotions in adolescents with borderline personality disorder and replace maladaptive strategies of emotion regulation in the vicious cycle of emotional and psychological arousal of borderline personality disorder (including internet addiction and high-risk behaviors), to act as an effective treatment. In addition to this, the results of this research indicated that the use of treatment based on an integrative meta-diagnostic approach, in terms of time and cost savings, efficiency and effectiveness of implementation compared to other treatments that emphasize a specific structure can be a suitable option especially for signs and symptoms of comorbid disorders.

The meta-diagnostic approach to diagnosis and treatment has many practical advantages that can be considered a powerful option for measuring the improvement of common symptoms (16). Barlow et al.'s integrative transdiagnostic treatment protocol targets the set of common and transdiagnostic factors that cause emotional disorders, and therefore, it is designed and formulated for people with unipolar mood disorders and anxiety disorders with the ability to be applied to other emotional disorders as well. It can fill the gap of pathology and coexistence of different emotional disorders (16). Transdiagnostic treatment is a good option for treatment when homogeneous groups cannot be formed. Also, this treatment is considered the best option for patients whose symptoms do not complete any of the diagnostic criteria (17). Due to this, in the field of clinical psychology, this protocol can be used for the professional control and management of mental crises, as well as at the policy level for the training of healthcare personnel in similar situations.

It is worth mentioning that the implementation of treatment online has a lot to do with the type of treatment approach and exercises used in it. In this way, the techniques that can be implemented in the form of discussion or do not require extensive physical activities, are better applicable in online therapy. In the implementation of online therapy based on compassion, this therapeutic approach follows the same basic framework and only in some cases, more explanations are needed for the patient. In addition, the exercises used in it should be presented in a way that can be understood and implemented by the patients. Another fundamental difference in online implementation compared to face-to-face therapy is the greater emphasis on the principle of confidentiality, especially in group implementation. In other points, online implementation is almost similar to face-to-face therapy, and therefore, it can be expected that by following these points and strictly implementing the treatment protocol, the result will be similar to face-to-face therapy, as was also observed in the present study.

Limitations and future research

While applying the findings of the present study, one of the limitations of this study was the available sampling method, the use of a unisex sample of female patients, and the short-term follow-up period, which makes it difficult to generalize the results. It is noteworthy that the current statistical procedure does not control for the effect of attrition (dropouts), and that future studies should consider following an Intention to Treat (ITT) analysis. In addition, it should be noted that the use of online methods to treat Internet addiction must be carefully considered precisely because of the risk of encouraging what one would like to reduce.

It is suggested that in order to develop the findings of the current research, male samples should be used. Furthermore, in order to evaluate the stability of grades, long-term follow-up periods should be measured. In addition, using a mixed sample size, examining the effectiveness of treatment on other age groups, and considering other mental disorders with high comorbidity with borderline personality disorder will greatly contribute to the development of knowledge in this field.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

Ethics statement

The studies involving humans were approved by Shiraz University Ethical Committee under approved N: IR.US.PSYEDU.REC.1402.027. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed

consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

FM: Writing – original draft, Writing – review & editing. NM: Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Social media addiction, escapism and coping strategies are associated with the problematic internet use of adolescents in Türkiye: a multi-center study

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Introduction: The literature highlighted that problematic internet use can have detrimental consequences on individuals' well-being. Social media addiction, escapism and coping skills are closely related to problematic internet use. However, no study has currently examined the relationship between problematic internet use and social media use, escapism and coping skills.

Method: This multicenter cross-sectional designed study evaluated the relationships between problematic internet use and social media addiction, escapism, and coping skills in 508 adolescents (319 female) aged 14-18 years. In order to collect data, sociodemographic data form, Internet Addiction Scale, Social Media Addiction Scale, Escapism Scale and Kidcope Adolescent Version have been used. First, adolescents who scored ≥50 on the Internet Addiction Test were classified as the problematic internet use group; adolescents who scored <50 were classified as the control group. Then, the relationships between problematic internet use and social media addiction, escapism and coping skills were evaluated.

Results: The results showed that problematic internet use was associated with duration of social media use, impairment in social media-related functionality, preferring virtual life, and virtual pleasure, escapism, avoidant and negative coping strategies.

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Conclusion: These findings may provide an empirical basis for problematic internet use prevention and intervention in adolescence.

KEYWORDS

problematic internet use, social media addiction, prefering virtual life, virtual pleasure, escapism, coping strategies

Introduction

Problematic internet use is defined as individuals excessively and uncontrollably using the internet, resulting in adverse effects on their daily life functioning (1). This pattern of use signifies a shift from primary social and personal responsibilities to a state of neglect or even danger. Problematic internet use is commonly associated with negative outcomes, such as social isolation, occupational or academic underachievement, psychological distress, family problems, and physical health issues (2).

The prevalence of problematic internet use can vary across countries and age groups (3–5). Nevertheless, numerous research studies emphasize that this issue is becoming an increasing public health concern (6). A score of 50 or higher on the Internet Addiction Scale is typically considered an indicator of problematic internet use (7–9). The variations in problematic internet use prevalence across studies using the same instrument, like the Internet Addiction Scale, can be attributed to cultural differences, demographic factors, methodological variations, the evolving nature of technology, and individual psychosocial factors (10). Different populations may have varying degrees of exposure to and reliance on the internet. Age groups may have distinct patterns of internet use, with younger individuals typically more immersed in online activities. As a result, prevalence rates might vary across age groups. The criteria for problematic internet use may be interpreted differently in various cultural contexts. For example, what is considered excessive internet use or addiction in one culture might be perceived as normal or acceptable in another.

Problematic internet use can significantly impact an individual's physical, mental, and social well-being, posing a threat to the general welfare of society (11, 12). Excessive internet use can lead to social isolation, strained interpersonal relationships, and decreased face-to-face interactions. This withdrawal from real-world social interactions may contribute to weakened social bonds, impacting community cohesion. Consequently, the societal impact of PIU stems from its potential to disrupt normal social dynamics, impair individual well-being, and contribute to broader issues such as decreased productivity and the deterioration of social relationships. Therefore, it is crucial for public health policies and treatment approaches to address this issue. Research and awareness-raising efforts can help individuals and families understand the risks associated with problematic internet use and contribute to the implementation of measures aimed at mitigating its effects (12).

Problematic internet use may relate to issues such as being addicted to social media, seeking escapism, and relying on certain coping mechanisms (13–16). Social media platforms provide an appealing avenue for individuals to satisfy their need for escapism, as users can adopt different identities or lifestyles in the virtual world. When this escape mechanism is employed to cope with emotional and psychological challenges, individuals may retreat from real-life problems, leading to problematic internet use. Furthermore, this behavior may undermine coping skills, as individuals may tend to use the internet as an escape route instead of addressing real-life issues (13). In this context, understanding the complex interplay between social media addiction, escapism, and problematic internet use is crucial for developing effective intervention strategies.

Despite numerous separate studies in the literature, there is a notable absence of research that concurrently investigates the relationship between problematic internet use, social media use, escapism, and coping skills within the same sample or a similar population. Given the potential variations in the prevalence of problematic internet use and its diverse clinical presentations/features (social isolation, academic or occupational impairment, psychological distress, sleep disturbances, neglect of basic needs, risk of cyberbullying, and financial consequences etc.), there is a pressing need for research examining these factors together in the same study. Such research could provide valuable insights into the underlying biopsychosocial mechanisms of problematic internet use and establish a foundation for improving the treatment and prevention approaches for this addiction. Filling this gap is an important step towards better understanding the effects of problematic internet use and enhancing the overall well-being of society.

Method

Setting and sample

This cross-sectional and multicenter (n=6) study was conducted between June and October 2023. Before starting the study, ethical approval was obtained from Atatürk University Faculty of Medicine Clinical Research Ethics Committee. Children aged 14-18 years and their families who were studying in high schools located in the study centers were informed by school staff. An informed consent form

was filled out by the children and their parents who agreed to participate in the study. The following inclusion criteria applied: (a) the school board grants permission for the research; (b) participants are between the ages of 14 and 18; (c) written consent from adolescents and their parents stating that they agree to participate in the study. The data collection phase of the study was carried out in selected schools between June 2023 and October 2023. The administrators of the identified schools were informed about the study. At the designated times, the scales to be used in the study were distributed to adolescents accompanied by the responsible researcher of the province and a teacher. The children were asked to fill in the sociodemographic data form, Internet Addiction Scale, Social Media Addiction Scale, Escapism Scale and Kidcope Adolescent Version. Six provinces located in the northern, central, eastern regions of Turkey were included to represent various major geographical regions in Turkey to reduce sampling biases associated with single field surveys and to increase sample representativeness. The high schools were selected from schools in provinces using the simple random selection method. Adolescents in randomly selected schools were again selected using simple random sampling technique. The number of participants in each center was determined by weighting according to the population size of each province. In order to increase the reliability of this study, which was conducted on 3755446 children registered in the national education system of the provinces, the researcher aimed to reach at least 500 adolescents, which is well above the number required to represent the country, based on power analysis (The sample size was calculated to be 369 students as calculated using the Open EPI program.). The sample of the study consisted of 508 adolescent between the ages of 14-18 who were attending high school in Erzurum, Sivas, Malatya, Konya, Trabzon and Giresun provinces.

Measures

Sociodemographic Data Form: Through this form, data such as adolescents' gender, age, parental education level, family income level, social media usage status and daily social media usage time were collected.

Internet Addiction Test (IAT): The scale was developed by Young et al. in 1998. It is adapted from the "Pathological Gambling" criteria of DSM-IV and used to define the level of internet addiction. In the IAT, individuals are asked to rate how often they experience certain situations on a six-point Likert-type scale ranging from "never" to "always". In this 20-item scale, higher scores indicate an increase in the severity of internet addiction. A score between 20-49 points indicates normal internet use and a score above 50 points indicates possible problematic internet use (17). The Turkish version of the scale was adapted by Bayraktar et al. and Cronbach's alpha value was found to be 0.898 (18).

Social Media Addiction Scale (SMAS): The scale was developed by Orbatu et al., to measure social media addiction in adolescents in 2020. It is a 5-point likert and 13-item scale consisting of three sub-dimensions: impairment of functioning, preference for virtual life and enjoyment of virtual life. As the score increases, there is an assumption that the level of addiction is on the increase. The Cronbach's alpha value of the scale was found to be 0.869 (19). Escapism Scale: The scale developed by Gao et al. in 2017, consists of four items measuring escape from the real world by using internet services or applications on personal devices (e.g. Social networking sites help me forget about the real world, Social networking sites help me get away from the problems and pressures in my life, etc.) (20). The Turkish version of the scale was adapted by Kırcaburun et al. and Cronbach's alpha value was found to be 0.89. This form of the scale is a 7-point Likert-type scale and includes modified versions of the four items in the scale created by Gao et al. (e.g. Instagram helps me forget the real world, Instagram helps me get away from the problems and pressures in my life) (21). In our study, this scale was questioned not only for Instagram but also for social media use.

Kidcope Adolescent Version: It was developed to measure adolescents' coping styles by Spirito et al. (22). It is an 11-item, 4-point Likert-type scale with three subdimensions: active, avoidant, and negative coping. Active coping involves cognitive restructuring, emotional regulation, social support, and problem-solving skills. Avoidant coping includes distracting, social isolating, suppressed thinking, and withdrawal strategies. Negative coping involves self-criticism and blaming others. The scale measures how often these coping strategies are used, with higher scores indicating more frequent use (22). The Turkish version was adapted by Bedel et al. The Cronbach alpha internal consistency values for the active coping, avoidant coping, and negative coping subscales of the scale were 0.72, 0.70, and 0.65, respectively (23).

Data analysis

All statistical analyses were performed with SPSS for Windows Version 24.0. Adolescents who scored ≥50 on the IAT were classified as the "PIU" group; adolescents who scored <50 were classified as the "control" group. According to this classification, 253 (49.8%) of the 508 adolescents who participated in our study had problematic internet use, while 255 (50.2%) had normal internet use. Kolmogorov-Smirnov test was used to evaluate the conformity to normal distribution. Chi-square test was used to compare categorical data between PIU and control groups. Since the data were normally distributed, Student t test was used to compare numerical data. Pearson correlation analysis was used to assess relationships between variables, as the data were normally distributed. To identify possible risk factors for PIU, binary logistic regression analysis was used. The level of statistical significance was set at $p < 0.05$ for all of the analyses.

Results

In our study, we first identified the groups with and without PIU according to IAT score. We compared these groups in terms of descriptive characteristics such as sociodemographic data, the daily social media usage time and the time since starting to use social media. Social media addiction, escapism and coping scale scores

were then compared between the groups. In the PIU group, relationships between sociodemographic and descriptive characteristics and scale scores were analyzed. Finally, we performed logistic regression analysis to identify predictors of PIU.

There was no significant difference between PIU and control groups in terms of socio-demographic data such as gender, age, parental education level, family income, academic achievement, and social media use ($p > 0.05$). In the PIU group, the daily social media usage time and the time since starting to use social media were significantly higher (Table 1).

In analyzing the Social Media Addiction Scale scores, all subscale scores (impaired functioning, preference for virtual life, virtual pleasure) were significantly higher in the PIU group. Escapism scale score was significantly higher in the PIU group. When coping scale scores were evaluated, avoidant coping and negative coping scores were significantly higher in the PIU group. Scores on the active coping subscale were not significantly different between groups (Table 2).

In the PIU group, there was a positive correlation between the IAT total score and the daily social media usage time, all subscale scores of social media addiction, escapism total score, and Kidcope avoidant and negative coping subscale scores (Table 3).

According to the results of logistic regression analysis, it was observed that the duration of social media use over seven hours, high scores on the functional impairment and social life preference subscales of the social media addiction scale, high scores of escapism and negative coping strategies predicted the development of PIU (Table 4).

TABLE 1 The sociodemographic data of the sample.

	PIU Group n=253	Control Group n=255	t/Z/X^2	p value
Age	15.67 ± 1.24	15.66 ± 1.19	0.037	0.971
Gender				
Gender Girl Boy	 155 (61.3%) 98 (38.7%)	 164 (64.3%) 91 (35.7%)	 0.505	0.477
Mothers' education (year)	10.41 ± 3.94	10.23 ± 4.15	0.479	0.632
Fathers's education (year)	12.0 ± 3.49	11.53 ± 3.68	1.347	0.179
Family income			5.333	0.069
Low	15 (5.9%)	25 (7.7%)		
Middle	64 (25.3%)	76 (27.6%)		
High	174 (68.8%)	154 (64.7%)		
Academic achievement			3.065	0.216
Low	28 (11.1%)	23 (9.1%)		
Medium	147 (58.1%)	135 (47.9%)		
High	78 (30.8%)	96 (37.8%)		
Social media use			0.471	0.595
Yes	238 (94.1%)	236 (92.5%)		
No	15 (5.9%)	1987.5%)		
Daily social media usage time			19,044	**<0.001**
less than 1 hour	19 (7.5%)	37 (14.6%)		
1-3 hours	108 42.7%)	124 (48.8%)		
4-6 hours	93 (36.8%)	83 (32.7%)		
7 hours and more	33 (13%)	10 (3.9%)		
Time since social media use			9,001	**0.029**
less than 1 year	18 (7.1%)	21 (8.2%)		
1-3 years	104 (41.1)	124 (48.6%)		
4-6 years	93 (36.8)	92 (36.1%)		
7 years and more	38 (15%)	18 (7.1%)		

PIU, Pathological internet using Bold data, p<0.05 (signifcance).

TABLE 2 Comparison of IAT, SMAS, Escapism and Kidcope scales between the PIU group and the control group.

	PIU Group n=253	Control Group n=255	t/Z/X^2	p value
SMAS				
Impairment in functionality	15.26 ± 5.12	11.25 ± 4.01	9.831	**<0.001**
Preferring virtual life	14.98 ± 5.20	10.79 ± 4.35	9.856	**<0.001**
Virtual pleasure	5.74 ± 2.95	4.43 ± 2.51	5.382	**<0.001**
Escapism total scores	3.79 ± 1.9	2.57 ± 1.51	7.926	**<0.001**
Kidcope				
Active Coping	5.83 ± 2.65	5.97 ± 2.51	-0,584	0.559
Avoidant Coping	6.98 ± 2.59	6.16 ± 2.34	3.777	**<0.001**
Negative Coping	3.83 ± 2.05	2.77 ± 1.79	6.211	**<0.001**

PIU, Pathological internet using; IAT, Internet addiction test; SMAS, Social media addiction scale Bold data, p<0.05 (signifcance).

TABLE 3 Correlations between IAT, SMAS, Escapism and Kidcope scales in the PIU group.

Scales		Daily social media usage time	IAT total scores	SMAS Impairment in functionality	SMAS Preferring virtual life	SMAS Virtual pleasure	Escapism total scores	COPE Active Coping	COPE Avoidant Coping	COPE Negative Coping
Daily social media usage time	r	–								
	p									
IAT total scores	r	.215	–							
	p	**.001**								
SMAS Impairment in functionality	r	.083	.349	–						
	p	.186	**<.001**							
SMAS Preferring virtual life	r	.117	.451	.328	–					
	p	.062	**<.001**	**<.001**						
SMAS Virtual pleasure	r	.094	.146	.243	.305	–				
	p	.137	**.020**	**<.001**	**<.001**					
Escapism total scores	r	.043	.192	.249	.309	.295	–			
	p	.497	**.002**	**<.001**	**<.001**	**<.001**				
Kidcope Active Coping	r	-.047	-.084	-.001	-.009	.066	.003	–		
	p	.460	.181	.984	.886	.297	.961			
Kidcope Avoidant Coping	r	-.058	.179	.102	.328	.059	.199	.194	–	
	p	.353	**.004**	.106	**<.001**	.350	**.001**	**.002**		
Kidcope Negative Coping	r	-.013	.292	.249	.169	.183	.246	-.068	.124	–
	p	.835	**<.001**	**<.001**	.007	.003	**<.001**	.281	**.048**	

PIU, Pathological internet using; IAT, Internet addiction test; SMAS, Social media addiction scale; r, Pearson correlation coefficient Bold data, p<0.05 (signifcance).

TABLE 4 Logistic regression analysis results for PIU.

Independent variables	OR	95% CI	p value
Age	.902	.754 -1.080	.262
Gender (reference: female)			
Male	1.645	1.036-2.612	.135
Daily social media usage time (reference less than hour)			
1-3 hours	1.474	.731 -2.971	.278
4-6 hours	1.438	.692-2.990	.330
7 hours and more	5.686	1.953-16.559	**.001**
Time since social media use (reference less than 1 year)			
1-3 years	.844	.381-1.869	.675
4-6 years	.899	.397-2.035	.798
7 years and more	1.260	.441-3.601	.666
SMAS Impairment in functionality	1.110	1.056 – 1.166	**>.001**
SMAS Preferring virtual life	1.134	1.072-1.199	**>.001**
SMAS Virtual pleasure	1.006	.925 -1.094	.884
Escapism total scores	1.201	1.049 -1.374	**.008**
Kidcope Avoidant Coping	1.010	.921-1.107	.836
Kidcope Negative Coping	1.178	1.049- 1.322	**.006**

PIU, Pathological internet using; SMAS, Social media addiction scale; OR, Odds Ratio; CI, Confidence interval Bold data, p<0.05 (signifcance).

Discussion

In this study, the relationships between problematic internet use and social media addiction, escapism and coping skills in adolescents were evaluated. To the best of our knowledge, no previous study has done this. In the PIU group, impaired functioning associated with social media addiction, preferring virtual life, virtual pleasure, escapism, avoidant and negative coping were significantly higher. In the PIU group, the severity of PIU increased as all these variables increased. Social media use for more than seven hours a day, impaired social media-related functioning and preferring virtual life, escapism and negative coping predicted the risk of PIU. This research has implications for the conceptualization of PIU in adolescents.

PIU and social media addiction

Studies have shown that there is a positive relationship between the duration of social media use and PIU (24, 25). Furthermore, social media use has been shown to be a predictor for IA (26, 27). In a study investigating the determinants of IA onset and persistence among adolescents, online activities, such as social media use, were found to be important determinants of IA onset and persistence (28). In a study evaluating IA risk factors among adult students, social media use was found to increase the risk of IA the most among all online activities (29). Social media use was found to increase the risk of IA by 3.2% in a study that evaluated risk factors for IA in adolescents (30). In our study, in line with the literature, we found that the duration of daily social media use was higher in the PIU group, the severity of problematic internet use increased as the time spent on social media increased, and the time spent more than seven hours predicted the development of PIU. We also found that impaired functioning, preference for virtual life and virtual pleasure associated with social media addiction were higher in the PIU group, the severity of problematic internet use increased as these variables increased, and these variables (except virtual pleasure) predicted the development of PIU. Although there are studies suggesting that social media addiction (SMA) is not a true addictive behavior but a secondary condition that emerges as a coping mechanism for negative life events (31), most studies show that SMA is a clinical condition and leads to impaired functioning (32–34). Despite these different views, there is a consensus that it is increasingly important to better understand the clinical features of SMA and PIU and that this should be based on criteria that do not risk over-pathologizing daily life habits (32, 34).

At this point, in addition to assessing the symptoms of social media addiction, assessing also functional impairment, which is a key criterion in many mental disorders, including gaming and gambling disorders (35) becomes important. To the best of our knowledge, no study has evaluated the relationship between problematic internet use and impairment in functionality associated with social media addiction. Our results that impairment in functionality associated with SMA increases the severity of PIU and predicts PIU suggest that it may be useful to evaluate the effect of risky behaviors related to social media on daily life and functionality in the prevention and management of PIU and to include them in the intervention plan. Social media facilitates social networking and interpersonal relationships and is preferred by people as a more comfortable social environment due to its nature that does not have many of the difficulties encountered in face-to-face communication. However, despite these advantages, studies have shown that a tendency to have more online friends and a preference for online communication are associated with an increased risk of IA (36, 37). This result is consistent with the result in our study that preferring virtual life is associated with PIU. Research has shown that communication pleasure is the strongest predictor of IA (38). It has been suggested that SMA, one of the most commonly used Internet applications for communication pleasure, is a risk factor for IA (29). In our study, the increase in the severity of PIU as the virtual pleasure associated with social media increases seems to be consistent with the literature. Our results suggest that in PIU assessment and intervention, there is a need for a better characterization of SMA and for specific counseling programs for SMA. Specifically considering the factors that predict PIU, such as social media use over 7 hours, impairment

in functionality associated with SMA and preferring virtual life, we suggest that it would be important for intervention programs to cover the following points: Determine the time limit rather than whether or not to use social media, evaluate the impact of social media use on adolescents' daily lives and adolescents' motivation to use social media (preferring virtual life for communication, virtual pleasure, etc.) and developing specific solution skills for them.

Escapism and PIU

Studies have shown a relationship between escapism and PIU (39, 40). A study examining escapism and internet addiction in senior high school students showed that psychological distress increased the tendency to escapism and escapism increased the tendency to internet addiction, causing negative effects on the individual's daily life. The authors described this relationship as the Escapism-Addiction model (15). In a study conducted in university students, escapism was shown to mediate the relationship between emotional dysregulation and PIU (41). In our study, the escapism scale was used for social media use. In the PIU group, the level of escapism was higher. As the severity of escapism increased in the PIU group, the severity of problematic internet use also increased. In addition, higher escapism was predictive for PIU. Moreover, in the PIU group, escapism was positively associated with impaired social media-related functioning, preference for virtual life, and virtual pleasure. Thus, both SMA itself and escapism, the use of social media to alleviate emotional distress, increase PIU. Because of the role of escapism as an initiator, amplifier, and reinforcer of addictive behaviors, we believe it is very important to address escapism in PIU prevention and intervention.

Although escapism and avoidant coping are separate constructs, they are closely related. In the literature we noticed that escapism studies have been conducted specifically in the context of Internet gaming disorder, and the terms escape and avoidance are often used interchangeably. The researchers argued that if the meaning of these constructs is not communicated clearly enough, the interpretation of the findings will be difficult. Therefore, they suggested that the nature of escapism, especially as an avoidant coping strategy, should be clearly defined (42). In our study, while escapism refers to the use of social media to escape from reality, avoidant coping means that the individual uses coping strategies such as trying to forget the problem by doing other things, trying to solve the problem by staying alone, wishing the event had never happened, and trying to accept the situation by thinking that there is nothing else to do. Although they are closely related constructs, there is no research in the literature that examines the relationship between escapism and coping skills in PIU and the effect of these two constructs together on PIU. Therefore, we included coping skills including avoidant coping as well as escapism in our study.

PIU and coping style

Many studies have investigated the relationship between coping strategies and internet addiction. Most of this research suggests that Internet addiction is associated with more negative coping and fewer positive coping strategies (43, 44). It was observed that the term negative coping strategies has different meanings in the literature and covers different strategies depending on the measurement tool used. In some studies, avoidance and negative coping strategies were evaluated separately; in others, both strategies were combined under the umbrella of negative coping and reflected a general statement. In a study examining Internet addiction, psychological distress, and coping responses, coping responses were categorized as maladaptive (rumination and acting out) and adaptive (resiliency, seeking social support, and self-care). This study has shown that high levels of rumination and low levels of self-care are the main factors that contribute to the development of IA in adolescents (13). In a study examining the moderating role of coping style in Internet addiction among adolescents, coping style was assessed on two dimensions: positive (e.g., "trying to find several different solutions") and negative ("imagining that miracles will happen and the current situation can change"). In this study, negative coping was found to be positively associated with IA, and adolescents who used more negative coping strategies were more likely to develop IA (45). Negative coping styles, including self-blame, fantasy, and avoidance, were found to play an important role in IA in a study that examined negative life events, negative coping styles, and IA in middle school students (46). In line with the literature, we found that the PIU group used avoidant coping strategies (trying to forget by doing other things, trying to solve the problem by staying alone, wishing the event had never happened, trying to accept the situation by thinking that there was nothing else to do) and negative coping stretegies (blaming oneself by thinking that the problem was caused by oneself, blaming others for the problem, shouting and harming the environment by expressing anger) more frequently. Avoidant and negative coping skills were positively associated with PIU severity. In addition, negative coping skills predicted the development of PIU. In addition to other studies, we found in the PIU group that avoidant and negative coping were associated with escapism, and avoidant coping was associated with a preferring virtual life. Adolescents who used more negative coping strategies were more likely to have PIU. This may be explained by the fact that, as shown in previous studies (47, 48) adolescents with PIU prefer to use the internet to distract themselves from problems by using negative coping strategies in case of stress because the internet provides them with more controllable conditions, unlike the uncontrollable nature of the real world. In other words, adolescents may consider internet use as a coping mechanism to get away from stressors. That both avoidant and negative coping were associated with escape in PIU group supports that PIU is a negative coping strategy. Davis's cognitive-behavioral theory of PIU suggests that this maladaptive coping strategy may lead an individual to spend more time online, to be attracted to the experience of being online, and to prefer virtual communication to face-to-face interpersonal communication (49). In our study, the result that adolescents who frequently used avoidant coping in the PIU group preferred more virtual life seems to be consistent with this theory. In addition to all these, our findings confirm

previous studies showing that maladaptive cognitions such as avoiding, maladaptive coping, or negative self-image are associated with addictive Internet use (50, 51).

Within the scope of the cognitive-behavioral treatment (CBT) of IA suggested by Young, it was emphasized that individuals' coping strategies and motivations for internet use should also be considered (52).

The findings presented in this study confirm the necessity of addressing dysfunctional cognitions related to internet use in CBT for IA and applying cognitive restructuring for them. For example, an adolescent with PIU may believe that virtual communication with other people through social networking sites fulfills a social need without experiencing the stress-inducing effects of real interaction. The therapeutic process for this individual should include assessing the maladaptive cognitions that keep him/her online, and cognitive restructuring that allows him/her to see alternative places where he/she can meet his/her social needs in a more functional way. In this way, clinicians can consider coping strategies as a way to prevent or intervene in PIU.

There were several limitations to consider in the current study. We used adolescents' self-report measures to collect data, which may have led to bias. Future studies may include information from different information sources such as parents, teachers, etc. to strengthen the reliability of the findings. It was not possible to differentiate between specific activities related to the use of social media (e.g. social media used, e.g. instagram, facebook). Future studies should focus on the detailed examination of specific activities and addictive behaviors related to social media. Finally, due to the cross-sectional nature of the study design, causal relationships between variables could not be revealed. Therefore, a longitudinal research paradigm should be applied in future studies.

Conclusion

Despite these limitations, we concluded that our study is the first to concurrently examine the relationship between problematic internet use and social media addiction, escapism and coping skills. The current study suggests that assessment of social media addiction, escapism, and negative coping styles may be useful mechanisms for clinical formulations of PIU. In other words, our results will provide a better understanding of the PIU clinic, by providing information in terms of factors that may pose a risk for PIU, evaluating the motivations for internet use that may cause PIU, identifying negative coping skills and maladaptive thoughts that may be associated with PIU. These findings provide targeted and actionable practical references to formulate prevention and intervention strategies for PIU in adolescents. Setting time limits on adolescents' use of social media, determining their motivations for social media use (escape from the real world, preferring virtual life, virtual pleasure, etc.) and developing coping strategies may contribute to the prevention and intervention of PIU.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Ataturk University, Faculty of Medicine, Clinical Research Ethics Committee approval number: B.30.2.ATA.0.01.00/418). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

EY: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing. MA: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. AB: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – review & editing, Writing – original draft. BB: Conceptualization, Data curation, Investigation, Writing – review & editing, Writing – original draft. BT: Conceptualization, Data curation, Methodology, Supervision, Writing – review & editing, Writing – original draft. SA: Conceptualization, Data curation, Investigation, Methodology, Writing – review & editing, Writing – original draft. İU: Conceptualization, Data curation, Investigation, Methodology, Supervision, Writing – review & editing, Writing – original draft. EA: Conceptualization, Data curation, Investigation, Writing – review & editing, Writing – original draft. GY: Conceptualization, Data curation, Methodology, Supervision, Writing – review & editing, Writing – original draft. AÇ: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – review & editing, Writing – original draft. HF: Conceptualization, Data curation, Investigation, Methodology, Writing – review & editing, Writing – original draft.

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Predictor of smoking cessation among school-going adolescents in Indonesia: a secondary analysis based on the transtheoretical model of behavioral change

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Introduction: This study elucidates the complex journey of adolescents toward smoking cessation, investigating the association of relevant demographic factors, advertising, promotion, anti-cigarette messages, and individual knowledge and attitudes with being in different smoking cessation stages.

Methods: Utilizing data from the 2019 Indonesia Global Youth Tobacco Survey, this secondary analysis included adolescents who reported ever smoking. The Transtheoretical Model (TTM) guided the categorization of the outcome variable into three smoking cessation stages based on the responses to two questions related to the intention and timing of the smoking cessation. This included contemplation, action, and maintenance stages. Multinomial logistic regression analyzed the associations between each independent variable and being in each stage of smoking cessation. The study comprised 3596 Indonesian adolescents from grades 7-12, of which 2484 responded to two questions related to intention and timing of smoking cessation and were included in regression analysis.

Results: Findings indicate that males and those aged ≥16 were predominantly in contemplation phase. Early smoking initiation, usage of other tobacco products, and exposure to various forms of smoke increased the likelihood of being in contemplation and action phases. Parental smoking, school smoking exposure, and second-hand smoke were significant contemplation phase predictors. Exposure to tobacco advertising was linked to an increased likelihood of being in contemplation and action phases, whereas anti-cigarette messages showed no significant impact. Awareness of cigarette and second-hand smoke harms reduced the odds of being in the contemplation phase, while enjoying smoking and willingness to accept cigarettes from friends increased the odds of being in contemplation and action phases rather than in maintenance phase.

Conclusion: Addressing age, gender, cultural influences, environmental factors, and attitudes towards smoking through tailored interventions is vital for aiding smoking cessation in Indonesian adolescents. Strengthened tobacco control in

schools and public places is recommended to bolster these efforts. Longitudinal studies are required to explore the evolving patterns of smoking cessation behaviors over time, enhancing our understanding of the factors influencing sustained cessation.

KEYWORDS

tobacco smoking, adolescents, Indonesia, cigarette, predictor

Introduction

Tobacco use is a global public health concern, with over 1.3 billion people, accounting for 22.3% of the world population, using tobacco products in 2020 (1). The reports indicate a significantly higher prevalence in men (36.7%) than in women (7.8%) (1). In Southeast Asia, nearly 600 million smokers live within the region, with Indonesia having the third-highest number of tobacco users in the world (2). The impact of tobacco use is not limited to adults; it also affects younger generations. In 2022, more than 1 in 10 middle and high school students, approximately 3.08 million, had used a tobacco product during the past 30 days. This includes 16.5% of high school and 4.5% of middle school students (3). In Indonesia, the prevalence of smoking among Indonesian adolescents has been increasing during the last decades, with 19.2% of adolescents aged 13-15 reported ever using tobacco products in 2019 (4). Furthermore, 43.2% of Indonesian youths started to consume cigarettes when they were 12 to 13 years old (4). Adolescent smoking is a global epidemic, with over 50% of tobacco users being young people worldwide (5). The United States Department of Health and Human Services (USDHHS) has confirmed that teen smokers are at a higher risk of becoming addicted to nicotine and suffering from tobacco-related diseases such as respiratory and cardiovascular system damage (5). Thus immediate actions to address this issue are due and studies exploring the underlying drivers of such trends among adolescents are warranted.

Cigarette smoking among Indonesian adolescents is a pressing public health issue, with a variety of factors influencing their decision to smoke. Studies have identified that having friends who are addicted to smoking, being offered cigarettes, and having easy access to tobacco products are major contributors to the initiation of smoking in this demographic (6). Furthermore, the adolescent social environment plays a significant role, with peers exerting a major influence on changes in smoking behavior (7). Intergenerational smoking habits, where parental smoking behavior influences the offspring's attitudes and behaviors toward smoking, also contribute significantly to this issue (7). Despite various interventions, the prevalence remains high, necessitating innovative approaches to address this issue. The lack of implementation and enforcement of tobacco advertising bans and the general public's acceptance of tobacco advertising in Indonesia hampers effective tobacco prevention among adolescents (5). Addressing this problem requires a comprehensive understanding of these influencing factors and the development of targeted interventions that address the social and environmental factors contributing to adolescent smoking in Indonesia.

A noticeable gap in the existing literature is the lack of comprehensive analysis of factors that are associated with the stages of behavioral change, based on the Transtheoretical Model (TTM), related to smoking cessation among Indonesian adolescents. Despite the high prevalence of smoking among Indonesian adolescents, there is a lack of research on the factors that affect their decision to take action, quit smoking cigarettes, and maintain a smoke free life. The TTM is a theoretical framework that categorizes the stages of behavioral changes into five stages: pre-contemplation, contemplation, preparation, action, and maintenance (8). It offers a structured understanding of the internal and external factors influencing behavior change, making it apt for this study. Leveraging TTM, we categorized the smoking cessation behavioral changes into three phases including contemplation, action, and maintenance based on the available data from Indonesia Global Youth Tobacco Survey (GTYS) in 2019. We aimed to provide a nuanced understanding of the adolescents' journey towards smoking cessation, examining the relationship of different demographic factors, exposure to advertisement, promotion, and anti-cigarette messages, as well as participants' knowledge and attitudes with being in each stage of the process.

Materials and methods

Study setting

The Global Youth Tobacco Survey (GYTS), a component of the Global Tobacco Surveillance System (GTSS), is a global standard for systematically monitoring youth tobacco use (smoking and smokeless) and tracking key tobacco control indicators. In Indonesia, GYTS was conducted in 2019 by the National Health Research and Development (NHRD) under the Ministry of Health.

Participants and sampling

The Indonesian GYTS 2019 was a cross-sectional study undertaken in Indonesia's public and private schools to evaluate tobacco use among students aged 13 to 15 years old. The sample was categorized into three main regions: Java, Sumatra, and others.

Each region comprises 25 junior high schools and 25 high schools, amounting to a total of 150 schools spread across 30 provinces. Sampling was carried out in two distinct stages: initially, schools were chosen based on a probability proportionate to their size (PPS), followed by a random selection of classes from various schools in the second stage. The entire students from the selected classes were eligible to participate in the survey (9). The overall response rate was 91.0%. A total of 9,992 eligible students in grades 7- 12 completed the survey, of which 5,125 were aged 13-15 years. However; in this study, we included all the adolescents who participated in the survey who ever smoked (n=3596). However, of 3596 students who reported ever smoked, only 2484 students responded to both questions related to intention and timing of the smoking cessations that inform the construction of the outcome variable and therefore, included in the regression analysis.

Data collection

The interviewers initiated the data collection through a brief dialogue with the administrative authorities at the school, clarifying the specific class chosen for the study, with all its students capable of participating in the survey. The interviewing process is set to engage each student in the selected class and is estimated to last for 45 minutes. The research team has provided all necessary survey materials including questionnaires, answer sheets, and writing utensils for the students. Before distributing the questionnaires to the students, the interviewers provided clear instructions on how to properly complete the answer sheets and the questionnaire. All students and guardians were then provided with a consent form before the survey.

Variables

Dependent variable

The TTM theory is chosen to specify the smoking cessation stages in which there are five stages to behavioral changes; namely pre-contemplation (not thinking to stop smoking), contemplation (thinking to stop smoking in the next 6 months), preparation (thinking to stop smoking within the next 30 days), action (has stopped smoking in 6 months), and maintenance (has stopped smoking for more than 6 months) (8). We have used the responses to two questions "Do you want to stop smoking now?", representing the intention, and "How long ago did you stop smoking", representing the timing, to construct the smoking cessation variable including three categories coded as "0" contemplation (thinking to stop smoking but not stopped yet), "1" action (has stopped smoking for last 3 months), "3" and maintenance (has stopped smoking for more than 3 months). The choice of 3 months for defining the action and maintenance stages was shaped by the choices to corresponding questions in GYTS 2019.

Independent variables

The independent variables in this study were classified into three categories including *individual factors*, *environmental factors*, and *knowledge and attitude*. Details of selected variables and corresponding questions and alternative responses were provided in Appendix 1.

Individual factors

Age (<14, 14-16, >16), sex (male, female), pocket money (Indonesian Rupiah), age at initiation of cigarette smoking (<10, 10-13, >13), ever tried other tobacco products (such as chewing tobacco, betel leaf with cane, and betel nut with tobacco), ever tried Shisha, ever tried smokeless tobacco products, and ever tried e-cigarette.

Environmental factors

Parental smoking; School environment (witness someone smoking inside the school in last 30 days, witness someone smoking inside the school in last 30 days, ever witness teacher smoking in school); Second-hand tobacco exposure (exposure to second-hand smoke inside the home, and at indoor or outdoor public places in last 7 days); advertising and promotions (have seen cigarette ads on TV or social media, at events or sale centers in last 30 days, has got free/discounted cigarettes from cigarette companies, can buy of cigarettes near school); anti-cigarette messages (have seen or heard anti-cigarette messages on social media or events in last 30 days). All variables were coded as 0 "no" and 1 "yes".

knowledge and attitude

Awareness of cigarette or second-hand smoke harm; taught about tobacco harms in school in last year; cigarette smoking is joyful; willingness to use a cigarette if offered by a friend; support for smoking bans in outdoor or indoor public places.

Statistical analysis

Descriptive statistics were employed to describe the distribution of individual and environmental factors as well as knowledge and attitude toward cigarette smoking among Indonesian adolescents in grades 7–12 who reported ever smoking. Multinomial Logistic regression analysis was used to examine the association between independent variables with being in each smoking cessation stage. Prior to regression analysis, adherence to the proportional odds assumption, and ensuring an adequate sample size for each category of the dependent variable was assessed. The results were reported as relative risk ratio (RRR) and 95% confidence interval (95%CI). Age and sex, as the most influencing factors on smoking cessation behavior (10, 11), were accounted for in all multivariate analyses to allow us to measure the independent effect of each factor on being in each smoking cessation stage, regardless of the potential confounding effects of age and sex (9). This adjustment also aimed to mitigate bias introduced by missing data in responses to questions regarding intention and timing of smoking cessation, which inform the study outcome. Understanding the independent association of each independent variable with being in each smoking cessation stage will help in formulating targeted interventions and preventive strategies at the school level for all

students in grades 7–12 while providing valuable policy insight (10). Due to the complex sampling design in GYTS 2019, sampling design and weights were defined and applied in all analyses in STATA 17. The statistical significance level was set at $p< 0.05$.

Results

In the GYTS 2019, a total of 3,596 Indonesian adolescents in grades 7-12 reported ever smoking. Among them, 2,484 responded to two questions regarding their intention and timing of smoking cessation. Of these respondents, 18.89% were in the contemplation stage, 19.73% in the action stage, and 61.38% in the maintenance phase. The following individual, environmental, and knowledge, and attitude factors were associated with being in each stage of smoking cessation:

Individual factors influencing the smoking cessation behavior

Age

Table 1 describes the associated individual factors with smoking cessation behaviors among school-going Indonesian adolescents in grades 7-12th. The significant factors are listed below. Approximately 33.78% of participants were below 14 years, 51.67% were between 14 and 16 years, and 14.54% were above 16 years. Compared to the maintenance phase, adolescents aged 14-16 years showed a higher likelihood of being in the contemplation phase with an RRR of 2.29 (95% CI: 1.68, 3.11). However, this age group did not show a significant with being in the action phase (RRR: 0.90, 95% CI: 0.71, 1.14). Adolescents older than 16 years exhibited a markedly higher propensity to be in the contemplation phase (RRR: 5.50, 95% CI: 3.78, 8.02), but again, no significant difference was observed for being in the action phase.

TABLE 1 Individual factors influencing the behavioral changes in smoking cessation among school-going Indonesian adolescents in grades 7-12, GYTS 2019.

		Contemplation vs. maintenance	Action vs. maintenance
	N (%)	RRR (95%CI)	RRR (95%CI)
Age (years)			
<14	1126 (33.78)	–	–
14-16	1817 (51.67)	2.29 (1.68, 3.11)	0.90 (0.71, 1.14)
>16	653 (14.54)	5.50 (3.78, 8.02)	0.98 (0.67-1.44)
Sex			
Female	649 (15.14)	–	–
Male	2955 (84.86)	3.77 (1.72-8.26)	3.17 (2.16-4.66)
Age at cigarette initiation			
<10	758 (21.71)	–	–
10-13	1828 (56.98)	1.41 (1.01, 1.97)	2.13 (1.40, 3.25)
>13	805 (21.30)	4.63 (3.06, 7.01)	2.97 (1.91, 4.62)
Pocket money (rupiah) [1]			
<20000	1725 (48.05)	–	–
20000-40000	673 (18.67)	0.89 (0.70, 1.23)	0.96 (0.71, 1.28)
>50000	1200 (33.27)	1.06 (0.83, 1.37)	0.90 (0.66, 1.22)
Ever tried other tobacco products [1]			
No	2803 (79.83)	–	–
Yes	698 (20.17)	2.98 (2.20, 3.86)	1.66 (1.28, 2.15)
Ever tried smoking Shisha [1]			
No	2787 (76.86)	–	–
Yes	806 (23.14)	1.99 (1.48, 2.68)	1.59 (1.20, 2.12)
Ever tried smokeless tobacco products [1]			
No	3323 (94.57)	–	–
Yes	208 (5.43)	1.46 (0.91, 2.34)	0.69 (0.42, 1.13)
Ever tried e-cigarettes [1]			
No	1776 (51.35)	–	–
Yes	1827 (48.65)	1.92 (1.47, 2.51)	1.67 (1.27, 2.20)

[1]Adjusted for age and sex.

Sex

Ever smoked sample comprised 15.14% female and 84.86% male participants. Males were significantly more likely to be in both the contemplation (RRR: 3.77, 95% CI: 1.72-8.26) and action phases (RRR: 3.17, 95% CI: 2.16-4.66) compared to females.

Age at cigarette Initiation

Adolescents who initiated smoking between ages 10-13 and after 13 were more likely to be in the contemplation phase rather than in maintenance phase with RRRs of 1.41 (95% CI: 1.01, 1.97) and 4.63 (95% CI: 3.06, 7.01), respectively. Similarly, for the action phase, these groups showed increased likelihoods with RRRs of 2.13 (95% CI: 1.40, 3.25) and 2.97 (95% CI: 1.91, 4.62), respectively.

Pocket money

Adolescents with different levels of pocket money did not show significant differences in being in the contemplation or action phases when compared to those receiving less than 20,000 rupiahs.

Usage of Other Tobacco Products: Adolescents who had tried other tobacco products were significantly more likely to be in both the contemplation (RRR: 2.98, 95% CI: 2.20, 3.86) and action phases (RRR: 1.66, 95% CI: 1.28, 2.15) rather than in maintenance phase.

Shisha, smokeless tobacco, and E-cigarette

Similar trends to other tobacco products were observed for adolescents who had tried smoking Shisha, with increased likelihoods of being in the contemplation (RRR: 1.99, 95% CI: 1.48, 2.68) and action phases (RRR: 1.59, 95% CI: 1.20, 2.12). However, no significant difference was found for those who tried smokeless tobacco products. For e-cigarette usage, there was an increased likelihood in both the contemplation (RRR: 1.92, 95% CI: 1.47, 2.51) and action phases (RRR: 1.67, 95% CI: 1.27, 2.20) as compared to maintenance phase.

Environmental factors influencing smoking cessation behavior

Table 2 illustrates the association between environmental factors and smoking cessation behaviors among school-going Indonesian adolescents in grades 7-12th. The significant factors are listed below.

Parental smoking

Parental smoking showed a significant association with the contemplation phase of smoking cessation. Adolescents with parents who smoke were 1.5 times more likely to be in the contemplation phase rather than in maintenance phase (RRR = 1.50, 95% CI: 1.12 – 2.01). However, there was no significant association between parental smoking and being in the action phase of smoking cessation (RRR = 1.01, 95% CI: 0.78 – 1.31).

School environment

Adolescents who had witnessed teachers smoking in school were 1.7 times more likely to be in the contemplation phase (RRR = 1.70, 95% CI: 1.22 – 2.36) and 1.44 times more likely to be in the action phase (RRR = 1.44, 95% CI: 1.04 – 1.97) compared to those who had not. Similarly, witnessing someone smoking inside the school in the last 30 days was associated with an increased likelihood of being in both the contemplation (RRR = 1.43, 95%

TABLE 2 Environmental factors that influence the behavioral changes in smoking cessation among school-going Indonesian adolescents in grades 7-12, GYTS 2019.

		Contemplation vs. maintenance	Action vs. maintenance
	N (%)	RRR (95%CI) [1]	RRR (95%CI) [1]
Parental smoking			
No	1773 (52.41)	-	-
Yes	1628 (47.59)	1.50 (1.12, 2.01)	1.01 (0.78, 1.31)
Ever witnessed a teacher smoking in school			
No	1011 (34.38)	-	-
Yes	2044 (65.62)	1.70 (1.22, 2.36)	1.44 (1.04, 1.97)
Witness someone smoking inside the school in the last 30 days			
No	2294 (62.95)	-	-
Yes	1286 (37.05)	1.43 (1.13, 1.82)	1.31 (1.01, 1.71)
Have seen tobacco smoking on TV or in movies in last 30 days			
No	1223 (40.21)	-	-
Yes	1878 (59.79)	1.02 (0.79, 1.32)	0.85 (0.68, 1.06)
Exposure to second-hand smoke inside home in last 7 days			
No	1072 (29.06)	-	-
Yes	2529 (70.94)	1.87 (1.44, 2.43)	1.92 (1.37, 2.68)
Exposure to second-hand smoke indoors in public places in last 7 days			
No	771 (21.53)	-	-
Yes	2828 (78.47)	1.90 (1.31, 2.76)	1.33 (1.00, 1.77)
Exposure to second-hand smoke outdoors in public places in last 7 days			
No	741 (20.83)	-	-
Yes	2856 (79.17)	1.87 (1.33, 2.63)	1.30 (0.94, 1.78)
Have seen or heard anti-cigarette messages on social media in last 30 days			
No	860 (24.01)	-	-
Yes	2727 (75.99)	1.09 (0.78, 1.51)	0.92 (0.70, 1.21)

(Continued)

TABLE 2 Continued

		Contemplation vs. maintenance	Action vs. maintenance
	N (%)	RRR (95%CI) [1]	RRR (95%CI) [1]
Have seen or heard anti-cigarette messages on social events in last 30 days			
No	1030 (44.85)	-	-
Yes	1218 (55.15)	0.92 (0.71, 1.20)	1.24 (0.95, 1.61)
Have seen cigarette ads on TV in last 30 days			
No	725 (23.55)	-	-
Yes	2429 (76.45)	1.42 (1.06, 1.91)	1.35 (1.09, 1.67)
Have seen cigarette ads on social media in last 30 days			
No	1639 (54.47)	-	-
Yes	1435 (45.53)	1.39 (1.10, 1.75)	1.43 (1.15, 1.77)
Have seen cigarette ads at social events in last 30 days			
No	1389 (65.94)	-	-
Yes	705 (34.06)	1.68 (1.26, 2.24)	1.61 (1.19, 2.17)
Have seen cigarette ads in sales centers in last 30 days			
No	950 (30.88)	-	-
Yes	2129 (69.12)	1.37 (0.98, 1.90)	1.04 (0.80, 1.35)
Has got free/discounted cigarettes from cigarette companies			
No	3187 (88.99)	-	-
Yes	401 (11.01)	1.64 (1.16, 2.32)	1.41 (0.97, 2.05)
Availability of cigarettes near school			
No	1735 (67.48)	-	-
Yes	870 (32.52)	2.48 (1.93, 3.19)	1.21 (0.93, 1.59)

[1]Adjusted for age and sex.

CI: 1.13 – 1.82) and action phases (RRR = 1.31, 95% CI: 1.01 – 1.71) rather than in maintenance phase.

Second hand tobacco exposure

Exposure to different second-hand smoke showed varying degrees of influence. Notably, exposure to second-hand smoke inside the home and in public places was significantly associated with being in both the contemplation and action phases. Specifically, exposure inside the home increased the likelihood of being in the contemplation phase by 87% (RRR = 1.87, 95% CI: 1.44 – 2.43) and the action phase by 92% (RRR = 1.92, 95% CI: 1.37 – 2.68).

Advertising and promotions

Exposure to cigarette ads on TV, social media, at social events, and in sale centers, as well as receiving free or discounted cigarettes from cigarette companies, were all significantly associated with an increased likelihood of being in both the contemplation and action phases of smoking cessation. The strongest association was observed for the availability of cigarettes near schools, with adolescents in this category being 2.48 times more likely to be in the contemplation phase (RRR = 2.48, 95% CI: 1.93 – 3.19).

Anti-cigarette messages

Exposure to anti-cigarette messages on social media or at social events did not show a significant association with being in either the contemplation or action phases.

Knowledge and attitude and their relation with smoking cessation behavior

Table 3 depicts the distribution and association of selected knowledge and attitude factors with smoking cessation behaviors among school-going Indonesian adolescents in grades 7-12th. The significant factors are listed below.

Awareness of cigarette smoke harm

A majority of the adolescents who ever smoked were aware of the harms of cigarette smoke (89.54%). The RRR showed that those with awareness were significantly less likely to be in the contemplation phase rather than in maintenance phase of smoking cessation (RRR = 0.65, 95% CI: 0.44, 0.95). However, there was no significant association between awareness of cigarette smoke harm and being in the action phase of smoking cessation (RRR = 0.94, 95% CI: 0.68, 1.31).

Awareness of second-hand smoke harm: A significant majority of adolescents who ever smoked (92.51%) were aware of the harms associated with second-hand smoke. Those aware were significantly less likely to be in both the contemplation (RRR = 0.36, 95% CI: 0.26, 0.51) and action phases (RRR = 0.61, 95% CI: 0.38, 0.97) rather than in maintenance phase.

Taught about tobacco harms in school in last year

About 69.37% of the adolescents who ever smoked reported being taught about the harms of tobacco in school in the last year. This educational exposure did not show a significant association with being in either the contemplation (RRR = 1.22, 95% CI: 0.92, 1.61) or action phases (RRR = 1.24, 95% CI: 0.92, 1.67).

Cigarette smoking is joyful

A subset of adolescents who ever smoked (24.83%) believed that cigarette smoking is enjoyable. This belief was strongly associated with higher odds of being in both the contemplation (RRR = 7.97,

TABLE 3 Knowledge and attitude toward smoking and their association with behavioral changes in smoking cessation among school-going Indonesian adolescents in grades 7-12, GYTS 2019.

		Contemplation vs. maintenance	Action vs. maintenance
	N (%)	RRR (95%CI)[1]	RRR (95%CI)[1]
Awareness of cigarette smoke harm [a]			
No	367 (10.46)	-	-
Yes	3220 (89.54)	0.65 (0.44, 0.95)	0.94 (0.68, 1.31)
Awareness of second-hand smoke harm [b]			
No	252 (7.49)	-	-
Yes	3344 (92.51)	0.36 (0.26, 0.51)	0.61 (0.38, 0.97)
Taught about tobacco harms in school in last year			
No	903 (30.63)	-	-
Yes	2115 (69.37)	1.22 (0.92, 1.61)	1.24 (0.92, 1.67)
Cigarette smoking is joyful			
No	2519 (75.17)	-	-
Yes	810 (24.83)	7.97 (5.90, 10.77)	2.87 (2.18, 3.79)
Willingness to use a cigarette if offered by a friend			
No	2642 (73.72)	-	-
Yes	957 (26.28)	15.65 (11.65, 21.02)	5.51 (3.85, 7.88)
Support for smoking bans in indoor public places			
No	449 (12.83)	-	-
Yes	3133 (87.17)	0.69 (0.45,1.04)	0.74 (0.53, 1.03)
Support for smoking bans in outdoor public places			
No	919 (26.09)	-	-
Yes	2673 (73.91)	0.38 (0.28, 0.52)	0.68 (0.50, 0.91)

[1] Adjusted for age and sex.

95% CI: 5.90, 10.77) and action phases (RRR = 2.87, 95% CI: 2.18, 3.79) of smoking cessation, as compared to the maintenance phase.

Willingness to use a cigarette if offered by a friend

About 26.28% of adolescents reported they would use a cigarette if offered by a friend, which was strongly associated with increased likelihood of being in both the contemplation (RRR = 15.65, 95% CI: 11.65, 21.02) and action phases (RRR = 5.51, 95% CI: 3.85, 7.88).

Support for smoking bans in Indoor public places

While a substantial proportion of adolescents (87.17%) were in favor of banning smoking in indoor public places, this attitude was not significantly associated with being in the contemplation (RRR = 0.69, 95% CI: 0.45, 1.04) or action phases (RRR = 0.74, 95% CI: 0.53, 1.03).

Support for smoking bans in outdoor public places

Similarly, a significant majority (73.91%) supported banning smoking in outdoor public places. This support was associated with a reduced likelihood of being in the contemplation phase (RRR = 0.38, 95% CI: 0.28, 0.52), as well as the action phase (RRR = 0.68, 95% CI: 0.50, 0.91), compared to the maintenance phase.

Discussion

Leveraging the Transtheoretical Model of Behavioral Change (TTM), this study provides insights into the adolescents' journey towards smoking cessation, understanding the association of demographic factors, exposure to anti-cigarette messages, and participants' knowledge and attitudes with being at each stage of the process. Our results highlight a significant relationship between age and smoking cessation behaviors. Adolescents aged ≥14 years demonstrated a higher likelihood of being in the contemplation phase as compared to maintenance phase, consistent with prior research indicating that age plays a critical role in smoking behaviors (12, 13). Additionally, early cigarette initiation was associated with an increased likelihood of being in the contemplation and action phases. It has been shown that onset of regular smoking at an early age is associated with higher odds of nicotine dependence and lower odds of attempting and intending to quit. Although our findings cannot predict the future changes in smoking behaviors due to its cross-sectional design, it may suggest that efforts to prevent access to tobacco products at an early age could reduce nicotine addiction and promote cessation later in life (14, 15). The findings suggested that male adolescents are more likely to be in both the contemplation and action phases as compared to maintenance phase. Similarly, prior research on smoking cessation among Indonesian adolescents has noted a greater tendency toward quitting smoking and maintaining a free smoke life among females (16, 17). In Indonesia, Indonesian men rank first in countries with a prevalence of smokers in the world at 63%, while only 5% of Indonesian women are smokers, making smoking the majority behavior of Indonesian men (18). Cultural factors, peer influences, and societal norms around masculinity and smoking in Indonesia may contribute to this discrepancy (19), and interventions tailored to address these gender-specific factors could be beneficial.

In this study, parental smoking was identified as a significant environmental factor associated with smoking cessation behaviors among Indonesian adolescents. The findings showed that adolescents with smoking parents were more likely to be in the contemplation

phase, aligning with previous research that highlights the influence of parental behaviors on adolescent smoking (20, 21). Although the adolescents in this study were not followed up to understand the progress or relapse in relation to parental smoking, prior studies have shown that parental smoking predicts future initiation and regular smoking among adolescents, suggesting intergenerational transmission of smoking behavior within families (20). Another important environmental factor that increases the likelihood of being in the contemplation phase is witnessing a teacher smoking at school. Evidence indicate that it could encourage cigarette initiation among students (22, 23), and studies have suggested the need to strengthen pre-service and in-service teacher training programs in smoking education, make smoking cessation programs available to teachers who want to stop smoking, and implement smoke-free policies in schools (24, 25).

Our study adds to the growing body of literature on the influence of using other tobacco products and exposure to smoke on smoking cessation behaviors (26–28). Adolescents who tried other tobacco products or were exposed to second-hand smoke were more likely to be in the contemplation and action phases rather than in maintenance phase. Although the cross-sectional design of this study hinders the predication of future progress or relapse among study population, this finding suggest the importance of comprehensive tobacco control policies and educational programs that address all forms of tobacco use and exposure. A smoke-free environment has been shown to support and encourage cessation decisions and attempts among smokers trying to quit (27). Smoke-free workplaces and communities make youth and young adults less likely to start smoking due to several factors, including lower visibility of people who smoke, fewer opportunities to smoke alone or with others, and reduced social acceptability for smoking (28). Additionally, the findings of this study indicated higher experiences of e-cigarette smoking among those in contemplation and action phases as compared to those in maintained phase. Studies on e-cigarette use and smoking cessation indicated inconsistent results among the adolescent population (29). Although e-cigarette use could be beneficial in smoking cessation in adult population, it could be a risk factor for smoking initiation among adolescents (29). Further, longitudinal studies are suggested to disentangle the complex interaction between smoking cessation attempts and the e-cigarette effect among adolescent population.

The results of the study among Indonesian adolescents suggest that exposure to cigarette ads on TV, social media, at social events, and in sale centers, as well as receiving free or discounted cigarettes from cigarette companies, were all significantly associated with an increased likelihood of being in both the contemplation and action phases of smoking cessation. These findings are consistent with previous research that has highlighted the influence of cigarette advertising and promotion on youth smoking behavior in Indonesia (30, 31) in which the cigarette ads were shown to be encouraging youths to initiate and maintain a positive attitude toward smoking (30) which hinder the attempts to stop or maintain smoke-free lifestyle. Moreover, anti-cigarette messages appeared to be ineffective in encouraging adolescents in quitting and maintain a smoke-free life which was consistent with a recent study in Indonesia (9). These findings have important implications for tobacco control policies and educational programs in Indonesia where tobacco consumption has limited control, regardless of age or sex (32). Additionally, a higher availability of cigarettes near schools appeared to be associated with adolescents being in the contemplation phase. The findings concerning the availability of cigarettes near schools and adolescent smoking are inconsistent. While some studies suggest that the density/proximity of tobacco outlets around schools shows no or inverse association with adolescent smoking (33), other studies suggest that the availability of cigarettes near schools is the strongest environmental factor associated with smoking cessation behaviors among adolescents (34, 35). Therefore, comprehensive tobacco control policies that address all forms of tobacco use and exposure, including cigarette advertising, promotion, and sale could be crucial components of strategies to promote smoking cessation among adolescents.

With regards to knowledge and attitude toward smoking, this study indicated that awareness of the harms of cigarette and second-hand smoke was associated with a reduced likelihood of being in the contemplation and action phases, emphasizing the role of knowledge in smoking cessation. In fact, previous studies have shown that knowledge about the harms of smoking is a key element for smoking cessation and prevention (36, 37). The knowledge-attitude-practice model suggests that behavior change involves acquiring relevant knowledge, changing related attitudes, and altering practices (36). However, on the other hand, the belief that cigarette smoking is enjoyable and willingness to use a cigarette if offered by a friend were strongly associated with an increased likelihood of being in both phases. Studies have shown that social cues, such as smoking by peers and family members, are strong predictors of smoking initiation and maintenance among youth (38). The belief that smoking is enjoyable and willingness to use a cigarette if offered by a friend are attitudes that are often shaped by social cues (39). Interventions that target social norms and attitudes towards smoking have been found to be effective in reducing smoking initiation and increasing smoking cessation among youth (39, 40). This highlights a potential area for targeted interventions, focusing on changing attitudes and beliefs around smoking enjoyment and social smoking.

Limitations and future research

This study is not without its limitations. While our study provides valuable insights into smoking cessation behaviors among adolescents, it is essential to acknowledge the limitation inherent in our cross-sectional design. The comparison between action and maintenance stages lacks temporal context, as our data do not capture the longitudinal trajectory of smoking cessation. Thus, our findings may reflect associations rather than causality, and caution should be exercised in interpreting the results. Longitudinal studies are warranted to elucidate the dynamic nature of smoking cessation behaviors over time, providing a more comprehensive understanding of the factors influencing sustained cessation. Additionally, since the Indonesian GYTS 2019 was conducted in school, the results are not representative of adolescents outside the school who might be at a higher risk of risky addictive behaviors (9, 41). Additionally, we

couldn't determine the number of individuals in the pre-contemplation phase due to data constraints. A lower response rate to questions on cessation intention and timing compared to total smokers suggests potential under-reporting or temporal smoking behavior. Although we adjusted for age and sex, residual confounding factors may exist, impacting our findings. Despite limitations, our study provides valuable insights into adolescent smoking cessation, emphasizing the need for targeted interventions and further research. Another limitation of our study is the discrepancy in timing observed during the assessment of smoking cessation stages. While the TTM traditionally categorizes individuals based on a 6-month timeframe for cessation, the GYTS questionnaire utilized a 3-month timeframe. Consequently, we redefined the action stage as individuals who had ceased smoking for the last 3 months and the maintenance stage as those who had abstained from smoking for more than 3 months. This deviation may limit comparability with studies adhering strictly to the traditional TTM categorization. To address this, future iterations of the GYTS questionnaire should consider aligning the timing of smoking cessation questions with established models like the TTM to enhance consistency and comparability across studies.

Conclusion

This study provides valuable insights into the factors associated with smoking cessation behaviors among school-going Indonesian adolescents. Tailored interventions that address age-specific barriers, gender disparities, cultural influences, environmental factors, and knowledge and attitudes toward smoking are crucial. Strengthening tobacco control policies, particularly in schools and public places, could further support adolescent smoking cessation efforts. Moreover, there is a need for longitudinal studies to examine the evolving nature of smoking cessation behaviors over time, facilitating a more comprehensive understanding of the factors that contribute to sustained cessation.

Data availability statement

The GYTS datasets are publicly available data and are available in the CDC website repository through the following link: https://extranet.who.int/ncdsmicrodata/index.php/catalog/926.

Ethics statement

This was a secondary analysis of the Indonesia Global Youth Tobacco Survey in 2019 (GYTS2019). The GYTS2019 protocol received approval and guidance from the Indonesia Health Research Ethics Commission and, National Health Research and Development Agency. Students were informed about the survey objectives, data confidentiality, and assurances that non-participation wouldn't affect their grades before the survey. All students and guardians were then provided with a consent form before the survey.

Author contributions

OD: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2024.1374731/full#supplementary-material

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Model of structural equations on the perception of aspects of school life and substance consumption as predictors of problem behavior in adolescents

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Introduction: Problematic behavior and drug use are behaviors of social concern, especially in adolescence. There are school factors that can contribute to their development or prevent them. The objective was to establish explanatory models of the relationship between various school variables with the consumption of alcohol, tobacco and cannabis; determining its direct and/or indirect relationship with problematic behaviors.

Materials and methods: The study was cross-sectional with a sample of 346 students (Main Age=14.81; 54% women) from secondary education. Structural Equation Model (SEM) were carried to analyze the relationship between the dimensions of the Scale of perception of aspects of school life and alcohol, tobacco and cannabis consume with the presence of Problematic Behavior.

Results: Problem behavior was predicted by alcohol, tobacco and cannabis consume, and binge drinking. Different aspects of school life differentially predicted problem behavior and drug use. Sense of challenge was observed as having a reciprocal predictive relationship with problem behavior. Perception of oneself at school predicts both alcohol and tobacco use; while the value given to school predicts binge drinking.

Discussion: These findings suggests that, when addressing problem behavior and drug use that affect minors in school and have repercussions on class dynamics and academic outcomes, we should not focus exclusively on these problem areas, but rather take a more integrated approach that includes modifying different school-related aspects that act as risk factors for these types of problems.

KEYWORDS

alcohol, tobacco, cannabis, problematic behaviors, school, sense of challenge, perception of oneself at school, value given to school

Introduction

Antisocial behavior is one of the most common problems in adolescence (1). Although it tends to decrease with age (2), it can lead to antisocial behavior disorders if it persists into adulthood (3).

Several studies have highlighted the connection between antisocial behavior in minors and the use of alcohol, tobacco, and cannabis (4–8). Behaviors such as deliberately damaging public property and theft have been associated with risky substance use or using multiple drugs (6, 8). The meta-analysis conducted by Bennet et al. (4) concluded that users of certain drugs were 2.8 to 3.8 times more likely to engage in criminal behavior compared to non-users, and marijuana users were 1.5 times more likely to engage in criminal behavior. Rocca et al. (9) showed a clear link between cannabis use in the past month and criminal behavior in minors aged 12 to 16, suggesting a higher tendency for diverse criminal activities compared to alcohol consumers and a 2.6 times higher likelihood of committing some form of aggression.

Scientific evidence has shown that school and family are the most influential agents of primary socialization. School can either protect or pose a risk to the development of problem behaviors (10, 11) and the use of alcohol, tobacco, and cannabis (12, 13). Greater school commitment has been negatively related to substance use and being involved in fights (14). A good relationship between teachers and students, a student's relationship with his or her classmates, opportunities for autonomy, and the clarity and consistency of rules are related to fewer behavioral problems (15, 16), given that they increase school satisfaction (17). In this regard, a positive school environment serves as a protective factor against the onset of substance use (18). Likewise, attachment or a sense of belonging to school (*school attachment*), a positive connection to it, and greater academic performance constitute protective factors against tobacco (19, 20) and cannabis consumption in adolescents (13, 19).

However, adolescence is a period in which academic motivation and achievement usually decrease (11). This lack of motivation, along with the punishments imposed by the school such as expulsions or suspensions, permanently affects the adolescent's sense of identity and their belief in their academic abilities (11). This favors a progressive disengagement from school and can lead to them dropping out. In this sense, low academic achievement and early school failure increase the likelihood of the onset of substance use (21) and exhibiting problematic or criminal behaviors in early adulthood (22). Likewise, these school problems are associated with issues such as loss of motivation (23), high student-to-teacher ratio (24), school and classroom environment (25), grade repetition policies (26), disciplinary measures (27), or negative peer influence and bullying experienced at school (19, 28).

Decades ago, Wight (29) proposed the need for a change from traditional teaching methods that do not foster student involvement and from the idea that not meeting competencies required by the educational system labels a student as incapable. Wight (29) argued that the existing reality had enormous repercussions on motivation, given that the teaching model laid the entire load of guilt on the students themselves. The importance of careful attention to aspects of school life has been made evident in different studies, where analyses have linked a sense of achievement to motivation (27), school experiences (30), and student engagement with their studies (31) and where parental expectations and opinions about the role of the school are a proven factor in influencing the value that the student gives to schooling (32).

Consequently, the objective of the present study was to establish models that explain the relationship between different school variables (perception of oneself at school, the value given to school, and the sense of academic challenge) and the consumption of alcohol, tobacco, and cannabis, as well as their direct and/or indirect connection to problem behaviors. In this regard, two different explanatory models were proposed: one for alcohol consumption and binge drinking (as a pattern of abusive alcohol consumption) and another for the consumption of tobacco and cannabis. This decision was based on the high rate of alcohol consumption among adolescents compared to the lower rates of tobacco and cannabis consumption, as shown by epidemiological studies (33). In addition, there is a significant relationship between the consumption of tobacco and cannabis. Findings indicate that nine out of 10 individuals who have consumed cannabis in the last month have also consumed tobacco during this period, and four of 10 daily tobacco users have also consumed cannabis in the past 30 days (33).

Method

Study design

The study was cross-sectional with a sample of students from different schools and different grade levels of secondary education in Teruel (Spain). Four compulsory secondary education public schools were randomly selected (73.5% of the student population were enrolled in public schools). The directors of three of these four schools agreed to be part of the study.

Participants

A total of 346 participants were recruited. The age span was 13 to 17 years (M = 14.81; SD = 0.68). Sex distribution was 46% (n = 159) boys and 54% (n = 187) girls.

Instruments

Sociodemographic questionnaire

Developed *ad hoc*, it included data on the school, sex, and age.

Scale of perception of aspects of school life

The general scale (34) is composed of 25 items and three subscales that assess the following: a) perception of oneself at school or PO (items *a–i*, e.g., "*Sometimes I am not sure about what is expected of me at school*"), b) sense of challenge or SC (items

j–r, e.g., "*I get a lot of satisfaction from solving the hard problems in class*"), and c) value given to school or VG (items *s–y*, e.g., "*A lot of what I do at school has nothing to do with real life*"). These subscales were measured on a 5-Likert-type scale according to the level of agreement with the statements given, where 0 means totally agreed and 4 totally disagree. Cronbach's alpha in this sample was 0.73 for the PO subscale, 0.84 for the SC subscale, and 0.75 for the VG subscale.

Scale of problem behavior

The instructions of the scale (34) provide a total score of problem behavior (PB) by requesting participants to indicate the answer that best matches how often, over the past 12 months, they have done each action expressed in the statements. The variable is measured on a Likert-type scale with five choices according to the level of agreement with the statements given. Scores range from 8 to 40 points, where a higher score indicates greater problem behavior. Cronbach's alpha was 0.86 with the sample of this study.

Questionnaire on frequency of drug use

This was an *ad hoc* questionnaire that incorporated different scales to assess the frequency of alcohol consumption and binge drinking behavior over a 30-day time period. Alcohol consumption was registered using a 7-point Likert scale, as follows: 1 day (1), 2 days (2), 3 days (3), from 4 to 5 days (4), from 6 to 9 days (5), from 10 to 19 days (6), and 20 days or more (7). Regarding binge drinking behavior (BD), the 7-point Likert scale was used, as follows: none (0), one (1), two (2), three (3), four (4), five (5), and more than five times (6). Tobacco consumption (TC) was registered using a 4-point Likert scale, as follows: never (0), less than once a week (1), once a week, but not daily (2), and daily (3). Cannabis consumption (CC) was registered using a 6-point Likert scale, as follows: no day (0), 1 or 2 days (1), 3 to 5 days (2), 6 to 9 days (3), 10 to 19 days (4), and 20 or more days (5).

Procedure

The data were collected during the 2019–2020 school year, between November and December 2019. Prior to administering the questionnaires, the schools were provided with an informational letter to be used for requesting informed consent from students' legal guardians. The letter explained the voluntary nature of participation and that data were kept confidential through the use of an alphanumeric code. In the beginning, the students' teacher was asked to confirm the guardians' authorizations. Next, the study was presented to the students, briefly explaining the research and requesting their collaboration. The protocol for administering the battery of instruments was a 30- to 40-minute duration, carried out in the regular classroom during normal class hours, under supervision by the researcher.

Participation in this study was subject to the ethical standards of the Declaration of Helsinki (35) and the Spanish Organic Law 3/2018, dated December 5, Protection of Personal Data and the Guarantee of Digital Rights (36). The data were treated confidentially, respecting participants' privacy. The study was approved by the Ethics Committee of the University of Santiago de Compostela (Spain) and the Ethics Committee of Clinical Research of Aragon (Spain).

Statistical analysis

The data were introduced into SPSS version 26.0, from which reliability analyses were carried out for all the scales and subscales, as well as partial correlations in order to explore statistical models of the possible relationships between variables explored.

Structural equation modeling (SEM) was carried out through AMOS v.26 to analyze the relationship between the dimensions of the *scale of perception of aspects of school life* (VG, SC, and PO) and consumption of alcohol, tobacco, and cannabis with the presence of problem behavior. Structural equation model sensitivity was tested following Harring et al. (37) adding sex (boys *vs.* girls), age, and interculturality (ethnical minority yes *vs.* no) variables due to previous studies highlighting their relevance on alcohol, tobacco, and/or cannabis consumption (8, 38). To evaluate the fit of the SEM, the following were checked: the goodness-of-fit indices of χ^2/df value, the comparative fit index (CFI), the goodness-of-fit index (GFI), the incremental fit index (IFI), the non-normalized fit index [Tucker–Lewis index (TLI)], the normalized fit index (NFI), and the root mean square error of approximation (RMSEA). Although the rest of the indices were examined, they are not presented in this study. It was set that a value lower than 3 shows a good fit of χ^2/df value. Moreover, the cut-off point for the other indices examined was >0.95 for the CFI, GFI, IFI, and TLI to show an optimal fit; greater than 0.90 for the NFI value (39); and less than 0.06 for the RMSEA (39).

All *p*-values reported are two-tailed, and the level of significance was marked at $p < 0.05$. When not otherwise specified, results shown are means ± standard error of means.

Results

Correlation analyses

Results from the correlation analyses (Table 1) showed that the subscales of perception of aspects of school life (VG, SC, and PO) were correlated positively with each other. PB correlated positively with AC and BD and negatively with SC (all $p < 0.01$). PO and SC were negatively correlated with PB, TC, and CC within the last 30 days. Likewise, TC was positively correlated with CC in the last 30 days and with PB (all $p < 0.05$). Finally, the VG subscale of perception of aspects of school life was negatively correlated with PB ($p < 0.01$) and TC ($p < 0.05$) within the last 30 days, but not with CC.

TABLE 1 Descriptive data and correlation analyses between perception of aspects of school life; alcohol, tobacco, and cannabis consumption; binge drinking; and problem behaviors.

	M	*SD*	Perception of oneself	Sense of challenge	Value given to school	Problem behavior
Perception of oneself	34.09	4.70	–	–	–	–
Sense of challenge	31.80	6.18	0.42**	–	–	–
Value given to school	24.38	4.18	0.48**	0.68**	–	–
Problem behavior	13.88	5.63	−0.21**	−0.31**	−0.18**	–
Alcohol consumption	5.57	4.04	−0.00	−0.01	−0.01	0.18**
Binge drinking	2.22	4.62	−0.03	0.05	0.09	0.21**
Tobacco consumption	0.61	1.11	−0.23**	−0.12*	−0.12*	0.47**
Cannabis consumption	0.24	0.82	−0.17**	−0.13*	−0.10	0.35**

M, mean; SD, standard deviation.
*$p < 0.05$.
**$p < 0.01$.

Structural equation model with alcohol and binge drinking variables

A SEM was tested on which the subscales of perception of aspects of school life (VG, SC, and PO) and alcohol behavior (AC and BD) predict PB. Considering the direct relationship observed between SC and PB on correlation analyses, the possible mediatory role of alcohol behavior (AC and BD) was explored only in the relationship of VG and PO with PB. Considering that the chi-squared test [$\chi^2(4) = 3.54$, $p = 0.47$] can be biased due to sample size or other factors, the corrected measure was used considering the degrees of freedom ($\chi^2/df = 0.886$), which showed a good model fit, as it was less than 3. In this line, the other fit indices confirmed an optimal fit model with a CFI value > 0.999, a GFI of 0.997, an IFI > 0.999, a TLI > 0.999, and an NFI of 0.994. Therefore, all of them showed values higher than the cut-off stated. Regarding the RMSEA, it showed a value < 0.01, which reflects a good model fit. The model tested was explored based on correlation analyses performed previously and is shown in Figure 1. No significant changes were observed in the model estimates when sex, age, and interculturality were introduced as control variables. Therefore, we can infer that there are no confounding effects. The covariance estimated between the three subscales of the Scale of perception of aspects of school life (VG, SC and PO) showed a positive and significant correlation (see Table 2).

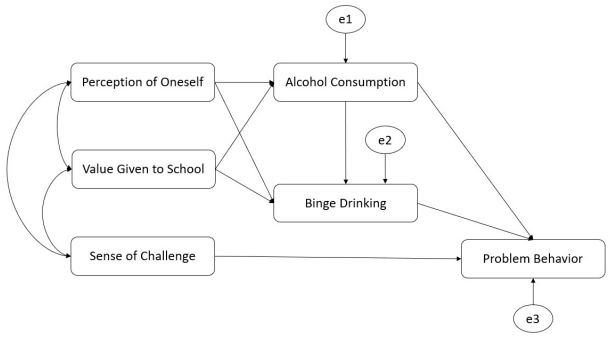

FIGURE 1
Structural equation model (SEM): aspects of school life, alcohol consumption, binge drinking, and problem behavior.

Table 3 shows the weight of the hypothesized regression in detail. All significant relationships shown in the table are those indicated in Figure 2, meaning that only SC showed a negative direct relationship with PB. There was no significant direct relationship of VG and PO with PB. Notwithstanding, SC, VG, and PO showed a significant and negative join effect over PB. Regarding indirect relationships, PO was indirectly related to PB in two ways: i) being negatively related to AC, which in turn was positively related to PB, and ii) being negatively related to AC, which was positively related to BD, which in turn was positively related to PB. In contrast, VG was related to PB only through its positive relationship to BD, which was positively related to PB. No significant relationships were found between VG and AC.

Structural equation model with tobacco and cannabis variables

The SEM tested the direct and indirect relationships of the *scale of perception of aspects of school life* (VG, SC, and PO) to PB through TC and CC through three paths: i) direct relationship of VG, SC, and PO with PB; ii) indirect relationship of VG, SC, and PO with PB through TC; and iii) indirect relationship of PB through TC and CC. Considering that the chi-squared test [$\chi^2(3) = 2.66$, $p = 0.45$] can be biased due to sample size or other, the corrected measure was used taking into account the degrees of freedom ($\chi^2/df = 0.888$), which showed a good model fit, as it was less than 3. In this line, the other fit indices confirmed an optimal fit model with a CFI value >0.999, a GFI of 0.997, an IFI >0.999, a TLI >0.999, and an NFI of 0.995. Therefore, all of them showed values higher than the cut-off stated. Regarding the RMSEA, it showed a value of <0.001, which reflects a good model fit. The model tested was explored based on correlation analyses performed previously and is shown in Figure 3. No significant changes were observed in the model estimates when

TABLE 2 Covariance weights of the hypothesized relationships.

Relationships between covariances			Covariance weight			
			Estimate	SE	CR	*p*
Sense of challenge	↔	Perception of oneself	9.480	1.171	8.099	***
Perception of oneself	↔	Value given to school	17.570	1.677	10.476	***
Sense of challenge	↔	Value given to school	12.290	1.692	7.262	***

SE, standard error; CR, critical ratio.
***p < 0.001.

sex, age, and interculturality were introduced as control variables. Therefore, we can infer that there are no confounding effects.

Figure 4 shows the model tested with values of the estimated parameters in the model after its re-specification. The correlation parameters, covariance, regression weights, and percentage of variance were collected. Only significant relationships were marked in the figure, with all of them significantly different from zero.

Table 4 shows covariance estimated between the three subscales of the *scale of perception of aspects of school life* (VG, SC, and PO). All correlations showed were significant.

Table 5 shows the weight of the hypothesized regression in detail. All the relationships shown in Table 5 are those indicated in Figure 4, and all of them were significant, meaning that only SC showed a negative direct relationship with PB. There was no significant direct relationship of VG and PO with PB. However, VG, PO, and SC had a significant and negative join effect over PB. Regarding indirect relationships, PO was indirectly related to PB in two ways: i) being negatively related to TC, which in turn was positively related to PB, and ii) being negatively related to TC, which was positively related to CC, which in turn was positively related to PB. In contrast, there were no significant indirect relationships of VG and SC with PB through TC and/or CC.

Discussion

The objective of the present study was to establish models that explain the relationship between different school variables (perception of oneself at school, the value given to school, and the sense of academic challenge) and the consumption of alcohol, tobacco, and cannabis, as well as their direct and/or indirect connection to problem behaviors. The findings confirm the relevance of various aspects of school life that predict both drug use and problem behavior. This finding clearly highlights the need to complement student-focused interventions with structural interventions related to the prevailing educational model as well as with school environmental characteristics, such as school policy.

In consonance with previous literature, problem behavior was predicted by alcohol, tobacco, and cannabis consumption and binge drinking (3, 5, 40, 41). However, different aspects of school life differentially predicted problem behavior and drug use. Our results thus concur with findings from other studies, where sense of challenge was observed as having a reciprocal predictive relationship with problem behavior (17, 42, 43). For its part, self-perception at school predicts both alcohol and tobacco consumption, while the value given to school predicts binge

TABLE 3 Regression weights of the hypothesized relationships.

Relationships between variables			Regression weight			
			Estimate	SE	CR	*p*
PB	←	SC	−0.245	0.040	−6.044	***
AC	←	PO	−0.046	0.022	−2.028	*
AC	←	VG	−0.004	0.025	−0.161	0.872
BD	←	AC	0.203	0.020	9.957	***
BD	←	VG	0.019	0.010	1.987	*
BD	←	PO	−0.017	0.009	−1.984	*
PB	←	AC	0.755	0.165	4.580	***
PB	←	BD	2.450	0.381	6.423	***

PB, problem behavior; SC, sense of challenge; VG, value given to school; PO, perception of oneself at school; AC, alcohol consumption in the last 30 days; BD, binge drinking in the last 30 days; SE, standard error; CR, critical ratio.
*p < 0.05.
***p < 0.001.
Meaning of arrow: direction of the relationship.

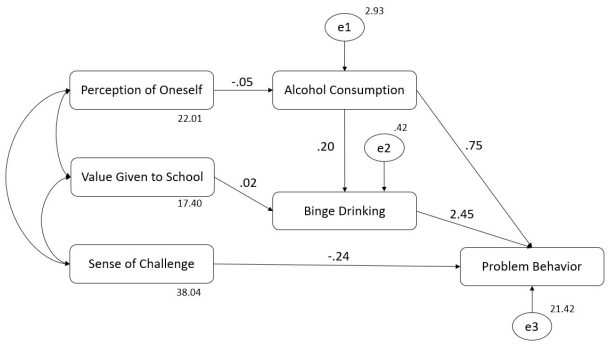

FIGURE 2
Structural equation model (SEM) with estimated parameters: aspects of school life, alcohol consumption, binge drinking, and problem behavior.

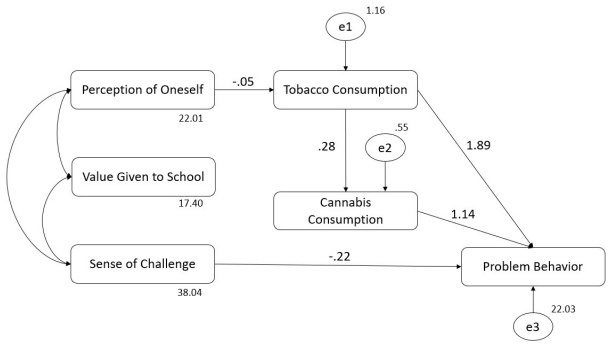

FIGURE 4
Structural equation model (SEM) with estimated parameters: aspects of school life, tobacco and cannabis consumption, and problem behavior.

drinking. These findings are new compared to the existing literature. It would be interesting to further study and confirm this relationship, as well as explore its explanation.

These findings suggest that, when addressing problem behavior and drug use that affect minors in school and have repercussions on class dynamics and academic outcomes, we should not focus exclusively on these problem areas but rather take a more integrated approach that includes modifying different school-related aspects that act as risk factors for these types of problems.

If perception of school-related aspects is a factor that favors or discourages the presence of antisocial behaviors and drug use, then the educational act cannot focus only on (cognitive) academic achievement and outcomes. This would be a partial view of educational reality; in the case of school failure, it contributes to a loss of expectations and rejection toward school (44), encouraging the appearance of antisocial behaviors in the educational context. Instead, one should work on students' identity construction (45) through the implementation of attitudes that create a positive predisposition toward education and give priority to students' perceived self-efficacy (46) and interests (47). However, as Wang and Eccles (48) maintain, schools are not always able to satisfy the psychological needs of adolescents.

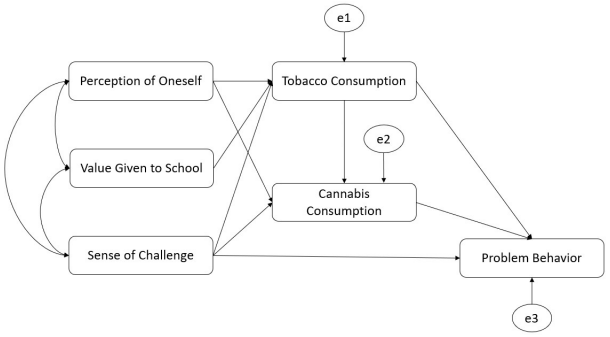

FIGURE 3
Structural equation model (SEM): aspects of school life, tobacco and cannabis consumption, and problem behavior.

Concerning how to foster student engagement in school, Sciarra and Seirup (49) indicated that this is strongly related to context variables, such as a) the size of the school, where small is preferable; b) class size, where a smaller number of students per classroom is beneficial; c) the type of teaching methodology and relational dynamics in the classroom, with preference to cooperative dynamics that emphasize shared responsibility, common goals, and decisions by consensus; d) power relations in the classroom, where there is clarity and flexibility of rules, and student–teacher roles are oriented toward cooperation and teacher support; and e) other aspects like acceptance of classmates, and assignments and learning that relate to real life.

The job of the school, then, is not limited exclusively to propaedeutic purposes pertaining to academic achievement and the acquisition of practical capacities of a vocational sort (50), but it involves learning that prepares one for life and makes life meaningful (51–53). If school is to provide training for life, it cannot be detached from it. Schools face the challenge of consolidating educational designs that are founded on a community-wide morality (54). In this way, our aim is to incorporate educational theories that encourage students' involvement in the formative process from a whole-person perspective (considering social, affective, and cognitive aspects), including theories of participatory education (29), education for social change (55), personalized education (56), and education adapted to the 21st century (57). For learners to have a share in their own progress and achievement has a positive impact on the self-image they acquire in the educational sphere, in their motivation toward the teaching–learning process, and in their perception of school. This fact encourages a positive evaluation of the school context, benefitting social reality in two realms: the academic, where society becomes equipped with greater competencies, tools, and skills for dealing with the different problems and difficulties that life presents; and the ethical–moral, reducing behaviors that negatively affect peaceful coexistence between persons and the values that they hold (freedom, tolerance, justice, respect, etc.).

In the face of substance use or problem behavior, educational institutions tend to implement measures aimed at modifying students' behavior. These measures place the students themselves as the focus of the problem, as the sole responsible parties for their conduct, thus fostering the development of stigma as problematic

TABLE 4 Covariance weights of the hypothesized relationships.

Relationships between covariances			Covariance weight			
			Estimate	SE	CR	*p*
Sense of challenge	↔	Perception of oneself	12.290	1.692	7.262	***
Perception of oneself	↔	Value given to school	9.480	1.171	8.099	***
Sense of challenge	↔	Value given to school	17.570	1.677	10.476	***

SE, standard error; CR, critical ratio.
***p < 0.001.

TABLE 5 Regression weights of the hypothesized relationships.

Relationships between variables			Regression weight			
			Estimate	SE	CR	*p*
Tobacco consumption	←	Perception of oneself	−0.051	0.014	−3.577	***
Tobacco consumption	←	Value given to school	0.002	0.020	0.101	0.920
Tobacco consumption	←	Sense of challenge	−0.007	0.013	−0.530	0.596
Cannabis consumption	←	Tobacco consumption	0.278	0.037	7.493	***
Cannabis consumption	←	Perception of oneself	−0.011	0.010	−1.124	0.261
Cannabis consumption	←	Sense of challenge	−0.008	0.007	−1.126	0.260
Problem behavior	←	Tobacco consumption	1.887	0.250	7.556	***
Problem behavior	←	Cannabis consumption	1.138	0.339	3.357	***
Problem behavior	←	Sense of challenge	−0.218	0.041	−5.257	***

SE, standard error; CR, critical ratio.
***p < 0.001.
Meaning of arrow: direction of the relationship.

students. However, educational institutions have a significant responsibility in deciding which preventive programs to incorporate into their policy. A recent systematic review of school-based preventive programs in Spain (58) indicates that only 37.5% are evaluated. This translates into an inadequate response or unknown effect regarding a health issue, such as substance use, which also predicts problem behavior. Consequently, educational institutions should only incorporate classroom interventions with proven efficacy in preventive programs. Likewise, antismoking school policies were considered a relevant factor in reducing the relationship between antisocial peers and tobacco consumption. It moderates that relationship through monitoring and sanctioning smoking behaviors while students are on campus and influencing their attitudes toward tobacco consumption (20).

In conclusion, interventions in the school context must focus not only on the subjective or personal characteristics of students but also on school environment factors.

Regarding study limitations, on the one hand, there are limitations relating to the sample, its size, and geographic origin. It would be interesting to obtain results from other geographic regions, as well as work with a larger sample. On the other hand, while we have realized a cross-sectional study, it would be useful to carry out longitudinal studies that provide an understanding of the relational dynamics of these variables throughout the entire developmental period of adolescence. Critical approaches sustain that research on learning and school cannot overlook questions such as school values and activities, even though this creates enormous difficulties for analysis. For this reason, we consider it equally important to include these variables in future studies.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Committee of Ethics of the University of Santiago de Compostela (Spain) and the Ethics Committee of Clinical Research of Aragon (CEICA) (Spain). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

VV: Conceptualization, Data curation, Investigation, Writing – original draft, Writing – review & editing, Funding acquisition, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization. BG: Visualization, Writing – original draft, Writing – review & editing. EC: Writing – original draft, Writing – review & editing, Conceptualization. SP: Writing – original draft, Writing – review & editing, Data curation, Formal analysis, Software, Supervision, Validation, Visualization.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Chronic tobacco smoking and neurocognitive impairments in adolescents and young adults: a systematic review and meta-analysis

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There is a lack of robust research investigating the association between neurocognitive impairments and chronic tobacco smoking in adolescents/young adults. Therefore, a systematic review and meta-analysis were conducted to examine this association by pooling cross-sectional studies published from 1980 to 2023. The systematic review assessed the neurocognitive performances between chronic tobacco smokers and non-smokers in each study. The meta-analysis included six studies that compared chronic tobacco smokers against non-smokers using neuropsychological tests covering three neurocognitive domains. The results showed a cross-sectional association between impairpments in *motor impulsivity* across two aspects: *reaction delay* and *incongruent errors*, with the effect size being (SDM = 0.615, p = 0.000) and (SDM = 0.593, p = 0.000) respectively. However, no significant associations were found for *intelligence* (SDM = 0.221, p = 0.425) or *working memory* (SDM = 0.150, p = 0.581). This study highlights the need for further research to explore a greater number of neurocognitive domains in the context of chronic smoking in adolescents/young adults, particularly motor impulsivity, intelligence and working memory, as well as the socioeconomic factors involved. There is also a need to further study the effects of emerging alternative nicotine administration methods in this age group.

KEYWORDS

nicotine, chronic smoking, tobacco, neuropsychology, neurocognitive impairment, adolescents, young adults, systematic review

1 Introduction

Chronic tobacco smoking, defined as daily cigarette smoking (>10 cigarettes per day) for 2 or more years, is considered by the World Health Organization (WHO) as significantly hampering effective global public health interventions (1). It is estimated that in 2019 there were 155 million individuals across the world aged 15-25 years who were smoking tobacco (2). Across all populations, smoking contributes to over 8 million deaths around the world each year, either directly or indirectly, and global tobacco consumption is a contributing factor to 7 million deaths per year, with around 1.2 million non-smokers dying from second-hand smoking each year (1).

In 2008, nicotine was identified as the most addictive substance across the world, with smoking tobacco a major cause of cardiac and respiratory disease (3–5). Data from the Health Survey for England show that in 2021, 13% of young people (16-24 years old) were current tobacco smokers, while the highest prevalence of smoking is between the ages of 25-34 years, at 18% (6). These rates can be compared to data from the Office for National Statistics (ONS), the UK's national statistical institute, which show that in 2021, the overall rate of smoking is 13.3% in people over 18 years of age (this figure reaches 21.1% in Scotland) (7, 8). However, the prevalence of chronic tobacco smokers in the UK has been decreasing since 1974, though over recent years this may be partially linked to the increasing popularity of electronic nicotine delivery systems (ENDS, also known as vapes or e-cigarettes) as an alternative source of nicotine, as well as variations in behaviour during the COVID-19 pandemic (8). Notably, the use of ENDS is most popular in the 16–24-year age group (8). Importantly, the number of deaths related to smoking remains high, with 74,600 recorded in England over 2019 – the most recent years for which data are currently published by National Health Service (NHS) Digital (9). Chronic tobacco smoking is still a significant behaviour among adolescents and young adults, demonstrating the importance of reducing the number of young people who smoke (10).

Chronic tobacco use often begins during the adolescent phase of life, with 90% of smokers beginning before the age of 18 years (11, 12). Additionally, the younger an individual begins smoking the harder it is to quit (13). Numerous studies indicate that individuals who begin smoking tobacco in their early life (<16 years old) have a higher probability of becoming chronic tobacco smokers, and developing an addiction to nicotine, in comparison to individuals who have a later onset of smoking (>16 years old), again contributing to the difficulty in quitting smoking once in adulthood (14–18). As a result, reducing the number of adolescents and young adults who start smoking would likely impact the total number of chronic smokers over time.

The transitioning phase between childhood and adulthood, known as adolescence, is characterized as a learning phase that includes behavioural changes, such as elevated levels of risk-taking behaviour, seeking novel experiences, and independence (19–21). According to WHO, the period of adolescence ranges from 10 to 19 years old. However, other studies have proposed that adolescence lasts until 25 years of age which can also be called the young adulthood phase, based on the brain's ongoing maturational processes (22). This ongoing maturation or "rewiring" of the brain is known to be governed by numerous specific stages of physical, emotional and cognitive maturation, and, as reported by Gavin et al. (23)Arain et al. (, 24), and Sylwester (25), it is known to start from around puberty, at the age of 10 years, until the brain reaches the stage where it is most mature at the age of 24 years.

A key consideration in the context of tobacco smoking during adolescence is the association this may have on an individual's neural development. Central nervous system (CNS) development begins in the third week of gestation and through to late adolescence, regulated and coordinated through complex cellular, genetic, and environmental factors (26). During the adolescent phase of life, the human brain is undergoing numerous neurodevelopmental transition and maturation processes (27). It is the phylogenetically more recent cortical regions of the CNS that demonstrate the ongoing and prolonged development through childhood and into adolescence (28). This is important to consider in the context of chronic tobacco smoking in this age range, as the development of these central neural regions underpins emotional, cognitive, and behavioural changes seen in adolescence (28).

Chronic exposure to nicotine during adolescence has also been shown to be associated with an increase in the probability of an individual developing major psychiatric disorders and neurocognitive impairments in later life. Most commonly, adolescent, and young adult chronic tobacco smokers experience a level of progressive attentional deficit (29). Specific neurocognitive disturbances seen in studies include changes to working memory and attention, with a notable reduction in the activation of the prefrontal cortex (PFC) (30, 31). There are also specific psychiatric conditions that are associated with chronic nicotine exposure in adolescence, including major depressive disorder, schizophrenia, and addiction to other substances (32–38).

In summary, there is a need for clinical research to improve the understanding of the complex relationship between chronic tobacco smoking and neurocognitive impairments in individuals from younger age groups, as suggested in a previous systematic review and meta-analysis in adult populations (39). Using restricted inclusion criteria for the age groups (10-24 years old) of participants assessed (23–25), the following is a systematic review and meta-analysis of the existing studies on chronic tobacco smoking and neurocognitive impairments in adolescents and young adults.

2 Methods

This review was done in compliance with the Meta-analysis of Observational Studies in Epidemiology (MOOSE) guidelines (40) and the Preferred Reporting Items for Systematic review and Meta-Analysis (PRISMA) guidelines (41) (Supplementary Table 5). The study protocol registration was made on the PROSPERO database (CRD42023428359).

2.1 Literature search

2.1.1 Inclusion and exclusion criteria

The PICO criteria utilised in this review were (1) studies including human participants (2) with ages ranging from 10 years to 24 years (23–25), (3) experiencing chronic tobacco use as defined by the WHO (1) and (4) including all types of studies. As for the comparison group, they were defined as healthy participants who do not smoke (nicotine naïve), of the same age group (10-24 years of age). Furthermore, these papers had to supply the name of the neurocognitive tests used and which neurocognitive domains (e.g., Impulsivity, Attention, Memory, etc.) were being assessed during each test (42). Chronic tobacco smoking was defined as daily cigarette smoking (>10 cigarettes per day) for 2 or more years.

The exclusion criteria used were as follows:

(A) Cohorts employing participants with illicit poly-drug use and/or dependence.

(B) Cohorts employing individuals with more than 14 units of alcohol per week as the alcohol cut-off.

(C) Cohorts employing individuals diagnosed with neurological illness and/or any Axis 1 Psychiatric Illness (DSM IV/V).

(D) Studies that had no healthy comparator group (non-smoker controls).

(E) Studies not utilising neurocognitive tests.

2.1.2 Search terms

The search terms utilised were: (Nicotine OR Cigarettes OR Tobacco OR 'Chronic Smoking') AND ('Neuropsychological impairments' OR 'Cognitive impairments' OR Neurocognition) AND (Adolescents OR Teens OR 'Young Adults').

Next, the search terms 'neuropsychological impairments', 'cognitive impairments', and 'neurocognition' were replaced by the names of the specific neurocognitive tests. These were: 'Rapid Visual Information Processing', 'Wechsler Adult Intelligence Scale', 'Spatial Working Memory', 'Ray Auditory Verbal Learning Test', 'Two Back Test', 'Trail Making Test', 'Stroop Test', 'Wisconsin Card Sorting Test', 'Stroop Colour Word Task', 'Reaction Time', 'California Verbal Learning Test', 'Verbal Fluency', and 'Gambling Test' (42).

2.1.3 Search engine

The literature search was conducted in May 2023 using the following databases: PubMed (1980-2023), APA PsycINFO (1980-2023), Cochrane Central (1980-2023), SciELO (1980-2023), and Scopus (1980-2023). Two further studies were located using Google Scholar. All the identified studies from the database search were reviewed and moderated by the authors for the selection of eligible and suitable papers to be used for this systematic review and the meta-analysis. Finally, to improve the comprehensiveness of the identified studies, the references of the accepted studies were reviewed, and a "snowballing" technique was employed.

Three authors (AE, SV, and AAC) screened the studies independently using the inclusion and exclusion criteria listed above. First, the title/abstract of the studies was screened. This utilised EndNote 20, from which search libraries were uploaded to Rayyan. Rayyan software was then used during the screening process. Subsequently, the full text of the articles that passed the title/abstract screening was inspected. Disagreements were resolved consensually.

2.2 Analysis

2.2.1 Qualitative analysis

Several papers were reviewed to further investigate the effect of chronic tobacco smoking and neurocognitive impairments in adolescents and young adults. Neurocognitive impairments were pooled from each paper. Then, these findings were compiled in a descriptive summary to be further investigated and used in a preliminary conclusion for the neurocognitive impairments that can be associated with chronic tobacco smoking in adolescence or young adulthood.

2.2.2 Quantitative analysis

2.2.2.1 Data extraction

This was followed by meta-analytic calculations to reach a quantitative estimate of the impact of chronic tobacco smoking on the neurocognitive functions of the identified cohort. Means (M) and Standard Deviations (SDs) of scores on neurocognitive tests/measures were extracted from six studies (5, 18, 21, 30, 43, 44) and inserted into the Comprehensive Meta-Analysis (CMA) version III software package for analysis (45). It was only possible to extract data from six studies as the other research papers pooled for the systematic review did not provide relevant statistical data. Data were limited to three neurocognitive domains: Motor Impulsivity, Intelligence, and Working Memory. These domains were identified from the neurocognitive tests utilised by the studies included in the review following a previous meta-analysis by Conti et al. (39) and Figueiredo et al. (46), and the guidelines of Baldacchino et al. (42) (Supplementary Tables 1–3). Regarding Motor Impulsivity, the data extracted included those pertaining to the Stroop Task 'response delay' outcome measure (measured by reaction time during the incongruent condition minus reaction time during the congruent condition) and Stroop Task incongruent errors.

2.2.2.2 Meta-analysis

A random effect model was selected to conduct meta-analytic calculations instead of a fixed effect model as it was assumed that the pooled studies were not 'identical' (i.e., not displaying the same true effect size) (47, 48). The 'Standard Mean Difference' (SMD) was selected as a statistical summary measure. Effect sizes were computed utilising Cohen's benchmark criteria; an effect size of 0.8 would have implied a 'large' effect size, an effect size of 0.5 would have implied a 'medium' effect size, and an effect size of 0.2 would have implied a 'small effect size' (49). Heterogeneity was assessed by using both Cochran's Q and I2 tests (47). It was not possible to run a

meta-regression by utilising relevant smoking characteristics of participants as moderators (e.g., number of cigarettes smoked x day, pack-years) due to the low number of studies (<10) pooled for each neurocognitive domain (47).

2.2.3 Publication bias

Publication bias refers to the tendency to publish studies reporting statistically significant results than studies reporting results that are not statistically significant (50, 51). Therefore, there is a possibility that studies included in a meta-analysis would be biased and consequently reflected in the results of the quantitative synthesis (39). Publication bias for the studies included in the meta-analysis was assessed through the visual inspection of Funnel's Plots (47).

2.2.4 Assessment of study quality

To evaluate the quality of papers that were included in the review, the National Institutes of Health (NIH) case-control quality assessment tool was utilised (52). Using the Study Quality Assessment Tools, the studies were either classified as 'poor' indicating that the study in question presents a high risk of bias, 'fair' indicating that the study in question presents a moderate but not to the extent to invalidate the results, or 'good' indicating that the study in question presents a low risk of bias (52).

3 Results

3.1 Search results

Initially, a total of 359 papers were identified. Then filtering tools on these databases were utilised to filter for the following: 'Clinical Trials', 'Human Trials', 'Adolescents', and 'Young Adults'. The citations were downloaded to EndNote20 and then uploaded together to Rayyan. Rayyan is an online software program designed specifically for researchers working on systematic literature reviews, which has tools that improve the organisation and efficiency of the screening and selection process of studies. Duplicate papers were removed manually by AE and SV, using Rayyan software to assist the process, excluding 63 duplicates and leaving 296 remaining unique studies. Titles and abstracts were then inspected to assess the studies for eligibility by AE, SV and AAC. This inspection process resulted in the exclusion of 272 papers; 251 papers were excluded by the title, and 21 were excluded after reading their abstracts. Next, using the inclusion and exclusion criteria, the remaining 24 papers were reviewed comprehensively for eligibility by AE, SV and AAC, which yielded the elimination of 12 more papers due to having non-matching age ranges and/or having the smoking group not meeting the criteria of inclusion. One paper was excluded due to concurrent marijuana use, one paper was excluded that had no control (non-smoker) comparison, and one paper was excluded that did not include neurocognitive tests. Eventually, this yielded 9 case-control studies that were selected to be included in the quantitative synthesis (Figure 1).

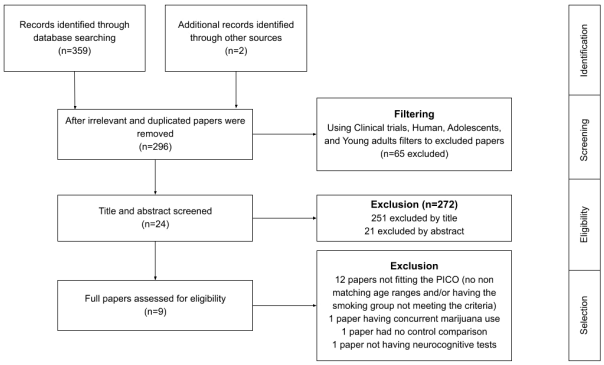

FIGURE 1
Neurocognitive associations of chronic smoking on adolescents/young adults.

One study included in the quantitative synthesis reported data from an additional comparator group ('Light Smokers') (53). Therefore, to comply with the exclusion and inclusion criteria and the aim of this study, only the appropriate comparator groups were included in this meta-analysis.

The studies included in the analysis originated from four countries, including the one from United States of America (30), five from China (5, 18, 21, 43, 54), two from Saudi Arabia (44, 55), and one from Belgium (53).

The quality of the studies was assessed consensually by AE and SV (Supplementary Table 4). Out of the nine studies that were accepted for inclusion in this current meta-analysis, three were classified as 'good' and six were classified as 'fair' (Table 1; Supplementary Table 4).

3.2 Sociodemographic

Demographic data were utilised from a total of (307) chronic tobacco smokers and (315) non-smoking controls, all free of any neuropsychiatric disorders. Since adolescents and young adults were the targets for this study, the mean age range of the adolescent and young adult tobacco smokers ranged from 17 years to 24.7 years, and for the control population their mean age ranged from 16.6 years to 23.3 years (30, 44, 55). Most of the studies were conducted on a predominantly male population except for two studies that had more females than males (30, 53). The average amount of time in education ranged from 10.1 years to 13.8 years. However, of the included studies that were pooled, several did not include data for the years of education (44, 53–55). Most of the papers included in this meta-analysis reported pack-years, years of smoking, and cigarettes per day, except for one study that did not report any of these data (55) and two studies not mentioning pack-years specifically (30, 54). Pack-years ranged from 3.5 to 6.4 (18, 43, 44), years of smoking ranged from 2 years to 7.3 years (44, 54), and cigarettes per day ranged from 11.7 Jacobsen et al. (30) cigarettes per day to 16.9 cigarettes per day (21) (Table 1).

TABLE 1 Demographics and smoking characteristics ♦.

Authors and year of publication	Quality of studies	Country	Study Type	Smokers Number (N)	Age (Mean ± SD) in years	Sex	Years of Education (± SD)	Pack-years	Years of smoking	Cigarettes per day	Poly-sub-stance use	Non-smokers Number (N)	Age (Mean ± SD) in years	Sex	Years of Education (± SD)	Poly-sub-stance use
Maurage et al. (53)	Good	Belgium	Case-Control	25	21.4± 2.3	10 Males	NA	4.2 ± 4.3	6.0 ± 3.5	13.1 ± 4.4	None	25	22.4± 2.3	8 Males	NA	None
Al-Mshari et al. (44)	Good	Saudi Arabia	Case-Control	31	24.7 ± 4.1	Males	NA	6.4 ± 8.3	7.3 ± 5.0	14.8 ± 9.2	None	42	20.9± 2.7	Males	NA	None
Bashir et al. (55)	Fair	Saudi Arabia	Case-Control	22	24.4± 5.3	Males	NA	NA	NA	NA	None	30	23.3± 2.7	Males	NA	None
Li et al. (5)	Fair	China	Case-Control	31	19.4 ± 1.3	Males	12.5 ± 0.7	3.7 ± 1.2	4.9 ± 1.9	15.0 ± 7.1	None	30	19.5± 1.5	Males	12.7± 0.7	None
Bi et al. (43)	Fair	China	Case-Control	40	19.6 ± 1.9	Males	12.0 ± 1.3	3.5 ± 2.4	4.2 ± 1.9	15.6 ± 5.3	None	40	19.8± 2	Males	12.2 ± 1.5	None
Yuan et al. (21)	Fair	China	Case-Control	60	20.0 ± 1.7	53 Males	13.8 ± 0.7	3.6 ± 1.7	4.4 ± 1.6	16.9 ± 5.4	None	60	19.9± 1.8	52 Males	13.6 ± 0.9	None
Zhao et al. (54)	Fair	China	Case-Control	30	21.4 ± 2.1	NA	NA	NA	≥ 2	16.8 ± 2.51	None	31	21.1± 1.2	NA	NA	None
Feng et al. (18)	Fair	China	Case-Control	27	20.7 ± 1.5	Males	12.6 ± 0.9	3.5 ± 2.4	4.9 ± 2.2	14.1 ± 4.6	None	25	20.5± 1.4	Males	12.6 ± 0.8	None
Jacobsen et al. (30)	Good	United States	Case-Control	41	17.0 ± 1.1	14 Males	10.1 ± 1.1	NA	3.9 ± 0.7	11.7 ± 6.7	None	32	16.6± 1.3	12 Males	10.1 ± 1.4	None

N, total number in study; Pack-Years, a person's cigarette consumption calculated as the packs of cigarettes smoked per day, multiplied by the length of consumption in years; NA, Not Available; SD, Standard Deviation.

♦ Note. One of the studies did not provide the gender of the population used in their study. These data are shown in the above table as they were provided in the respective studies.

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3.3 Neurocognitive tests

In the papers that were pooled for this systematic review, researchers used specific neurocognitive tests to investigate the neurocognitive domains of adolescent and young adult chronic tobacco smokers (Table 2). The Stroop colour-word task, used to test motor impulsivity and cognitive flexibility, was the most utilised neurocognitive test in the studies included in this review (5, 18, 21, 43). The Wechsler Adult Intelligence Scale Third Edition (WAIS-III) was used by four of the included studies to specifically measure intelligence in chronic tobacco smoking adolescents and young adults (18, 21, 30). As well as using WAIS-III, the domain of attention was measured using several tests throughout the papers included. One of the studies, by Bashir et al. (55), assessed attention in chronic tobacco smoking adolescents and young adults using the Attention Switching Task (AST). This study included another neurocognitive domain, Pattern Recognition Memory Task (PRM), to measure learning and memory (both short- and long-term memory) in the chronic tobacco smoking group. Maurage et al. (53) assessed attention in chronic tobacco smoking cohort with the Attention Network Test (ANT). Li et al. (5) also explored how attention is affected by adolescent and young adulthood chronic tobacco smoking by measuring Reaction Time (RT). Al-Mshari et al. (44) used numerous tests to assess multiple neurocognitive domains. This included RT to test for attention, as well as the Spatial Working Memory Task (SWM) to investigate any association between impairments in spatial working memory and chronic tobacco smoking status in adolescents and young adults. The same study also used the Multitasking test (MTT) and Rapid Visual Information Processing Task (RVIP) to assess the participants' attention and impulsivity. Zhao et al. (54) used the Go/No-Go Task to assess motor impulsivity in their assessments of chronic tobacco smokers. Finally, as well as exploring intelligence, Jacobsen et al. (30) included four different neurocognitive tests: the Hopkin's Verbal Learning Test (HVLT) was used to assess verbal learning and memory; the Auditory n-Back Task was used to assess working memory; the Kauffman Brief Intelligence Test (KBIT) was used to assess intelligence; and the Continuous Performance Test (CPT) was used to assess selective, divided, and sustained attention in chronic tobacco smokers.

TABLE 2 Neurocognitive tests and domains.

	Neurocognitive Tests	Neurocognitive domains
Maurage et al. (53)	ANT	Attention
Al-Mshari et al. (44)	RT SWM MTT RVIP	Attention, Spatial Working Memory, and Impulsivity
Bashir et al. (55)	AST PRM	Attention & Learning and Memory (Short-Term and Long-Term memory)
Li et al. (5)	Stroop colour-word task RT	Cognitive Flexibility & Attention
Bi et al. (43)	Stroop colour-word task	Cognitive Flexibility
Yuan et al. (21)	Stroop colour-word task	Cognitive Flexibility
Zhao et al. (54)	Go/no-go task	Motor Impulsivity
Feng et al. (18)	Stroop colour-word task	Cognitive Flexibility
Jacobsen et al. (30)	HVLT KBIT Auditory n-back task CPT	Verbal Learning and Memory, Intelligence, Working Memory, and Selective, Divided & Sustained Attention.

AST, Attention Switching Task; SOC, Stockings of Cambridge; PRM, Pattern Recognition Memory; CRT/DR2, Sample Choice Reaction Time; RT, Reaction Time; RVP, Rapid Visual Information Processing; SWM, Spatial Working Memory; SST, Stop Signal Test; CGT, Cambridge Gambling Task; WAIS-III, Wechsler Adult Intelligence Scale/Third Edition; TVPS, Test of Visual Perceptual Skills; KBIT, Kauffman Brief Intelligence test.

3.4 Qualitative analysis

All 9 studies were included in this qualitative systematic review. The 9 selected papers assess neurocognitive functional impairments associated with chronic tobacco smoking in adolescence and young adulthood (5, 18, 21, 30, 43, 44, 53–55).

Maurage et al. (53) proposed that when looking into attention (alerting, orienting and executive control) using the Attention Network Test (ANT), adolescent chronic tobacco smokers face more impairments in executive control when compared to non-smokers of the same age range. Additionally, they reported adolescent and young adult chronic tobacco smokers show impairments in attention and reaction time compared to healthy non-smoking individuals of the same age group (53), having slower reaction times in incongruent stimuli and having difficulty ignoring the distractors used. They have also suggested that there is a significant association between the chronic smoking group and negative urgency ($p<0.05$), positive urgency ($p=0.01$) and lack of premeditation ($p=0.02$), where they had higher scores than the healthy control group.

Al-Mshari et al. (44) provided evidence that adolescent and young adult chronic tobacco smokers show higher levels of cognitive impairments in comparison to non-smokers of the same age group. These cognitive impairments were in sustained attention, as assessed by the Rapid Visual Information Processing task (RVIP), and attention and impulsivity, as assessed by the Multi-Tasking Tests (MTT). This study additionally showed that there is a significant difference in Rapid Visual Information Processing A (RVPA) ($p=0.001$), Rapid Visual Information Processing Probability of False Alarm (RVPPFA) ($p=0.027$), and Multi-Tasking Test Reaction Latency (Median) (MTTLMD) ($p=0.007$) in the performance of non-smokers when compared to smokers, with non-smokers performing much better in these domains. Insignificant differences ($p>0.05$) between young adult smokers and non-smokers were reported in relation to spatial working memory as assessed by the Spatial Working Memory Strategy (SWMS) test. Furthermore, the researchers propose that the occurrence of impairments in sustained attention and executive function in young smokers is supported by previous studies that provide the same results (56–58).

Bashir et al. (55) proposed that chronic tobacco smokers exhibited notable deficits in neurocognitive function, as demonstrated by the Attention-Switching Task (AST) and Pattern Recognition Memory (PRM) tests. The AST test revealed that chronic tobacco smokers had significantly higher values in the AST-latency ($p=0.001$), congruent ($p=0.001$) and incongruent ($p=0.001$) conditions compared to non-smokers, indicating impaired attention, memory, and reaction time tasks between the two groups. Although the PRM test was also utilised, no significant difference ($p=0.101$) was found between the two groups. This would suggest that adolescent or young adult chronic tobacco smokers have a significant difference in their performance when compared to non-smokers in reaction time and attention. They also suggest that the lack of difference in the performances of both groups in the PRM test can be due to memory function preservation in smokers.

According to Zhao et al. (54), the authors observed that in a specific stimulus in the go/no-go task (600 ms), there was no significant ($p>0.05$) difference between the chronic tobacco smoking group compared to the non-smoking controls. However, when changing the stimulus of the test (200 ms), the smoking group had more significant ($p<0.001$) on-the-go and no-go phases when compared to the non-smoking controls. Additionally, when using the short stimulus on the go task, the chronic smoker group had a much faster response to the stimulus (RT) when compared to the non-smoking control. This describes how chronic tobacco smoking may not only be associated with impairments in the go/no-go tasks, but that chronic smokers also tend to increase their reaction time in tasks that involve responding to a fast stimulus and, additionally, make more errors.

Feng et al. (18) used the colour-word Stroop Task to measure response errors, reaction times, and response delays of participants under congruent and incongruent conditions. The results showed that smokers made a significantly higher number of incongruent errors ($p<0.05$) and had significantly shorter reaction delay times ($p<0.05$) compared to non-smokers. The results also provided evidence of minor, but non-significant, differences in the other conditions including congruent errors, and incongruent and congruent reaction times. These findings were further supported by Bi et al. (43), who also used the colour-word Stroop Task and found that smokers had a longer reaction time during congruent conditions ($p<0.001$) compared to non-smokers. The smoking group also showed a significant difference in their scores in reaction delay ($p<0.05$), where they had shorter reaction delay scores when compared to the non-smoker group. Additionally, the smoker group made more errors during the incongruent condition ($p<0.01$) compared to the non-smoker group, which was also observed in the study by Yuan et al. (21) in the colour-word Stroop Task, where they also provided evidence that smokers had significantly more errors ($p<0.05$) and shorter reaction delay times ($p=0.005$) in the incongruent condition. Similarly, Li et al. (5), using the colour-word Stroop Task, found that both tobacco smokers and non-smokers made more errors ($p<0.005$) and had shorter reaction delay times ($p<0.01$) during the incongruent condition compared to the congruent condition. They all noted a trend of shorter response delay in adolescent and young adult smokers when compared to non-smokers (5, 18, 21, 43). Additionally, it was reported by Li et al. (5), ($p<0.001$), Bi et al. (43) ($p<0.001$), and Yuan et al. (21) ($p<0.005$) that there was a significant Stroop effect noticed in both smoking and non-smoking groups, where they demonstrated longer reaction times when performing in the incongruent conditions compared to when performing in the congruent condition. Studies by Feng et al. (18), and Yuan et al. (21) also performed WAIS III on adolescent and young adult chronic tobacco smokers in order to measure their intelligence quotient (IQ), where they proposed that there were no significant differences between the adolescent or young adult smoking group and the non-smoking group.

Jacobsen et al. (30) reported adolescent smokers perform significantly ($p<0.05$) less accurately on the dichotic 1-back and 2-back conditions, and the binaural 1-back condition of an n-back task in comparison to non-smokers. It proposes that adolescent smokers have impairments in working memory in comparison to adolescent non-smokers. These impairments were found to be more severe during a nicotine withdrawal condition. No significant differences ($p>0.05$) were identified between the two groups in relation to verbal memory during a nicotine-satiated condition. However, verbal memory, as assessed by the Verbal Learning Test-Revised (HVLT-R), worsened during nicotine withdrawal for adolescent smokers. No significant differences ($p>0.05$) were detected in relation to sustained, selective, and divided attention task performance accuracy between adolescent smokers and non-smokers. Nonetheless, as stated by the same authors "across test sessions, smokers performed this attention task significantly more slowly than did non-smokers [smokers reaction time (RT) = 1056.7 ± 305.9 msec, non-smokers RT = 944.5 ± 262.5 msec; $\beta = 144.0$, $t(65) = 2.1$, $p = .04$]" (30). Group differences in reaction time did not vary between nicotine-satiated and withdrawal conditions.

There were variations in the nicotine administration state of chronic smokers between the studies. Two studies did not mention the duration since the last nicotine administration at all, reflecting a less detailed assessment of participants (44, 55). Two studies assessed participants at 30 minutes post-administration (18, 43). While this is soon after administration, the studies demonstrated statistically significant impairments in smokers versus non-smokers in multiple neurocognitive tests. Three studies assessed smokers at 1 hour after administration (5, 21, 54). Li et al. (5) elaborated on this, stating that no chronic smoking participants demonstrated an urge to smoke during the pre-testing questionnaire. Maurage et al. (53) alone measured smokers at 3 hours post-administration. This study found that the executive function of heavy smokers was independent of current tobacco craving, as measured in the pre-test questionnaires, and correlated more with the heaviness of smoking rather than the duration of smoking. Jacobsen et al. (30) most comprehensively assessed the effects of nicotine withdrawal on neurocognitive performance. Their chronic smoking participants were assessed twice: the first was following "ad libitum" smoking (smoking as one wishes – no clear definition), and then again two weeks later at 24 hours post-administration of nicotine. From this, Jacobsen et al. (30) suggested an association between nicotine withdrawal (at 24 hours) and the domains of working memory and short-term verbal memory, with no associations determined elsewhere.

3.5 Quantitative analysis

3.5.1 Motor impulsivity

For *Motor-Impulsivity*-Stroop Task-Reaction Delay, a significant and medium effect size was found in favour of the tobacco non-smoker group (z=5.317, p<0.0001), indicating that young non-smokers take more time/are less impulsive when reacting between congruent and incongruent conditions compared to young chronic tobacco smokers (Figure 2). Results of Q and I^2 tests indicated the absence of heterogeneity between the pooled studies (Q=0.471, p=0.925, I^2 = 0.000). Visual inspection of Funnel's Plot revealed the absence of publication bias (Supplementary Figure 1).

For *Motor-Impulsivity*-Stroop Task-Incongruent Errors, a significant and medium effect size was found in favour of the young chronic smoker group (z=-5.130, p <0.0001), indicating that young chronic tobacco smokers make more errors during cognitive conflict conditions compared to young non-smokers (Figure 3). Results of Q and I^2 tests indicated the absence of heterogeneity between the pooled studies (Q=1.705, p=0.636, I^2 = 0.000). Visual inspection of Funnel's Plot revealed the absence of publication bias (Supplementary Figure 2).

3.5.2 Intelligence

For *Intelligence*, a non-significant and small effect size was found in favour of the young non-smoker group (z=0.798, p=0.425) (Figure 4). Results of Q and I^2 tests indicated heterogeneity between the pooled studies (Q=8.496, p<0.05, I^2 = 76.459). Visual inspection of the Funnel's Plot revealed moderate publication bias (Supplementary Figure 3).

3.5.3 Working memory

For *working memory*, a non-significant and small effect size was found in favour of the young non-smoker group (z=0.150, p=0.581) (Figure 5). Results of Q and I^2 tests indicated small heterogeneity between the pooled studies (Q=2.599, p=0.107, I^2 = 61.517). It was not possible to compute a Funnel's plot to assess publication bias as the number of included studies was too low.

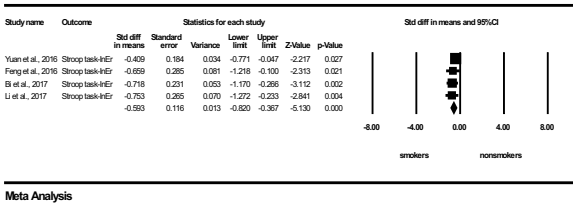

FIGURE 3
Motor impulsivity-Stroop Task-Incongruent Errors-forest plot (std diff, standard difference; Z value, one sample z statistics; p value, probability that Z statistics is significantly different than 0; Lower limit, lower limit of the 95% confidence interval for the effect size; Upper limit, upper limit of the 95% confidence interval for the effect size; InEr, Incongruent errors).

4 Discussion

4.1 Summary of results and key findings

This systematic review and meta-analysis were conducted to provide a quantitative synthesis regarding the association between chronic tobacco smoking and neurocognitive impairments during adolescence and young adulthood (Table 3). Both quantitative and qualitative analysis results showed an association between chronic tobacco smoking and impaired motor impulsivity in chronic tobacco smoking adolescents and young adults, while qualitative analysis of these nine studies demonstrated that smoking behaviours in younger age groups may be associated with impairments of various neurocognitive domains. Of the papers included in this study, Li et al. (5) Yuan et al. (21) Bi et al. (43), and Feng et al. (18) propose that early onset of tobacco smoking is associated with neurocognitive impairments in the domain of attention, specifically when performing incongruent error and reaction delay tasks. Jacobsen et al. (30) provided evidence that adolescent smoking may be associated with impairments in working memory. Al-Mshari et al. (44) Maurage et al. (, 53), and Bashir et al. (55) suggest that adolescent and young adulthood smoking can be associated with impairments in executive function and attentional domains. Finally, Zhao et al. (54) have provided

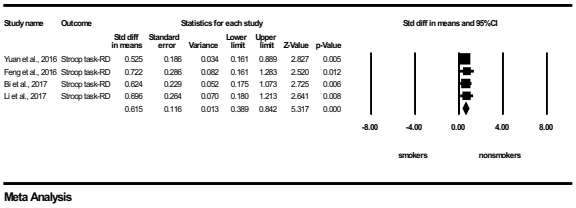

FIGURE 2
Motor impulsivity-Stroop Task-Reaction Delay-forest plot (std diff, standard difference; Z value, one sample z statistics; p value, probability that Z statistics is significantly different than 0; Lower limit, lower limit of the 95% confidence interval for the effect size; Upper limit, upper limit of the 95% confidence interval for the effect size; RD, Reaction delay).

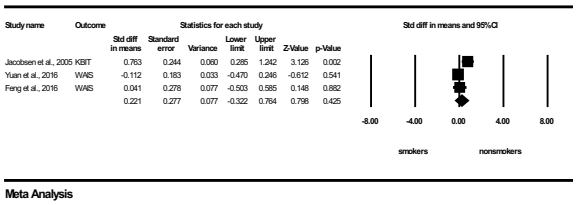

FIGURE 4
Intelligence forest plot (std diff, standard difference; Z value, one sample z statistics; p value, probability that Z statistics is significantly different than 0; Lower limit, lower limit of the 95% confidence interval for the effect size; Upper limit, upper limit of the 95% confidence interval for the effect size; WAIS, Wechsler Adult Intelligence Scale; KBIT, Kauffman Brief Intelligence test).

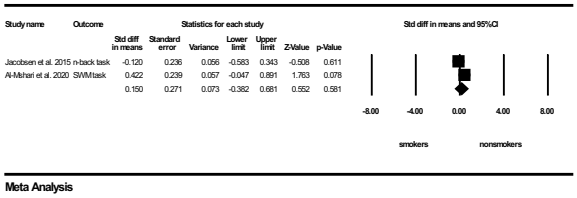

FIGURE 5
Working Memory forest plot (std diff, standard difference; Z value, one sample z statistics; p value, probability that Z statistics is significantly different than 0; Lower limit, lower limit of the 95% confidence interval for the effect size; Upper limit, upper limit of the 95% confidence interval for the effect size; SWM, Spatial Working Memory).

evidence that there are associations between adolescent or young adulthood smoking and impairments in the domains of intelligence and impulsivity respectively.

The association between chronic tobacco smoking and these neurocognitive impairments support the findings of the literature review conducted by Campos et al. (59) and of the systematic review and meta-analysis conducted by Conti et al. (39). However, the findings of the systematic review and meta-analysis conducted by Conti et al. (39) are primarily related to middle-aged adult chronic tobacco smokers, unlike the population used in the current study. Therefore, the findings of this review and meta-analysis contribute to the body of literature by showing an association between chronic tobacco smoking and neurocognitive impairments in younger age groups with a shorter smoking history.

4.2 Mechanistic interpretations

In the context of neurocognition, exposure to nicotine, either directly or indirectly, has been associated with neurobiological changes (21, 39, 60, 61). According to Conti et al. (39), exposure to nicotine is linked to complex cognitive modulation, where acute nicotine use may enhance cognitive functions, particularly in the domains of attention and memory (39, 62, 63). Aside from changes to working memory and attention, chronic nicotine exposure may be associated with neurocognitive impairments in impulse control, the speed of processing information, intellectual ability, auditory-verbal memory, and vocabulary (oral arithmetic, receptive and expressive) (4, 30, 64–66). In the qualitative analysis of Maurage et al. (53), their data suggests that young chronic tobacco smokers have more difficulty inhibiting or resisting irrelevant or distracting stimuli when focusing on relevant ones. Additionally, they indicate that chronic smokers have deficits in impulsivity and executive attentional control.

One mechanistic interpretation for the findings of this study could consist of the neurotoxic effect of nicotine on the developing adolescent brain as proposed by the Tobacco-Induced Neurotoxicity theory of Adolescent Cognitive Development (TINACD) (67). According to this paradigm, chronic tobacco smoking at younger ages may lead to structural and functional impairments in frontostriatal brain regions (e.g. PFC, ACC) modulating cognitive control, attention, and impulsivity. Alongside this, a neuroimaging study conducted by Conti and Baldacchino (68) reported a correlation between the age of regular smoking initiation during adolescence (16 years) and reduced Gray Matter (GM) volume in the VLPFC of chronic tobacco smokers (69, 70). Nicotine exposure is also associated with accelerated brain ageing and brain structural damage through its neurotoxic properties, which in turn may be associated with the reinforcing and inducing of other forms of substance dependencies (70).

The results of this meta-analysis will need to consider likely confounders. One significant consideration is that these young individuals may demonstrate neurocognitive impairments, such as impulsivity, prior to initiating smoking, meaning that the neurocognitive phenotypes demonstrated an increase in the probability of an adolescent or a young adult picking up the tobacco smoking behaviour. This is likely to be attributable to complex socioeconomic factors involved, such as education, adverse childhood experiences and other social disadvantages (71). Subsequent negative effects or neurocognitive impairments caused by chronic tobacco smoking may then lead to further impulsive reactions to avoid the unwanted negative effects of tobacco smoking

TABLE 3 Compiled effect sizes for each neurocognitive domain.

		Effect size and 95% CI				Test for Null (2 fail)		Heterogeneity		
Neurocognitive Domain	Studies	Effect Size	SE	Lower Limit	Upper Limit	Z	p for Z	Q	p for Q	I^2
Motor Impulsivity										
a. Reaction delay in ST	4	0.615	0.116	0.389	0.842	5.317	0.000**	0.471	0.925	0.000
b. Incongruent errors in ST	4	-0.593	0.116	-0.820	-0.367	-5.130	0.000**	1.705	0.636	0.000
Intelligence										
Intelligence	3	0.221	0.277	-0.322	0.764	0.798	0.425	8.496	<0.05	76.459
Working Memory										
Working Memory	2	0.150	0.271	-0.382	0.681	0.552	0.581	2.599	0.107	61.517

N, Total number of studies. P, Significance, * significant at the $p < 0.05$ level. ** significant at the $p < 0.01$ level. CI , Confidence interval; SE, Standard error; Z value, One sample z statistics; p value, Probability that Z statistics is significantly different than 0; Q, Cochran's Q; I2, Percentage of variance due to heterogeneity.

cessation, causing these adolescents and young adults to continue this smoking behaviour, establishing a positive feedback loop (72). Determining the relationship between socioeconomic factors and an individual's neurocognitive outcome in chronic adolescent smokers is of high importance.

Impulsivity has been shown to be a primary reason for the initiation of tobacco smoking, as well as the sustainment of this habit to help avoid the aversive and negative consequences of abstinence from smoking (73). According to Balevich et al. (74), it is hypothesized that this impulsiveness to initiate smoking is related to sensation seeking (reward-seeking) and curiosity while the impulsiveness to sustain the smoking behaviour is related to disinhibitory impulsiveness. This disinhibitory impulsiveness is related to the aversion of the negative effects of cessation, which are associated with nicotine dependence. As chronic tobacco smokers are at risk of dependence, this is a form of impulsiveness that is of high importance (75). Young adults who are chronic smokers also show more risk-taking behaviours than their counterparts (4, 76).

Intriguingly, when considering the younger ages of the individuals included in this meta-analysis, it is proposed that neurocognitive impairments are associated with a relatively short history of chronic tobacco smoking. This may suggest that smoking at an early stage of life predisposes the brain to progressive neurocognitive impairments, (e.g. heightened motor impulsivity). This may lead to the development of compulsive tobacco-seeking and smoking behaviour during adulthood, therefore negatively impacting quality of life and increasing the risk of adverse health outcomes (77). This proposed relationship between early onset tobacco smoking and compulsive tobacco smoking during adulthood, however, remains speculative at this stage due to the lack of robust longitudinal studies.

4.3 Strengths and limitations of the methods used and the results

To gather both qualitative and quantitative data, various online databases were used to identify the studies pooled for this systematic review and meta-analysis. The inclusion and exclusion criteria were stringent and allowed us to exclude participants with concurrent psychiatric illness, excessive alcohol intake, or polydrug use, as these were considered confounding variables.

The number of papers used in the current meta-analysis was low due to the lack of relevant research conducted on adolescents and young adults. This may have affected the results of the meta-analysis testing the association between chronic tobacco smoking and working memory impairments, as it was only possible to include three studies. There are discrepancies between the results of the quantitative and qualitative analyses for the domains assessed. This may have occurred due to the low number of studies that could be included in the meta-analysis and may also be the result of studies utilising different neurocognitive tests to assess the neurocognitive domains.

The reliability of results may be affected by including case-control studies, which are considered non-randomised studies (NRS). This may allow a larger or more unpredictable uncalculated bias to cause an underestimation or overestimation of the results (78). The inclusion of case-control NRSs is due to the lack of Randomized Controlled Trials (RCTs) carried out on chronic tobacco smoking.

The results of the meta-analysis identified an association between adolescent and young adult chronic tobacco smoking and neurocognitive impairments from cross-sectional data. Therefore, a direct causation cannot be inferred. Many other substances, such as alcohol, opioids, and stimulants, have been extensively explored in individuals, and subsequently have shown to affect neurocognitive functions (42, 79–81). The results of this meta-analysis could be considered confounders for these individuals, as the users of these substances are likely to be concurrent chronic tobacco smokers, which may account for a degree of neurocognitive impairment identified in users of other substances (39, 82–84). In the studies included in the current systematic review and meta-analysis, the number of pack years was not consistent and not reported in some studies. This may be also considered a confounding factor as research has shown a negative association between neurocognitive impairments and the number of pack-years (39).

The results of the study may have been influenced by confounding variables. This includes sociodemographic factors such as socioeconomic status, level of education, adverse childhood experiences, and parental difficulties. These variables have been shown to negatively affect the neurocognitive abilities of individuals (51, 85–90).

Considering that the neurocognitive impairments identified by the current review may have been pre-morbid, longitudinal studies would be needed to investigate the directionality of the association between chronic tobacco smoking and neurocognitive impairments in adolescents and young adults. One such example has been demonstrated in a longitudinal study using Scottish data, where a lower childhood intelligence was found to be associated with a higher risk of becoming a smoker and continuing to smoke throughout life (91). Another confounding factor is the prevalence of concurrent undiagnosed neurodevelopmental disorders, such as attention deficit hyperactivity disorder (ADHD), in the assessed populations, which may influence the measured outcomes in neurocognitive testing.

A limitation of the studies being analysed during systematic review and meta-analysis is the lack of consistency in the nicotine withdrawal state of the tested chronic tobacco smoking participants. This is demonstrated through the insufficient descriptions of nicotine states and the variability in post-administration durations prior to assessment. Two studies did not include any information on this at all. This variability impacts the direct comparison of results between studies. It is important as the effects of nicotine withdrawal can begin after 4 hours, up until 3 days from the last administration of the nicotine (92). Using this cut-off, all the studies that declared the duration between the last administration of nicotine and neurocognitive assessments are within a defined and comparable period of nicotine administration that excludes states of nicotine withdrawal (5, 18, 21, 30, 43, 53, 54). Additionally, the statistically significant impairments in smokers versus non-smokers in multiple neurocognitive tests conducted shortly after nicotine administration suggest that any acute neurocognitive enhancing effects of nicotine administration were limited.

4.4 Clinical relevance

The neurocognitive impairments identified by the current review could be targeted by therapies such as Cognitive Rehabilitation Treatments (CRTs) and pre-treatment neuropsychological assessments, as aids for smoking cessation programs. CRTs are specialised procedures used to treat or improve neurocognitive functions, such as attention, problem-solving, learning and memory, and planning (39). Adolescents and young adults who are chronic smokers show more impulsivity in their decisions than their counterparts, therefore, some treatments that target this neurocognitive domain, such as Dialectical Behavioural Therapy (DBT) or Cognitive Behavioural Therapy (CBT), may be beneficial in smoking cessation programs (39, 93–96).

Components of psychological therapy will benefit from improving the understanding of neurocognitive associations with chronic tobacco smoking, and other substance abuse disorders. Psychoeducation (PE) typically involves educating a patient about their condition to explore the emotional and motivational components they experience, which aims to improve the efficacy of treatment for that individual (97). This can be combined with education on related neuroscientific pathophysiology of a health condition, termed neuroscience-informed psychoeducation (NIPE). This could include any neurocognitive associations of chronic tobacco smoking, which the healthcare professional can employ to provide the patient with an enhanced understanding, and therefore improve their insight and decision-making, whilst also destigmatising the challenges of the conditions, leading to better compliance with treatment (97). An example of the application of neuroscientific understanding to PE is the program termed "Neurocognitive Empowerment for Addiction Treatment" (NEAT), which is planned to be implemented on patients with substance abuse disorders in an RCT undertaken by Ekhtiari et al. (98).

The socioeconomic associations with adverse long-term health and social outcomes have become well established, as described in the WHO Commission on Social Determinants of Health in 2008, as well as many other government-affiliated and independent institutions (99–101). By understanding the interactions between the determinants of health and the specific outcomes in adolescent chronic tobacco smokers, policymakers can target appropriate interventions. For example, recent data from the UK show that one in four unemployed adults are smokers, almost twice the probability of an employed person, and over 28% of people with no formal qualifications are smokers, compared to 12% of people who have obtained higher education (8). Using data from the English Index of Multiple Deprivation, the rate of smoking in the population (over the age of 16) is 19% for the most deprived quintile, in comparison to 6% for the least deprived quintile (6). Identifying adolescent smokers as a high-risk group thus allows policymakers to target the population group's circumstances that contribute most to the increased risk of commencing smoking during adolescence, such as school attendance or adverse childhood experiences, as well as their carers' social circumstances including education and social capital, to improve overall long-term health and social outcomes across the population (71, 100, 102–104). Additionally, the syndemic nature of poor socioeconomic factors compounded by cognitive impairments at an early stage of tobacco smoking will be associated with a reduced probability of quitting smoking as an adult (105).

The significant increase in the adoption of electronic nicotine delivery systems (ENDS, also known as vapes or e-cigarettes) will be an ongoing concern. Survey data from the Action on Smoking and Health (ASH), carried out on the UK population, show that in 2022 more young people (11-18 years old) had participated in the use of vaping products (8.6%) than tobacco smoking (6.0%), in comparison to previous years, in which tobacco smoking had been more prevalent (106). A recent paper investigating ENDS by Wade et al. (107) suggests that the use of ENDS in 16-22-year-old participants is not associated with any neurocognitive impairments, once controlled for alcohol use, substance use, and sociodemographic factors. It demonstrated that there were no significant differences in neurocognitive performance between nicotine users and nicotine-naïve users, whilst the comparison between the ENDS and the tobacco-smoking group is confounded by the concurrent use of ENDS by the tobacco-smoking group.

5 Conclusion

This systematic review and meta-analysis proposed a cross-sectional relationship between chronic tobacco smoking and neurocognitive impairments in adolescents and young adults. The number of studies pooled for both qualitative and quantitative analyses was, however, relatively low, suggesting that further research is needed to investigate the cross-sectional relationship between chronic smoking and neurocognitive impairments in young people. Furthermore, longitudinal studies are needed to investigate the temporal relationship between tobacco smoking uptake during adolescence or young adulthood and neurocognitive impairments. A comprehensive understanding of the relationship between young smokers and adverse neurocognitive outcomes may provide opportunities to optimise clinical and public health policymaking to improve outcomes in mortality, morbidity, and quality of life. This is especially important in the context of the increasing popularity of alternative methods of nicotine administration, such as e-cigarettes or vapes, which also need particular focus.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material. Further inquiries can be directed to the corresponding author.

Author contributions

AE: Data curation, Formal analysis, Investigation, Methodology, Software, Visualization, Writing – original draft, Writing – review & editing. SV: Data curation, Formal analysis, Investigation, Methodology, Software, Writing – original draft, Writing – review & editing. AC: Conceptualization, Data curation, Formal analysis, Methodology, Software, Supervision, Visualization, Writing – original

draft, Writing – review & editing. AB: Conceptualization, Funding acquisition, Methodology, Project administration, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2024.1384408/full#supplementary-material

SUPPLEMENTARY FIGURE 1
Funnel's plot for Motor impulsivity-Stroop Task-Reaction Delay.

SUPPLEMENTARY FIGURE 2
Funnel's plot for Motor impulsivity-Stroop Task-Incongruent errors.

SUPPLEMENTARY FIGURE 3
Funnel's plot for Intelligence.

SUPPLEMENTARY TABLE 1
Impulsivity.

SUPPLEMENTARY TABLE 2
Cognitive Flexibility and Attention.

SUPPLEMENTARY TABLE 3
Memory and learning.

SUPPLEMENTARY TABLE 4
National Institutes of Health Study Quality Assessment Questionnaire.

SUPPLEMENTARY TABLE 5
PRISMA Checklist.

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Screened realities: a Grounded Theory exploration of gaming disorder dynamics among Iranian male adolescents

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Introduction: The increasing prevalence of gaming Disorder (GD) among adolescents has become a global concern. Despite the rising number of studies investigating GD, the cultural and socio-economic factors influencing GD with a qualitative approach are scarce. This study aims to explore the underlying factors, processes, and consequences of GD among Iranian male adolescents and contextual factors related to GD within Iran's unique socio-cultural and psychological tapestry.

Methods: The study used a qualitative design based on the Grounded Theory Method (GTM). The researchers conducted semi-structured interviews with 13 male adolescents aged 15-18 who Dignasoed according to DSM-5 and ICD-11 criteria. The interviews were transcribed and analyzed using the GTM approach, which involves open, axial, and selective coding.

Results: The study revealed nine main themes and a core category: (1) interaction seeking, (2) encounter and familiarize with games, (3) games attraction, (4) Socialization, (5) game careerism, (6) dexterity, (7) lack and compensation, (8) physical harm, territorial-cultural barrier, (9) second life, and "life crafting" as the core category.

Discussion: The study's findings provide valuable insights into the cultural and socio-economic factors influencing GD among Iranian male adolescents. For example, Iran's economic conditions make adolescents choose gaming as their job and try to earn money in this way, which makes them more dependent on gaming. On the other hand, communities related to games play an essential role in the identity development of adolescents with GD.

KEYWORDS

gaming disorder, internet gaming disorder, adolescents, qualitative study, grounded theory method, Iran

Introduction

Leisure time is increasingly spent on online video games (1). Newzoo reports 3.2 billion video game users and $200 billion in industry revenue (2). Gaming might benefit individuals (3), while a minority may develop addictions (4). The APA introduced Internet Gaming Disorder (IGD) as a tentative disorder in Section III of the DSM-5 in 2013 (5). However, there have been several arguments over the classification of gaming as a mental disorder (6, 7); WHO has included gaming disorder (GD) in the ICD-11 (8). Despite the distinct frameworks of DSM and ICD (9), both are valid and consistent (10). An essential symptom in both classifications is "loss of control over gaming" (11). In instances of discrepancies, however, ICD employs a stricter criterion, excluding individuals who do not exhibit functional impairment (12). Delphi survey experts agreed that ICD-11 criteria can diagnose GD without pathologizing normal gaming behavior (13). Threshold variations elevate IGD prevalence estimations (14). different classifications yield multiple assessment tools with various cut-off points (15), which results in disparate GD prevalence rates (16, 17). Nevertheless, recent reviews estimated GD global prevalence around 3% (18, 19); notably, male adolescents show higher GD incidence (20, 21).

Adolescents are susceptible to addictive disorders like gaming addiction (22, 23) due to their underdeveloped cognitive capacities (24, 25). Excessive gaming impacts physical activity, sleep, quality of life, academics, and social ties (26, 27). Furthermore, Excessive gaming correlates with low conscientiousness (28), self-esteem problems (29), anxiety, and depression (30, 31). Problematic gaming is associated with increased family conflict and poor relationships (32). Additionally, both the mental health of children and their parents are related to GD (33). Symptoms of GD are linked to motivations such as the avoidance of negative emotions, escapism, stress relief, and in-game social interactions (34, 35).

The Digital Games Research Center (DIREC) reports a twofold increase in Iranian digital gamers over a decade, reaching 34 million (36). Children and teenagers aged 2–17 comprise about 45% of participants. The average daily video game usage is 125 minutes for 69% of Iranian adolescents (36). Research indicates that GD prevalence among Iranian adolescents ranges from 4.2% to 17% (37–39). Gaming addiction in this group correlates with reduced physical and mental health (40).

Areshtanab et al. (41) identified a relationship between IGD and the authoritative parenting style among Iranian primary school students. However, their research needed to include the cultural depth of Iranian parenting and the significant peer influence in this age group. A recent study by Hejazifar and Livarjani (42) identified a strong link between sensation-seeking behaviors and online gaming addiction in Iranian youth. However, these sensation-seekers' more profound personal experiences and motivations remain largely unexplored.

Abbreviations: APA, American Psychiatric Association; DSM-5, Diagnostic and Statistical Manual of Mental Disorders, fifth edition; ICD-11, International Classification of Diseases, eleventh-edition; WHO, World Health Organization.

Iran exhibits the highest per capita opium use globally (43), which puts the Iranian society and culture in a unique situation in case of addiction (44). Previous studies have shown that variations in cultural settings may affect the patterns and correlates of online video gaming and pathological online gaming (45, 46). As GD is a novel diagnosis, it is necessary to provide a psychological understanding of this phenomenon within Iran's social and cultural context (9, 47).

The majority of research on GD and IGD undertaken in Iran has used quantitative methods, creating a significant gap in understanding the cultural intricacies and profound personal experiences of gamers with GD. The present study adopts a qualitative design utilizing the Grounded Theory Method (GTM) to address this gap. The primary aim is to explore the underlying factors, processes, and consequences of GD among Iranian male adolescents. Additionally, this research seeks to uncover the contextual factors related to GD within Iran's unique socio-cultural and psychological tapestry.

Methods

Study design

The study was based on consolidated criteria for reporting Qualitative research (COREQ) and the Journal Article Reporting Standards checklist (JARS). The research study was conducted using a qualitative method known as the grounded theory method, which is effective in describing individual behavioral patterns and lived experiences and developing theories about the major concerns in people's lives (48). Grounded theory research primarily investigates social experiences, psychosocial processes, and the sequential steps that constitute a phenomenon or event (48, 49). The GTM is founded on symbolic interactionism, which enables people to find and comprehend meaning by interacting with others (50, 51). This approach also allows researchers to identify novel characteristics of events and provides a hypothesis that is founded on real-world experiences and is systematic (52).

The GTM stands out for its adaptable approaches to data collection, analysis, meaning extraction, and upgrading codes from the conceptual to the formal theory levels (53). The emerging theory is significant because it expands on the experience from the perspective of a particular group or environment (54). The GTM consists of theoretical sampling, continual comparative data analysis, memoing, establishing the core category, and building an exploratory theory (52). In this study, Corbin and Strauss's Grounded Theory approach (52) was employed to examine the data and explore the underlying factors, processes, and consequences of IGD and GD among male adolescents in Iran.

Measures

The present study utilized measurement instruments to screen participants for IGD and GD before participation. These are described below.

Farsi version of the Gaming Disorder Scale for Adolescents (GADIS-A): The scale was developed by Paschke et al. (55) as a screening tool for adolescents' GD according to ICD-11 criteria. It has nine Likert scale items ranging from 0 (strongly disagree) to 4 (strongly agree) and an extra question assessing time criteria with options from 0 (not at all) to 3 (almost daily). Cronbach's alpha reported 0.91 for GADIS-A. Mazaherizadeh et al. (37) adapted this scale to Persian with a Cronbach's alpha of 0.85.

Structured Clinical Interview for Internet Gaming Disorder (SCI-IGD): Koo et al. provided SCI-IGD to evaluate IGD, considering DSM-5 criteria (56). The interview contains twelve questions evaluating nine IGD criteria. The study's authors assessed its content validity. Seven experts from clinical and psychometric fields deemed each item necessary on a three-point scale. Based on Lawshe's formula (57), SCI-IGD's content validity was affirmed.

Structured Clinical Interview for DSM-5 Research Version (SCID-5-RV): The First et al. (58) tool used in this study to assess participants' comorbid disorders. It is the most detailed version of SCID-5, encompassing numerous disorders, subtypes, severity, and periodic traits. A key feature of SCID-5-RV is its customizability for research purposes. In Iran, Mohammadkhani et al. (59) validated its content and deemed it appropriate for diagnosing disorders.

Semi-structured in-depth interview: Concerning the research literature on addictive behaviors such as gaming and gambling, researchers provided a primary interview with open-answer questions. This interview tested the pilot on three individuals who were not included among the participants. Then, the interview was fitted to be performed (the primary version of this interview is attached in the Appendix).

Participant recruitment

The study recruited participants through SMS invitations sent to 3000 individuals from the DIREC database. Of these, around 600 expressed interest, with only three women over 18. As a result, the study was limited to male participants, which is mentioned as the study's limitation. Of these 600 individuals, 128 were from Tehran aged 13-18, and GADIS-A was sent to them for the primary screening, which led to 28 individuals for diagnostic interview. Their diagnosis was rechecked during the interview to ensure the accuracy of their responses and prevent random answers. The participants who met the diagnosis criteria according to ICD-11 were then assessed for IGD using the SCI-IGD. Eventually, six participants were recruited. Furthermore, the study utilized snowball, purposive, and theoretical sampling. These six individuals introduced the other seven participants. The interviews were conducted online, and voice recordings and field notes were taken. The participants' demographic information is presented in Table 1, with assigned numbers to protect their privacy.

Procedure

Data was collected from June 2022 to June 2023. Before interviews, participants were briefed on the study, anonymity, and their voluntary involvement. The first author, with over four months of qualitative study training and seven years of experience as a school counselor and life skills coach for teens, conducted interviews via Skype or WhatsApp. An experienced psychologist then administered the SCID-5-RV in a separate online session. Participants were thanked with a $25 gift card. Comorbid disorders are detailed in Table 1.

Ethical considerations

The study was approved by the University of Tehran's Ethics Committee (code: IR.UT.PSYEDU.REC.1399.025). After qualifying via GADIS-A, the participant and their parents were informed about the research. Following their consent, the SCI-IGD assessment took place. Parents received further details if the criteria were met, and approved consent forms were sent for signature. Written informed consent was obtained from the minors' legal guardians to publish any potentially identifiable data included in this paper. Participants were entitled to know their diagnosis and interview findings.

Data analysis

All interviews were subsequently transcribed. The extensive data corpus included more than 200 pages of transcripts. Data analysis was conducted based on Strauss and Corbin's guidelines following each interview (52). Consequently, the interview guide could be adapted to go deeper into growing concepts, and participants could be selectively chosen for further investigation. Following the transcription of the interviews, each text went through multiple readings to allow for an in-depth immersion into its contents. Data coding was performed by the first author and another expert out of the research simultaneously. The coding procedure was regularly reviewed by the research supervisors, who were the second and third authors of the study and who were university boards. The open coding process resulted in the identification of axial codes and the core category.

The data analysis process was characterized by its non-linear nature, as it involved a dynamic and continuous process that necessitated ongoing comparative analysis and subsequent modifications to the coding system. The analytical process comprises two stages, namely the paradigmatic and procedural steps. The core category emerged, and other themes were linked to this core theme. The procedure was carried out in five distinct phases: initial analysis of the data and identification of the concepts for open coding; constant comparative analyses to identify differences and similarities and provide a comprehensive description of the concepts through axial coding; analyzing the information to establish a foundation; incorporating the process into the analysis; Finally, categories were combined, linked to the core category, and the theory was refined until the theory has emerged (52). A detailed audit trail was maintained to ensure trustworthiness, and respondent validation (60) was used to verify the analysis's credibility. Four participants were consulted for

10.3389/fpsyt.2024.1357211

TABLE 1 Demographic Information of Participants.

Participant number	Age	Grade	Birth order	Father age	Father education	Mother age	Mother education	Interview duration	Comorbid disorder(s)
1	13	Seventh	Second	45	Bachelor	45	Master's	79	None
2	18	Twelfth	Second	53	Diploma	44	Diploma	41	Social Anxiety Disorder
3	17	Eleventh	Second	51	Middle school	45	Middle school	49	Past Major Depression Disorder
4	17	Eleventh	Second	53	Bachelor	50	Master's	37	Persistent Depressive Disorder
5	18	Twelfth	Third	59	Middle school	46	Elementary	51	Social Anxiety Disorder
6	15	Ninth	Second	49	Elementary	47	Diploma	45	Separation Anxiety Disorder, Obsessive-Compulsive Disorder
7	18	Twelfth	Second	50	Master's	45	Diploma	30	Generalized Anxiety Disorder, Obsessive-Compulsive Disorder
8	16	Tenth	First	42	Diploma	39	Diploma	82	Obsessive-Compulsive Disorder
9	14	Eighth	Second	55	Bachelor	40	Bachelor	36	Attention Deficit Hyperactivity Disorder
10	16	Ninth	First	45	Diploma	35	Diploma	56	Generalized Anxiety Disorder, Past Obsessive-Compulsive Disorder
11	14	Eighth	First	50	Bachelor	45	Bachelor	54	Social Anxiety Disorder
12	13	Seventh	First	52	Bachelor	48	Master's	31	Past Generalized Anxiety Disorder
13	16	Ninth	First	42	Bachelor	39	Bachelor	43	Intermittent Explosive Disorder

feedback, leading to grounded theory adjustments based on their insights.

Results

Through data analysis, one core theme and ten main themes were discerned under the direction of Corbin and Straus (52). The themes were categorized into three main groups: Contextual Factors, Actions/Interactions, and Consequences. In the following section, we will elaborate on each theme and present a conceptual model encompassing all the themes and processes associated with developing IGD and GD in Iranian male adolescents. Figure 1. depicts the interplay and connections among the core themes, contextual factors, actions/interactions, and consequences.

Core category: *Life crafting*

The core theme, "Life crafting," delves deep into the profound influence of excessive gaming on an adolescent's life trajectory and identity. The online gaming environment introduces teens to notable

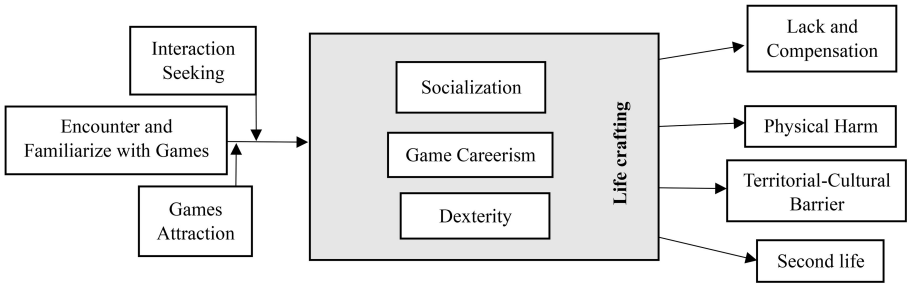

FIGURE 1
Integrated diagram of main themes around core themes.

figures who have attained success, wealth, and fame, altering their perception of traditional life milestones. For instance, watching professionals on platforms like YouTube can reshape their career outlook, making gaming seem lucrative and enjoyable. This shift in perspective can sometimes lead to devaluing traditional education, seeing it as redundant or a waste of time. If gaming is not accessible, they might be reluctant to engage in academic activities due to a lack of motivation or an altered value system. Participant 1 described one of these role models,

> *I was actually watching different entertaining videos on YouTube, and I came across a particular video in which a person was playing professionally, and he really attracted me to that video. In general, I realized how much money this man is making, how much he is having fun with this work, and finally, it has become his job.*

These gaming experiences also influence their future job aspirations. While some aim to pursue a gaming career, others are drawn to IT and computer-related jobs even if they are unsuccessful. Participant 8 said,

> *At first, I wanted to reach a place in my field where I could become a teacher, but now that I see it is better, it is easier for me to work with a computer. I can go into interior design and decoration; working with a computer is better for me.*

The online environment fills their social interaction void and introduces them to influential figures in the gaming world. These figures often take on a guiding role, influencing their life choices and helping shape their identities. This category also highlights the importance of internet games in how teens' identities are acquired through excessive gaming and related activities.

Contextual factors

Contextual factors are incidents and events influencing the emergence and progression of a phenomenon, notably impacting actions/interactions. They signify individuals' initial encounters with video games.

Encounter and Familiarize with Games: This theme shows the person's exposure to games and how he learned about gaming, especially online games. Initial involvement was a significant predisposing factor in developing GD in this study. The participants' first encounter with the game occurred between the ages of 3 and 12. Friends and social media were crucial resources for teenagers to learn about and become familiar with the games. For instance, their schoolmates introduced them to gaming or online gaming. Participant 2 described the encounter process,

> *When I was between 8 and 9 years old, a friend of mine had an Android mobile phone on which he played Clash of Clans, and I loved it. At the age of nine, I received my first phone and began playing Clash of Clans.*

Games Attraction: Research participants played diverse game genres. The theme emphasizes games' broad appeal, not specific genres. Some noted their game's appeal, such as the allure of FPS games or an offline game's engaging plot. However, the participants' comments showed many game characteristics crucial for problematic gaming among teenagers. The game's endless nature encourages repeated play, regardless of outcomes. Winning or losing evokes strong emotions. This allows teenagers, often engrossed in games, to experience various feelings. An engaging, endless game seems attractive and can immerse players so deeply that they lose track of time. Participant 4 explained this sensation seeking and immersion,

> *People might think playing while agitated is not satisfying, but that's not true. We may feel frustrated, but we still derive pleasure from it. This enjoyment is so intense that I become completely immersed in the game and ignore other things.*

Interaction Seeking: All participants mentioned a "cold" family environment, indicating a lack of emotional connection at home. Because teenagers lack relationships in the real world, they turn to online games for social interaction. This desire for communion influences their game choice, drawing them into excessive gaming. For instance, several used Zula, an Iranian FPS online game, for its communicative features. While in-game communication is vital for coordination, Iranian teenagers often extend these relationships outside games, compensating for their real-world relationship void. Participant 13 detailed the family atmosphere,

> *I don't go out of my room much. No one has anything to do with anyone in our home; only Mom and Dad sometimes speak to each other. There is no such a common connection between us. I would instead enjoy playing games with my friends because nothing is interesting about my family.*

No participant considered themselves social except one. Their underdeveloped communication skills hindered forming new relationships. Comorbid disorders with GD cannot be causally linked. However, anxiety disorders, notably social anxiety disorder, had the highest proportion of comorbidity in this study, suggesting an interaction-seeking behavior. As Participant 6 put it,

> *I am timid. when I am said to buy three loaves of bread, I will turn beet red in the bakery. I don't know why, but this is how I am.*

Actions/interactions

Individuals use actions/interactions to engage with situations, solve problems, or navigate contexts purposefully or reactively.

These acts, significant in daily life, manage or highlight phenomena. They encompass visible behaviors, emotions, beliefs, and specific responses to circumstances.

Dexterity: To profit and excel in a game, one must master it, altering their lifestyle to prioritize gameplay. This professional player's lifestyle, briefly depicted in the game, overshadows other daily activities. Becoming a pro requires skill development through effort, extended play, and observing other pros. Increased gaming can also expose one to disordered gaming and its negative impacts. Participant 7 explained this professional transition,

> *Someone who cares about the game becomes his priority; He follows new games everywhere and spends some time watching the games of professional players. On the other hand, a professional gamer should play at least 7-8 hours a day to maintain that level of playing.*

Socialization: Online games, played among real people, facilitate interaction between players. The social connections forged in games compensate for real-life relationship voids and provide a sense of belonging, which can lead to problematic gaming to maintain these connections. Many online games emphasize cooperation, where players form teams to outdo opponents collaboratively. This team dynamic offers a sense of belonging and a feeling of achievement. Such game affiliations help users feel less isolated and satisfy their social needs. Participant 8 remarked,

> *Online games appeal to me because they allow you to engage with other people from all over the world. The fact that we should work well together differs from the fact that everyone can do anything they want. Furthermore, you have a team that supports you.*

Game careerism: Most participants were drawn to online gaming for financial gains, using unique strategies like modifying and selling user accounts. While most employed unconventional methods, only one earned through traditional gaming avenues like Esports tournaments. Two participants abstained from financial pursuits due to religious concerns. Some, like Participant 2, claimed their earnings surpassed their family's income. Regardless of their current earnings, the prospective income remained a strong motivator, making them view gaming as a potential well-paying job with fame opportunities. This strong motivation to earn money often pushed teens to play excessively. Participant 11 put it,

> *I always wanted to do something as entertainment or to earn some money or something like that. After realizing I could make money through games and become famous, I became a gamer and thought of doing online games professionally.*

Consequences

Actions/interactions in response to a phenomenon have consequences, which can be desired or unwanted, immediate or gradual, and predictable or not. These consequences can range from minor to extensive, potentially creating a chain of events that influence future actions/interactions.

Physical Harm: Excessive playing causes physical injuries, which are visible consequences of GD. These bodily injuries are most likely evident to the adolescent and his family; the family's worry is focused on these effects. The primary repercussions teenagers experienced in this study were weight gain, musculoskeletal issues, and sleep disturbance. In this regard, Participant 6 stated,

> *For example, I sit down and play if I have been playing for an extended period, my eyes feel a bit heated. If you don't have a good seat, your back will ache.*

Second Life: Online gaming can replace socializing, feeling accomplished, and motivating teens to work and gain money. Since he has a second life in the game, he loses essential aspects of real life. Virtual life does not have the same duties as real life. The game's virtual world has no obligations or expectations, making it more enjoyable. Consequently, vital aspects like education may be neglected. Participant 5 stated,

> *When you are playing, maybe you have a dispute with your friend in the game, but not too much. In the outside world, you have to study, take tests, or fight and argue with people who don't like you.*

Lack and Compensation: The game dominates the adolescents' lives, becoming integral to their identity. Without it, they feel a significant void, disconnected from relationships and meaningful activities. This "lack" often arises from being restricted from playing. The game also serves as a coping mechanism, helping the teenager manage negative emotions. Some even equate its importance to necessities like food and water. Participant 7 mentioned,

> *I slept more that week when I was banned from playing. I used to sleep like this till midnight, wake up and watch a movie on my phone, then sleep again until morning. That week flew by, and it was really awful that I don't want to remember it.*

Territorial-Cultural Barrier: Unique to Iranian society, cultural and social constraints influence adolescent gaming expectations. Families, having seen the negative impacts of gaming on their child, are often at odds when the child wants to pursue gaming as a career. This difference in views leads to conflicts between the teen and their parents. When the teenager is involved in the family's cultural limitation conflict and endures much tension, even if parental attitudes shift, certain territorial constraints persist. In Iran, there is a pressing need for better gaming facilities. Challenges include the high costs of systems and slow internet speeds, which are crucial for online gamers. According to participant 12,

> *Look, this is Iran, and there are many limits; for example, the internet connection is so slow that you can't even access WhatsApp with it, or I purchased a handheld device that can't play many games, so you can't select gaming as a job.*

Discussion

This research aimed to cultivate a comprehension of GD and IGD within male adolescents in the context of Iranian culture. To the best of the author's knowledge, this study is the first investigation into the phenomenon of IGD and GD amongst Iranian gamers utilizing a qualitative research methodology and the grounded theory approach. This study has discovered new and culturally influenced observations in GD, which will be discussed further.

The study identifies three subcategories in "Encounter and Familiarize with Games": age of initiation, social media, and peer influence. Early exposure is linked to problematic internet use (61) and IGD (62), with peer influence, often through game invitations, correlating with gaming intensity (63, 64). Today's "digital natives" (65) are immersed in the digital world from a young age (66), frequently encountering online games via social media.

This study suggests that certain game features may contribute to Game Disorder (GD), including endless nature, complexity, first-person shooter, fantasy graphics, strategy, immersion, and role-playing elements (67, 68) a wide range of games could lead to GD regardless of genre (28). Sensation-seeking, which encompasses positive and negative emotions experienced during gaming, is linked to GD (69). Competitive and interactive elements in games, fostering player competition and a sense of achievement, are shown to excite players and are associated with GD (9). It seems that games capable of providing these immersive and competitive experiences could potentially possess addictive qualities.

In the context of GD, interaction-seeking involves two subcategories: emotional fulfillment and social anxiety. Adolescents with poor family attachments, a known risk factor for GD (27, 70), often turn to online gaming for communication needs. These findings align with Salehi et al.'s study (71) which indicated a negative correlation between secure attachment and IGD among Iranian adolescents. Additionally, social anxiety plays a dual role. It's seen as an inherent trait in introverts, linked to IGD (9, 27), and as a disorder where virtual spaces provide a safer environment for socializing, especially beneficial for those with social anxiety, as it's less stressful than face-to-face interactions (72).

The socialization category in online gaming, crucial for adolescents seeking connections and belonging (73), is a response to interaction seeking and a key motivator for those with disordered gaming symptoms (74). Its role in excessive gaming is notable (28). However, a study by Rafiemanesh et al. (75) showed that Iranian university students prioritize recreation over socialization, possibly due to their communication needs being met within the university environment, unlike adolescents. Consequently, gaming communities become vital for teenagers, offering recognition and a sense of authenticity. Vilasís-Pamos et al. (76) identified five gamer categories, with two groups, celebrity-platform gamers, and professional gamers, aiming for fame, fans, and professional status. This desire for recognition and achievement in gaming communities is a primary motivation for participants in this study.

The second life means a person provides a complete life in the game's virtual world. Online games allow individuals to meet real-life needs (70) (e.g., belonging, achievement, and connection with others). This virtual life in the game space separates the teenager from the difficulties and responsibilities of real life, causing him to ignore one of his most important personal responsibilities which is education. Previous research suggests academic failure as a consequence of GD (21).

In this study, physical harm indicates damage to the body, such as inactivity, weight gain, and skeletal-muscular problems, which are also associated with excessive playing, according to previous studies (16). As previously stated, sleeping problems are a significant side effect of GD (26). However, Due to internet restrictions in Iran, teens opt to play games at night to obtain better quality internet, which worsens the difficulty of sleeping among Iranian teenagers suffering from GD.

The SCID-5-RV results revealed that all participants -except one- had at least one clinical diagnosis besides GD and IGD, with significant comorbidity of psychological disorders, especially anxiety disorders, suggesting excessive gaming as a distress-related coping mechanism (77). This supports the study's model linking the need for communication and relationship formation in Iranian adolescents with GD and IGD. Comorbidity with disorders like anxiety, depression, and obsessive-compulsive disorder aligns with prior research (31, 72). While intermittent explosive disorder (IED) isn't typically comorbid with GD, its associated impulsivity, a common symptom in IED and ADHD (78, 79), is a known risk factor for GD (16, 80). Further research is needed in Iran to explore comorbid disorders with GD.

In IGD research, escape, or mood modification is akin to gaming to change mental state in this study. Montag et al. (9) identified escape motivation as a critical predictor of GD. Another study found that individuals with IGD use gaming to alleviate negative emotions linked to disorders like major depression and dysthymia (81). This trend is evident in our study, where most participants with psychological disorders used gaming to improve their mental state, aligning with Davis's model (77) that suggests underlying psychological issues drive the problematic use of games for mood regulation.

DSM-5 characterizes withdrawal symptoms in gaming as arising from an inability to access games (82). In this study, such withdrawal, termed 'lack' following game deprivation, was prevalent among participants. This finding varies from Holm et al. (83), who reported withdrawal symptoms in 59% of their sample, and Yen et al. (84), who observed that 85% of their IGD participants experienced symptoms like an urge to play and emotional distress, which gaming alleviated. These results are consistent with our study, indicating that adolescents use gaming to compensate for their experienced lack.

The "life crafting" category highlights the significant impact of GD on the lives and worldviews of affected youth. During the interview, the researcher was incredibly driven by the participants' passionate descriptions of the game and related events. Memos show that the interviewer desired to experience the discussed online games personally after some interviews. Life crafting was chosen as the core theme because of this profound experience and continual comparisons of concepts and categories. This choice reflects the profound influence of gaming, particularly during adolescence, a crucial stage for identity development (85). The influence of group norms and virtual communities on behavior and social identity is notable (86, 87), with some games enabling players to craft alternative identities (88).

In this study, participants' identities were deeply intertwined with gaming, shaping their attitudes towards school, careers, and relationships, aligning with Bacchini et al. (88), who found MMORPG players often neglect real-world responsibilities and question their life choices. This research uniquely explores online gaming's impact on various identity dimensions, revealing that games significantly influence adolescents' identity and life direction. Participants, having played games since early childhood without alternative identity exploration sources, often model their identities on prominent figures in gaming communities. This aligns with social identity theory (89), which suggests connections to social referents shape self-concept. Future research should investigate the impact of these figures (e.g., professional gamers, YouTubers, and Streamers) on adolescents' identity and gaming behavior.

Teenagers' career choices are shaped by their gaming-influenced identity in three ways. First, those who don't see themselves as superior gamers often pivot towards computer-related careers, perceiving them as convenient, flexible, and profitable. Second, the 'game careerism' category reflects a desire among adolescents to pursue game-related professions. This aligns with the growing popularity of professional gaming and e-sports among youth (90). Finally, this study reveals that beyond traditional gaming careers like streaming, YouTubing, or professional gaming, some participants consider ancillary roles, such as editing videos for YouTubers, viable career options. Participants in this study chose eSports careers based on factors like convenience, flexibility, and entertainment, which is consistent with Said et al.'s findings (91). Additionally, the potential for monetary gain was a key motivator. With technology's expected growth, the demand for computer-related jobs is likely to increase, influencing young people's career choices due to the prevalence of computers, games, and media in everyday life. Longitudinal research is needed to assess the impact of GD on adolescents' career paths and its broader individual and social effects.

Financial incentives were a key motivator for nearly all participants in this study, linked to the increased severity of IGD symptoms as shown in previous research (92). However, Iranian adolescents aspiring to become professional gamers face cultural-territorial challenges, including high costs of gaming systems, poor internet quality, and sanctions hindering participation in e-sports events. Culturally, many parents in Iran, similar to findings by Jiow et al. (93), do not recognize pro-gaming and YouTube careers as legitimate, often expressing concerns about time management and academic neglect. This reflects a parental perspective similar to that in Iran, though children's attitudes may differ.

Despite cultural-territorial barriers, Iranian adolescents continue to pursue gaming as a source of income and career choice. They engage in activities like enhancing and selling gaming accounts or trading in-game items for profit. Iran's challenging economic conditions, marked by a limited job market, inflation, and financial instability (94, 95), drive adolescents towards alternative income sources like gaming. The global nature of the gaming sector offers access to international markets and the potential to earn more valuable foreign currencies amidst the national economic crisis. This unique economic context in Iran may fuel the trend of adolescents seeking income through gaming, a notable difference from their peers in more stable economies. Further research is needed to understand the relationship between economic conditions and the pursuit of gaming-related income.

In gaming, individuals find a sense of belonging, achievement, and potential income, leading them to improve their skills continually. The 'dexterity' category highlights the belief in the importance of skill enhancement, which is achievable only through frequent play. Professional gamers facing high-performance demands show higher rates of disordered gaming (96). Despite its slim chances of success, the pursuit of professional gaming may increase the risk of excessive gaming among players (90).

Limitations

The present study has limitations that need careful consideration. Primarily, the necessity for remote data collection, with interviews conducted online, might have influenced the depth of information obtained. This method of data gathering could potentially impact the accuracy of participants' self-reported data.

Furthermore, the coexistence of IGD and GD within the same study sample raises the possibility of symptom severity overlap, potentially confounding the differentiation between the two conditions and affecting the conclusions' precision. Additionally, the recruitment of some participants through DIREC might have introduced bias, as individuals who actively chose to participate could represent a more engaged subgroup with distinct experiences, potentially affecting the findings. Furthermore, the study was limited to male participants due to the lack of access to female participants, resulting in limited gender diversity and potential bias in findings.

Conclusion

This pioneering qualitative study offers an understanding of GD among Iranian male adolescents, unveiling its cultural nuances and multifaceted nature. The research highlights the significance of early exposure, social media, and peer influence in driving excessive gaming while delving into the psychosocial dimensions of interaction seeking, family attachment, and social anxiety. The concept of "life crafting" reveals how gaming shapes adolescents' identities and career aspirations. Furthermore, the clash between aspirations for professional gaming careers underscores the need for culturally sensitive interventions. By contextualizing GD within the Iranian context, this study provides valuable insights for tailored strategies and opens avenues for cross-cultural exploration of the phenomenon.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by University of Tehran's Ethics Committee (code: IR.UT.PSYEDU.REC.1399.025). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin. Written informed consent was obtained from the minors' legal guardians for the publication of any potentially identifiable data included in this paper.

Author contributions

AM: Writing – review & editing, Writing – original draft, Methodology, Investigation. ZT: Writing – review & editing, Supervision, Methodology. HF: Writing – review & editing, Supervision, Methodology, Data curation. ZH: Writing – review & editing, Supervision.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Appendix

Main questions	Following questions
What's your idea about internet gaming?	- How did you get acquainted with online games? - When did you start? (How long have you been playing)? - How often do you play? - When do you usually play during the day? - How much time do you spend each time you play?
Tell me about the games you play.	- What games do you play? - Do you play one specific game or play various games? Have you experienced other games? - What is attractive about this game rather than other games? Why do you prefer this game? - Do you practice your game when you are offline? - Do you spend money for gaming? How much? - Have you ever been in trouble for spending a lot money? - What is your rank? Does your rank matter to you? Why?
What is your motivation/reason for playing?	- When do you go to play usually? When do you need more playing? - What makes you start playing? (thoughts, feelings, special moments)
Tell me about your experience when you are playing.	- What do you feel when you are playing? - How does this type of game make you feel compared to than other games? - What is your reaction when you fail? What about winning? - What is enjoyable about gaming? - Do you feel like that something is preventing you to stop gaming? Can you explain it?
Tell me about the people you play with?	- Who are you playing with? Are they your friends or meet them in game space? - Do you care who are your teammates? Do you care about real personality of your teammates? - How is your relationship with your teammates? Do you have relations out of game space?
Does playing affected your life?	- Relationships, family, friends - lifestyle, goals - school, home works - is there anything else you want to do?
Can you explain me a regular day of your life?	- How do you spend your leisure time? Is it different now than before familiarize with gaming? – What is enjoyable about these leisure activities?
Tell me about your family?	- Parents relationship with each other - Parents relationship with other sibling - Parents attitude toward gaming - Your relationship with sibling - family atmosphere in general - Can you describe your parents?
How do you describe yourself?	- How does your family and friends describe you? - How did teachers describe you? - How many close friends do you have? Do others consider you a social person?
Are you active in social networks?	- Which networks or applications? - how much time do you spend on them? - Do you post about your gaming through social networks? - Does it matter to you that your gaming activities seen by others on social network?
Have you ever been banned from playing?	- How was your experience during that period? - family, therapy or….
What do you think about earning money from gaming?	- have you ever been made money from gaming? How much? - How did you made this money?
Is there anything that I didn't ask and you want to explain?	

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Resting-state brain networks alterations in adolescents with Internet Gaming Disorder associate with cognitive control impairments

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Objective: Research indicates that cognitive control is compromised in individuals with internet gaming disorder (IGD). However, the neural mechanisms behind it are still unclear. This study aims to investigate alterations in resting-state brain networks in adolescents with IGD and the potential neurobiological mechanisms underlying cognitive dysfunction.

Materials and methods: A total of 44 adolescent IGD subjects (male/female: 38/6) and 50 healthy controls (male/female: 40/10) were enrolled. Participants underwent demographic assessments, Young's Internet Addiction Scale, Barratt Impulsiveness Scale 11 Chinese Revised Version, the Chinese Adolescents' Maladaptive Cognitions Scale, exploratory eye movement tests, and functional magnetic resonance imaging (fMRI). FMRI data were analyzed using the GIFT software for independent component analysis, focusing on functional connectivity within and between resting-state brain networks.

Results: In comparison to the control group, impulsivity in adolescent IGD subjects showed a positive correlation with the severity of IGD ($r=0.6350$, $p < 0.001$), linked to impairments in the Executive Control Network (ECN) and a decrease in functional connectivity between the Salience Network (SN) and ECN ($r=0.4307$, $p=0.0021$; $r=-0.5147$, $p=0.0034$). Decreased resting state activity of the dorsal attention network (DAN) was associated with attentional dysregulation of IGD in adolescents ($r=0.4071$, $p=0.0017$), and ECN increased functional connectivity with DAN. The degree of IGD was positively correlated with enhanced functional connectivity between the ECN and DAN ($r=0.4283$, $p=0.0037$).

Conclusions: This research demonstrates that changes in the ECN and DAN correlate with heightened impulsivity and attentional deficits in adolescents with IGD. The interaction between cognitive control disorders and resting-state brain networks in adolescent IGD is related.

KEYWORDS

Internet Gaming Disorder, adolescents, independent component analysis, resting-state brain networks, cognitive control

1 Introduction

Internet Gaming Disorder (IGD) is characterized as a distinct behavioral addiction marked by the excessive and compulsive engagement with video games (1). Recent epidemiological studies (2, 3) have shown that the morbidity of IGD among adolescents is approximately 5.5%. In China's urban regions, it is estimated that approximately 14% of adolescents are affected by IGD, totaling around 24 million individuals (3, 4). The notion of Internet Gaming Disorder (IGD) was initially introduced in the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) (5). In 2018, the 11th revision of the International Classification of Diseases (ICD-11) officially recognized gaming disorder as a mental disorder stemming from addictive behaviors (6). Cognitive control deficits are viewed as a significant risk factor for behavioral addictions, characterized by inadequate emotional regulation, compromised cognitive skills, attention deficits, and impulsive behavior. The progression of IGD further deteriorates an individual' s cognitive capacities, creating a vicious cycle (7, 8). Currently, there is a lack of high-quality evidence-supported effective treatment measures (9), which may be related to the still unknown pathophysiology and cognitive mechanisms of IGD (10).

A neural network model derived from functional magnetic resonance imaging (fMRI) data holds promise for elucidating the pathogenesis of IGD. Menon et al. proposed the triple network model (11). The salience network (SN) is believed to be associated with detection and coordination (12), including regulating the activities of the default mode network (DMN) and the executive control network (ECN). DMN is active during an individual's resting state, participating in processes such as introspection, memory integration, emotional processing, and social cognition (13). ECN participating in multiple advanced cognitive tasks and playing an important role in cognitive control. Networks are widely connected and influence each other. The neurobiological mechanisms of various mental disorders, including addiction, can be explained using a triple network model (14). However, there is less research on other intrinsic connectivity networks (ICNs) (15), although these ICNs have been proven to be related to cognitive functions (16), such as the dorsal attention network (DAN) involved in top-down action and perception processes and attention control, and the ventral attention network (VAN) related to stimulus-driven attention control. In network analysis techniques, the independent component analysis (ICA) method allows for better identification of ICNs, and then studying how functional connectivity related to these networks is regulated (17).

Zhang et al. found that compared with HCs, IGD had significantly increased SN-DMN connectivity, suggest that the deficient modulation of ECN versus DMN by SN (18). One study suggested that the diminished cognitive control during real-time gameplay was associated with FC alterations, involving a weak FC in the cognitive control network, suggesting that individuals with IGD may have less cognitive control (19).Recent resting-state fMRI studies indicating that IGDs show enhanced rsFC between the ventral attention network and regions within the somatomotor network, suggesting that the interaction between stimuli-driven attention and addictive behavior might be facilitated (20, 21). However, The specific pathological mechanisms of these network interactions in IGD cognitive control disorders are uncertain and therefore require more research. Since the prevalence of IGD is highest during adolescence (2), the developmental characteristics of the brain in adolescents should be considered when exploring the pathogenesis of IGD. The Executive Control Network is still not fully developed during adolescence (22), so it may play a different role in the neural mechanisms of adolescent IGD compared to adult IGD. Diverging from prior research, this study investigates alterations within and among resting-state brain networks, emphasizing the association between these changes in brain networks and impaired cognitive control abilities. It is the first study to examine the role of modifications in the ECN in the mechanism of IGD in adolescents.

In this study, we examined the resting-state functional connectivity within and between ICNs in adolescents with IGD and HC. We analyzed the differences in internal interactions of ICNs between the IGD and HC groups and assessed the functional connectivity between ICNs. Drawing on prior resting-state functional magnetic resonance imaging (rs-fMRI) research, we investigated the DMN, ECN, SN, VAN, and DAN. We hypothesized that compared to the HC group, the functional connectivity between these networks would be reduced in adolescent IGD, indicating neurodevelopmental changes that may be associated with cognitive dysfunction.

2 Materials and methods

2.1 Study participants

The study recruited adolescent participants from the outpatient and inpatient units of the Department of Psychiatry at the First Affiliated Hospital of Zhengzhou University between September 2021 and September 2023. Inclusion Criteria for the IGD Group: 1. Age range of 12-18 years, regardless of gender. 2. Asian ethnicity and right-handedness. 3. Diagnosis of internet gaming disorder as per DSM-5 criteria by a psychiatrist. 4. A total score of ≥40 on Young's Internet Addiction Scale. Inclusion Criteria for the HC Group: 1. Age range of 12-18 years, regardless of gender. 2. Asian ethnicity and right-handedness. 3. A total score of <40 on Young's Internet Addiction Scale. Common Exclusion Criteria: 1. History of severe brain trauma or organic brain diseases (e.g. encephalitis, epilepsy). 2. Mental retardation. 3. Comorbid or past history of psychiatric disorders (e.g. schizophrenia, depression, anxiety disorders, bipolar disorder). 4. Family history of psychiatric illnesses or hereditary diseases. 5. History of substance or drug abuse. 6. Contraindications to MRI scanning. Additional Exclusion Criteria for the IGD Group: 1. Use of psychiatric medications or other treatments such as physical therapy or psychotherapy within the past month. The study received approval from the Ethics Committee of the First Affiliated Hospital of Zhengzhou University and was conducted in accordance with the Declaration of Helsinki. Informed consent was obtained from all participants and/or their guardians, who signed the consent form.

2.2 Methodology

2.2.1 General data collection

Psychiatrists evaluated all study subjects based on the IGD criteria to determine their eligibility and exclusion. Basic information, including gender, age, educational background, ethnicity, history of mental and physical health conditions, and family history, was gathered from all participants. Moreover, participants were assessed using various scales, and their rs-fMRI data were collected.

2.2.2 Psychological scale assessments

Young's Internet Addiction Scale: All subjects were evaluated using the Young's Internet Addiction Scale (23), a 20-item questionnaire scored on a 5-point scale, resulting in a maximum score of 100. The scale categorizes addiction severity into mild (40 ≤ Young score < 60), moderate (60 ≤ Young score < 80), and severe (Young score ≥ 80), with higher scores indicating more severe internet gaming disorder.

Barratt Impulsiveness Scale 11 Chinese Revised Version (BIS-11): The BIS-11 (24) is composed of three subscales: cognitive impulsiveness, motor impulsiveness, and non-planning impulsiveness. Each subscale has scores ranging from 10 to 50, where higher scores denote increased impulsivity.

The Chinese Adolescents' Maladaptive Cognitions Scale (CAMCS) (25): This scale comprises 12 items, each rated on a Likert scale from 1 (strongly agree) to 5 (strongly disagree), with higher scores reflecting greater maladaptive cognitions. It demonstrates good internal consistency (alpha = 0.81) and validity.

The scales were filled out by the patient themselves, and the evaluation work was completed by a professional psychiatrist from the First Affiliated Hospital of Zhengzhou University.

2.2.3 Exploratory eye movements monitoring

All subjects participated in EEM testing utilizing the Shanghai Dekang DEM-2000 eye movement detection system. EEM studies may facilitate understanding of the neurobiology of populations with mental disorders, and evaluate mechanisms involved in attention processes. For example, reflexive saccades are considered to be type of cognitive parameter that evaluates attention (26). In this study, assess the presence of attentional deficit in subjects by analyzing the number of eye fixations (NEF), search score responses (RSS), and discriminant (D) values within the initial 15 seconds of observing a target image.

2.2.4 MRI data collection

MRI data were acquired using a Siemens Magnetom Prisma 3.0T MRI scanner equipped with a 64-channel head coil. Participants were advised to lie in a supine position, keep their eyes open, breathe calmly, and refrain from any spontaneous mental activities. Initially, a standard MRI head scan sequence was conducted to eliminate individuals with notable brain structural abnormalities. Subsequently, rs-fMRI scans were performed utilizing single-shot echo-planar imaging (EPI) technology. The detailed scanning sequences and parameters were as follows: 1. Routine MRI scan: T1-weighted imaging (T1WI) sequence with a repetition time (TR) of 190 ms, echo time (TE) of 2.6 ms, interslice spacing of 1 mm, slice thickness of 5 mm, flip angle of 70°, and field of view (FOV) of 240 mm × 240 mm, covering 20 slices. Rs-fMRI scans were performed on subjects with no abnormal T1WI sequence. 2. Rs-fMRI scan: Blood-oxygen-level-dependent (BOLD) sequence with a TR of 1000 ms, TE of 30 ms, flip angle of 70°, slice thickness of 2.2 mm, covering 52 slices. The total scan duration was 360 seconds.

2.2.5 fMRI data preprocessing

The preprocessing of data was conducted using the DPABI toolkit on the MATLAB platform, involving the following steps: (1) Conversion of data format: Transforming files from DICOM to NIFTI format. (2) Elimination of initial images: Discarding the first 10 time points to mitigate noise in the early scan phase. (3) Timing of slices: Adjusting for differences in timing between slices, using the middle slice as the reference point. (4) Realignment: Excluding participants with head movement exceeding 3 mm in displacement or 3° in rotation; however, no participants were excluded for excessive head motion in this study. (5) Normalization: Adapting rs-fMRI images to fit the EPI template and resampling them to a resolution of 3 mm × 3 mm × 3 mm. (6) Smoothing: Applying a Gaussian filter with a full width at half maximum (FWHM) of 6 mm for spatial smoothing of the images.

2.2.6 Resting-state activity analysis within ICNs

Group ICA (gICA) was performed using the GIFT software (SedDB, RRID: SCR_024416), a method for decomposing a set of images into statistically independent components. The process involved data decomposition, ICA computation, reconstruction of individual components, and Fisher z transformation. For each participant, The minimum description length (MDL) algorithm is used to determine the number of independent components (ICs) to 30, decompose 30 ics and generate independent spatial maps. IC selection was based on visual inspection and spatial correlation values between ICs and templates. Spatial maps of selected ICNs for each participant were converted to Z values, indicating their contribution to the temporal dynamics of the independent components. Resting-state brain network analyses for each group were performed using SPM 12 software in MATLAB. Firstly, the voxel single sample t test ($P<0.05$, FDR correction) was performed on the spatial maps of all subjects, and the independent component of the network were selected to obtain the corresponding mask. Statistical analysis (two-sample t test) was then performed for each component to compare the differences between the IGD and HC groups ($P<0.05$, FDR correction), using the mask obtained in the previous step.

2.2.7 Functional connectivity analysis between ICNs

Multivariate analysis of covariance (Mancovan) module in GIFT software, Pearson correlation coefficients between brain functional networks in IGD group and HC group were calculated, respectively, which is functional network correlations (FNC), after Fisher Z transformation to ensure the normality of the data, the differences in FNC values between the groups were calculated (test level $p < 0.05$, FDR correction, two-tailed).

2.3 Statistical analysis

Statistical analysis was conducted using SPSS software (version 25.0, Chicago, Illinois) to compare the general and clinical characteristics of the two groups of participants, with a significance threshold set at P<0.05. Independent sample t-tests were used for continuous variables, and chi-square tests were utilized for categorical variables. Additionally, Pearson correlation analysis was performed to evaluate the association between scale scores and functional connectivity in both groups.

3 Results

3.1 Demographics and scales

The adolescent IGD group consisted of 44 participants, with 38 males and 6 females, while the HC group had 50 participants, including 40 males and 10 females. No significant differences were observed between the adolescent IGD and HC groups in terms of age, gender, and educational background. The scores on Young's Internet Addiction Scale were significantly different between the two groups (P<0.05). On the Barratt Impulsiveness Scale, the adolescent IGD group exhibited significantly higher scores than the HC group in all three dimensions: motor impulsiveness, cognitive impulsiveness, and non-planning impulsiveness (P<0.05). The NEF and RSS scores also showed significant differences, with the adolescent IGD group scoring lower than the HC group in both measures (P<0.05). Additionally, there was a significant difference in CAMCS scores between the two groups, with the adolescent IGD group scoring higher than the HC group (P<0.05). Refer to Table 1 for details.

TABLE 1 Demographic and clinical characteristics of participants.

	IGD (n=44)	HC (n=50)	T	P
Age (years)[a]	14.55 ± 2.02	14.70 ± 3.74	-0.253	0.801
Years of Education(years)[a]	8.75 ± 1.74	9.06 ± 2.37	-0.753	0.453
Gender(male: female)[b]	38:6	40:10	0.706	0.401
YIAS[a]	64.23 ± 10.82	25.58 ± 5.97	21.049	<0.001
BIS-11[a]	38.52 ± 3.27	22.02 ± 4.20	33.798	<0.001
Motor impulsiveness[a]	38.23 ± 3.53	22.30 ± 6.49	17.100	<0.001
Cognitive impulsiveness[a]	40.80 ± 5.80	21.99 ± 7.30	20.984	<0.001
Non-planning impulsiveness[a]	36.39 ± 8.00	21.60 ± 6.70	22.814	<0.001
NEF[a]	27.77 ± 0.94	30.76 ± 5.17	-13.405	<0.001
RSS[a]	6.61 ± 1.65	8.50 ± 0.99	-6.614	<0.001
D[a]	2.73 ± 1.34	0.54 ± 0.97	8.967	<0.001
CAMCS[a]	44.26 ± 5.44	32.11 ± 4.19	12.00	<0.001

[a]represents independent sample t-test, [b]represents χ^2 Inspection. YIAS, Young Internet Addiction Scale; BIS-11, Barratt Impulse Scale 11 Chinese Revised Edition; NEF, number of eye fixation; RSS, responsive of search scores; D, discriminant; CAMCS, the Chinese Adolescents' Maladaptive Cognitions Scale.

3.2 Spatial distribution of ICNs

From the 30 components derived using GIFT, five were selected based on our criteria: IC17, IC4, IC10, IC9, and IC15, which are represented in Figure 1 as significant neural networks. The spatial maps of these five chosen ICN are depicted in Figure 1. Within these networks, the DMN consists of regions such as the medial prefrontal cortex, anterior cingulate cortex, posterior cingulate cortex, precuneus, and angular gyrus. The ECN encompasses areas like the medial prefrontal cortex, inferior frontal gyrus, and inferior parietal lobule, with the dorsolateral prefrontal cortex (dlPFC) being its central region. The SN comprises the insular cortex, dorsal anterior cingulate cortex, amygdala, and temporal pole. The VAN includes the ventral frontal cortex and temporo-parietal junction. Lastly, the DAN contains the bilateral intraparietal sulcus and the junction area of the precentral sulcus and superior frontal sulcus (frontal eye field).

3.3 Resting-state activity differences within ICNs related to adolescent IGD

To assess differences in resting-state activity within ICNs associated with adolescent IGD, a two-sample t-test was utilized. Figure 2 displays brain regions with significant differences between groups. Adolescent IGD participants exhibited enhanced resting-state activity in the middle frontal gyrus (MFG) and precentral gyrus, part of the dLPFC, a key node of the ECN, compared to the HC group. In contrast, resting-state activity in the frontal eye field (FEF) of the DAN was diminished. Refer to Table 2. No differences in resting-state activity related to adolescent IGD were detected in other ICNs at the same significance threshold.

3.4 FC differences between networks related to adolescent IGD

Figure 3 depicts the functional connectivity among all five networks. It was observed that in comparison to the HC group, the interaction between the ECN and SN was reduced($t = -3.1$, $p < 0.01$), whereas the interaction between the ECN and DAN was heightened ($t = 2.4$, $p < 0.01$). No notable differences in interactions involving these networks were detected between the two groups (all p-values > 0.01), suggesting that these connections might not be linked to IGD.

3.5 Correlation analysis

Pearson correlation analysis (refer to Figure 4) in IGD group showed correlations between BIS-11 scores and three measures: YIAS scores(r=0.6350, P<0.0001), abnormal resting-state activity in ECN(r=0.4307,p=0.0021), and abnormal functional connectivity in SN-ECN(r=0.-5147,p=0.0034). The abnormal resting-state activity of DAN was correlated with NEF value(r=0.4071,p=0.0017), and the abnormal functional connectivity of ECN-DAN was correlated with YIAS score(r=0.4283, P=0.0037).

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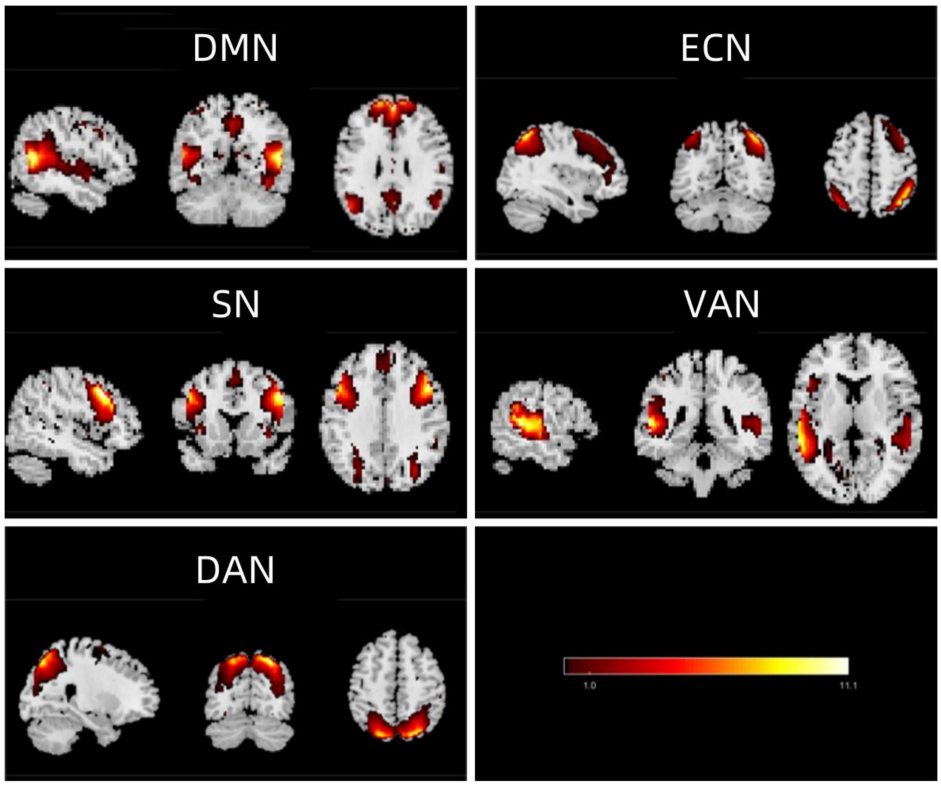

FIGURE 1
Extracted independent components. From the group ICA of resting-state data, five independent components were identified and classified as follows: DMN (default mode network), ECN (executive control network), SN (salience network), VAN (ventral attention network), and DAN (dorsal attention network).

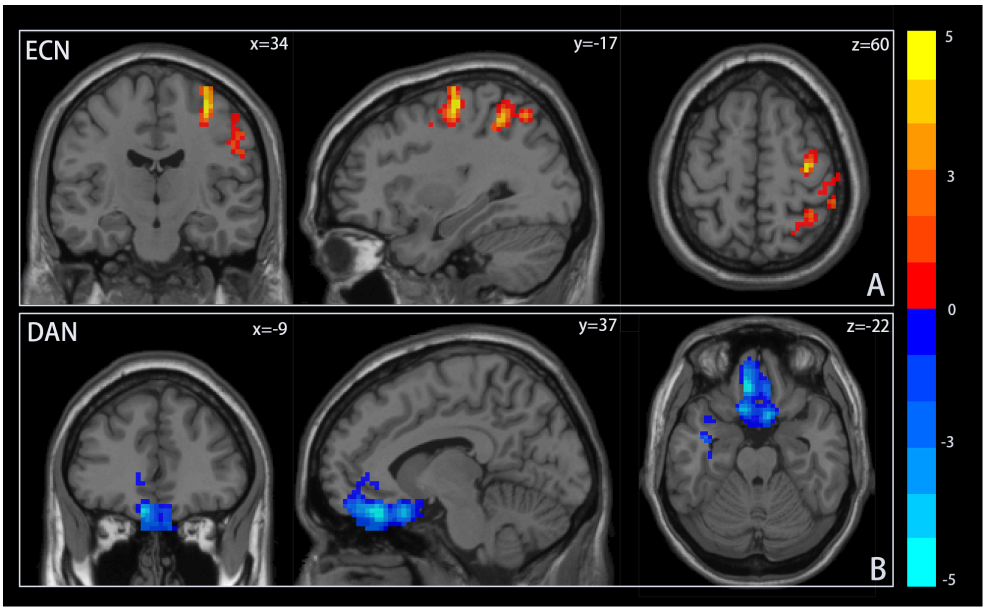

FIGURE 2
Resting-state activity differences within ICNs. Notes: **(A)** Resting state activity in the frontal gyrus and precentral gyrus within the executive control network(ECN) was significantly higher in the adolescent group with Internet Gaming Disorder (IGD) than in the healthy control group (HC). **(B)** In contrast, resting state activity in the frontal eye area within dorsal attention network(DAN) was significantly reduced compared to the HC group. Areas in red or blue indicate increased or decreased resting state activity, respectively.

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TABLE 2 Brain regions with differences in resting-state activity in the IGD group.

Abnormal brain area	ICN	Peak MNI coordinates	T	Voxel size
		X Y Z		
Middle frontal gyrus	ECN	44 33 42	3.2771	31
precentral gyrus	ECN	34 -17 60	4.3327	86
Frontal eye region	DAN	-9 37 -22	-3.6770	99

P<0.05, FDR correction, clump ≥ 30, MNI, Montreal Institute of Neurology; ECN, executive control network; DAN, dorsal attention network.

4 Discussion

Relative to the HC group, adolescents with IGD displayed increased resting-state activity within the ECN and reduced functional connectivity between the ECN and SN, linked to heightened impulsivity, which correlates positively with IGD severity. Studies have shown that participants with IGD exhibit enhanced functional connectivity in the ECN during cognitive tasks, which is related to a decline in the ability of IGD subjects to control impulsivity (27). Our results show that the CAMCS scores of the adolescent IGD group were higher than those of the HC group (P<0.05), indicating impaired cognitive function in adolescent IGD. In the Barratt Impulse Scale, the IGD group had the highest score for cognitive impulsivity factors and the highest standard deviation for unplanned impulsivity factors. This indicates that adolescents with IGD have higher variability in cognitive impulsivity and unplanned behavior, suggesting that the increased resting-state activity in the ECN cannot effectively suppress their impulsivity. One possible reason is that the ECN in adolescents is still not fully developed, and even if the resting-state activity within this network increases, it still cannot suppress impulsivity as effectively as in adults. Yuan et al. found that the interaction between the SN and the right ECN during the Stroop task was reduced in 28 IGD subjects compared to the control group (28). Our results show that the interconnection between the SN and ECN is reduced, indicating that adolescents with IGD cannot adequately suppress ECN activity in the switching process within the brain network during rest, leading to poor impulse control.

In comparison to the HC group, adolescents with IGD showed decreased resting-state activity in the frontal eye field (FEF) within the DAN and elevated functional connectivity between the ECN and DAN, linked to attentional deficits. The strengthened functional connectivity between the ECN and DAN was positively associated with the severity of IGD. The FEF is activated during finger pointing and saccade tasks (29). Eye movements are related to the control of attention and decision-making (30). Exploratory eye movement tests can serve as an objective behavioral indicator for detecting higher cognitive processes in the cerebral cortex and subcortex (31). NEF (number of eye fixations) and RSS (response exploration score) reflect an individual's cognition, memory, and attention. Results showed that the NEF and RSS scores of the adolescent IGD group were significantly lower than those of the HC group (P<0.05), indicating attentional deficits related to weakened resting-state activity within the DAN. A possible explanation is that the extensive attentional shifts through multitasking, a characteristic of IGD, may impair cognitive function through habituation (32). The ECN is extensively connected with the DAN and plays a role in regulating perceptual attention (33). Studies have found (34) that reduced functional connectivity between the ECN and DAN is related to attentional development in adolescents with Attention-deficit/hyperactivity disorder (ADHD). Our study is the first to find increased functional connectivity between the ECN and DAN in adolescent IGD, related to attentional deficits. Dixon (35) et al.'s study found that the ECN can prioritize involvement in DAN connections during attentional deficits. Our results show that the DAN exhibits weakened resting-state activity, while the functional connectivity between the ECN and DAN is increased, related to attentional deficits in adolescent IGD subjects. Compared to adults, the effect

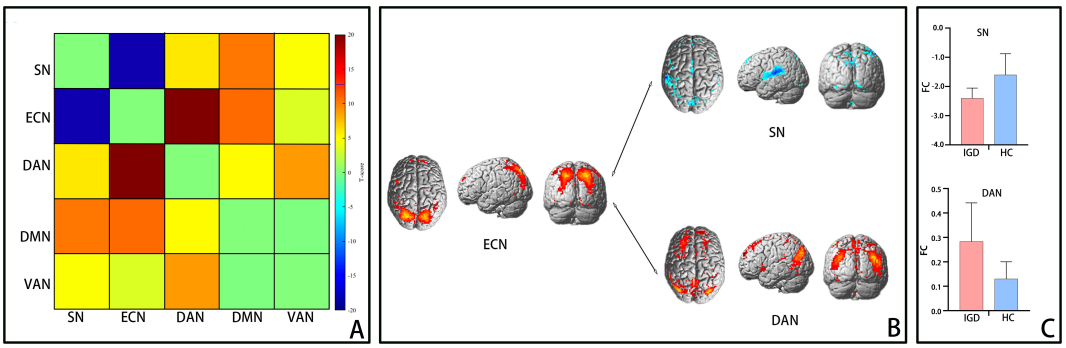

FIGURE 3
Functional connectivity differences between networks. Notes: **(A)** Heat map of functional connectivity between brain networks in the IGD group. Warm and cool colors represent areas with higher or lower functional connectivity between networks. **(B)** Display the statistical significance of functional connectivity between networks in brain 3D rendering of networks. The functional connectivity between ECN-SN decreased, while the functional connectivity between ECN-DAN increased (P<0.05, FDR corrected). **(C)** Use a two sample t-test to display the bar plot of functional connectivity between IGD and HC networks (P<0.05). The upper figure shows that compared with the HC group, the IGD group shows a decrease in the functional connections of ECN-SN, while the lower figure shows an increase in the functional connections of ECN-DAN. IGD, internet gaming disorder; HC, healthy controls; ECN, executive control network; SN, salience network; DAN, dorsal attention network.

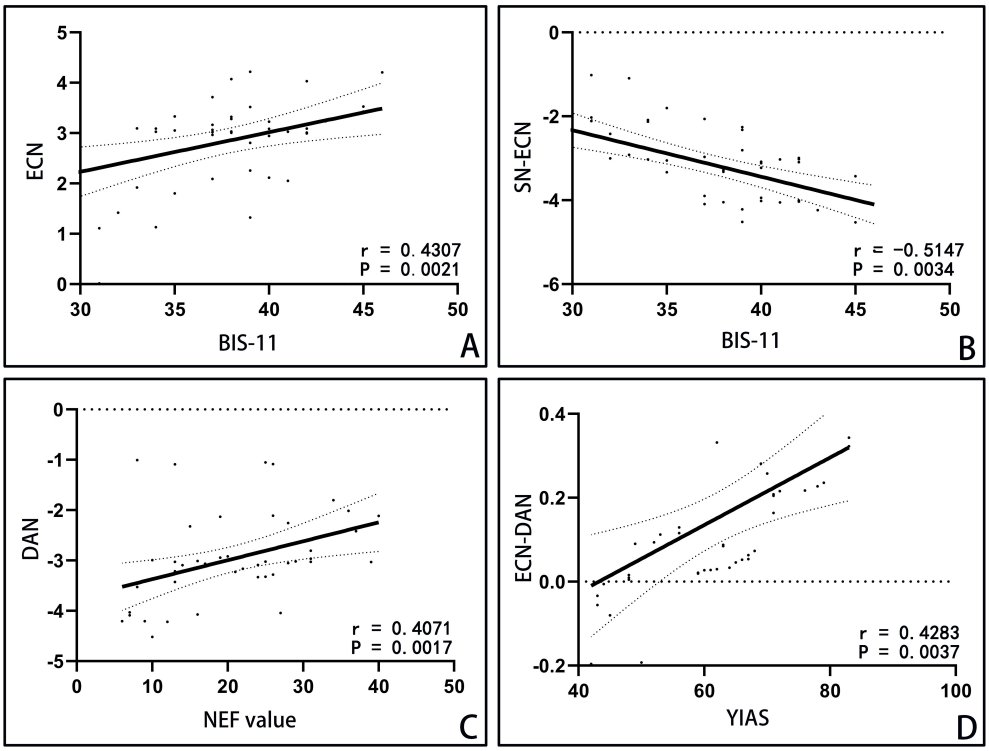

FIGURE 4
Correlation analysis in IGD group. Notes: **(A)** Abnormal resting-state activity of ECN was positively correlated with BIS-11 score. **(B)** Abnormal functional connections of SN-ECN were correlated with the score of BIS-11. **(C)** The abnormal resting-state activity of DAN was correlated with NEF value. **(D)** The abnormal functional connection strength of ECN-DAN was positively correlated with the total score of Young scale. ECN: executive control network; BIS-11: Barratt Impulse Scale 11 Chinese Revised Edition; SN: salience network; DAN, dorsal attention network; NEF, number of eye fixation.

size of attentional deficits in adolescents is lower (36). A possible reason is that the ECN in adolescents may not be as flexible as in adults in regulating prioritization of DAN connections, and attentional abilities continue to develop during adolescence. Fair et al. highlighted the significance of network segregation in the brain and cognitive development during adolescence (37), with attentional performance potentially improving as the ECN becomes more segregated from other brain networks. Enhancing the autonomy of the ECN and diminishing its connections with the DAN could contribute to the advancement of attentional development in adolescents. The functional connectivity between the ECN and DAN is positively correlated with the score on Young's Internet Addiction Scale, suggesting that attentional deficits could result in increased functional connectivity between these networks, potentially leading to extended gaming behavior. This increased functional connectivity may serve as a predictor of the severity of adolescent IGD.

Brewer et al. found that decreased cognitive control ability can predict treatment outcomes and relapse of drug use (38). Therefore, understanding the neural mechanisms behind cognitive control in IGD is very important. Currently, there is limited understanding of the changes in connectivity within the ECN and between the ECN and DAN in behavioral and cognitive impairments (39). However, this seems to be a different area of functional connectivity in cognitive control for adolescent IGD. Changes in functional connectivity may specifically distinguish between adolescent IGD individuals with and without cognitive control impairments, and altered functional connectivity may predict the severity of adolescent IGD, which may be beneficial in developing specific treatment plans for adolescent IGD. Our study further demonstrates changes in the ECN, SN, and DAN and their interactions in individuals with adolescent IGD. Future treatments may enhance brain network connectivity through cognitive behavioral therapy (CBT) or external stimuli like transcranial magnetic stimulation, thereby enhancing the cognitive control ability of IGD (40), which may be an important goal of IGD treatment.

5 Limitations

This study has two limitations. Firstly, as a case-control study, it does not establish a causal link between adolescent IGD and compromised cognitive function. Longitudinal studies are required to explore this causal relationship. Secondly, the study predominantly involved male adolescents, potentially reflecting the higher incidence of IGD among males. Future research should examine the variations in resting-state brain networks of adolescent IGD across different genders.

6 Conclusion

This research demonstrates that changes in the ECN and DAN correlate with heightened impulsivity and attentional deficits in adolescents with IGD. The interaction between cognitive control disorders and resting-state brain networks in adolescent IGD is related.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by The Ethics Committee of Zhengzhou University First Affiliated Hospital. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin. Written informed consent was obtained from the individual(s), and minor(s)' legal guardian/next of kin, for the publication of any potentially identifiable images or data included in this article.

Author contributions

TZ: Conceptualization, Software, Writing – original draft. YZ: Data curation, Formal Analysis, Writing – review & editing. YGL: Conceptualization, Writing – review & editing. JW: Data curation, Formal Analysis, Writing – review & editing. RW: Data curation, Formal Analysis, Writing – review & editing. QL: Data curation, Formal Analysis, Writing – review & editing. DL: Data curation, Formal Analysis, Writing – review & editing. YL: Conceptualization, Methodology, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Young and adult patients with gaming disorder: Psychiatric co-morbidities and progression of problematic gaming

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Background: Previous research suggests age-dependent differences in the progression of addiction, and evidence is accumulating, showing that an early initiation of gaming increases the risk for addiction. With the recent introduction of gaming disorder (GD) as a psychiatric diagnosis, there is a need to extend the knowledge of the clinical characteristics of patients seeking treatment for GD of all age groups. Compared to adolescents and young adults, less is known about treatment-seeking adults. This study aimed to investigate whether there are clinically relevant age-dependent differences among patients seeking treatment for GD.

Method: Participants were recruited among patients seeking treatment and fulfilling diagnosis for GD at an outpatient clinic specialized in the treatment of GD. During the study period, 142 patients went through assessment for GD at the clinic, 37 did not fulfill the diagnosis for GD, and 36 declined participation, leaving a sample of 69 patients (age range = 15–56) for analysis. The sample (men, n = 66; women, n = 3) was divided in two age groups: adolescents and young adults (25 years or younger) and adults (26 years or older). Gaming-related data and information about psychiatric co-morbidity was collected through structured clinical interviews and questionnaires.

Results: The adolescents and young adults (AYAs) reported a more rapid progression into problematic gaming than the adult group. The younger group developed problematic gaming four years faster than the adults. We also observed comparable clinical profiles in both groups. Both age groups had similar levels of GD as well as symptoms of psychiatric co-morbidities including possible attention deficit hyperactivity disorder (ADHD), autism spectrum disorders (ASD) and problematic gambling. We also noticed that half of our study population consisted of adults.

Conclusion: With the increasing prevalence of gaming in all age groups, it is unknown how the occurrence of GD will develop in different stages of life. We

conclude that the adolescents and young adults had almost double as fast progression to problematic gaming than the adult group, highlighting the need for preventive strategies. The similarity in clinical profiles indicates that treatments with the same type of interventions could be offered to both age groups.

KEYWORDS

gaming disorder (GD), adolescents and young adults (AYAs), adults (MeSH), age, progression, psychiatric co-morbidity

Highlights

- Problematic gaming exists in all age groups, but adults are often excluded in treatment studies. Therefore, we wanted to compare young and adult patients with gaming disorder.
- Half of our patients were adults.
- The younger patients were 14 years old and the adults were 21 years old when they first developed problems with gaming.
- Many of our patients also had symptoms of ADHD or autism.
- We suggest that the same type of treatment could be useful for both adolescents and adults with gaming disorder.

Introduction

Gaming has rapidly increased during the last decades. Technological advances have made it possible to design more complex games offered through a variety of platforms, and online gaming is now available around the clock. Gaming is now a widespread popular activity in both younger and older age groups (1), and it is predicted that more than one-third of the global population will be videogame players in the end of 2024 (2). For most people, gaming is a pleasurable pastime, but for some gaming gradually comes to dominate daily activities, causing significant impairment that develops into a gaming disorder (GD).

The phenomenon of being addicted to videogames has been reported as early as in the 1980s, although a large increase of studies was observed parallel with the introduction of online gaming in the 2000s (3). In 2019, GD was included by the World Health Organization (WHO) as a new diagnosis in the International Classification of Diseases (ICD-11) under the section for substance use and addictive behaviors (4, 5). Gaming disorder is defined by impaired control over gaming, increasing the priority given to gaming and continuation of gaming despite the occurrence of negative consequences. A similar diagnostic construct named Internet gaming disorder was included among "Conditions for Further Studies" in the Statistical Manual of Mental Disorders (DSM-5) (6). In DSM-5, it is described that individuals with GD often devote at least 8–10 h per day and a minimum of 30 h per week to gaming. The amount of time spent gaming is, however, not a valid discriminator between engaged gamers and those with GD (5, 7). Even though the time spent on gaming is not a diagnostic criterion, it has been found to be positively associated with GD. In a cross-sectional study with adolescents, it was found that those fulfilling GD typically spent an average of 5 h per day gaming, whereas the non-addicted gamers generally spent around 3 h (8). Furthermore, in a sample consisting of both teenagers and adults, the average time spent gaming among those at risk for GD was 42 h per week, while those not at risk played on average 24–26 h per week (9).

Recent meta-analyses indicate global prevalence rates for GD of 1.96% and 1.39%, respectively, when only including studies with representative samples (10, 11). However, studies show global differences, with especially high prevalence in Asian countries (10, 11). There are also indications that the prevalence of GD is rising, especially among women, although analyses show that part of this rise might be attributable to changes in ways to measure GD (11). There are further considerable differences in the prevalence rates between different demographic groups. Gaming disorder is 2.5 times as common among men than women (11), and about three times as common among children, adolescents, and young adults compared to adults (10). There is also an association between the prevalence rates and types of games being played, with genres such as massively multiplayer online-playing games (MMORPGs), first-person shooter (FPS), and multiplayer online battle arena (MOBA) being more associated with GD (12) as well as online games more than offline games (13).

Although there is a scarcity of longitudinal studies, research suggests that starting gaming at a younger age is a risk factor for the development of GD (14) and that early exposure can contribute to more severe levels of GD (15, 16). An association between younger age of initiation and development of addiction has also been found in other behavioral addictions. Two large cross-sectional national surveys found an increased risk for gambling disorder when gambling is started at an early age (17, 18). Similar findings have also been reported regarding the early use of the Internet (19, 20).

This mirrors earlier research on substance use disorders. Research has shown that early experiences of drugs—for example, alcohol—are associated with a higher risk for dependence and related problems during adult life (21). Individuals with an early exposure to drugs have also been found to progress faster to addiction than those with a later onset (22, 23). It has also been described that those who begin drinking at an early age (around 12 years of age) are more heavily genetically predisposed to alcohol use disorder (AUD) compared to those who start drinking at an older age (24). Interestingly, in a longitudinal twin study, time spent gaming was similarly found to be dependent on genetics with a heritability of 19%–63%, with an increased genetic contribution at older ages for boys, but not for girls (25).

Comparably to other addictions, research has shown that psychiatric co-morbidity is common among those with GD. Closely related to GD is depression and anxiety (13, 26–28). Meta-analyses have also shown positive correlations between ADHD and GD (29) and between ASD and GD (30). Studies also indicate a possible relationship between excessive gaming and psychosis in young people (for a summary see 31) and that overexposure to videogames could trigger a psychotic onset or worsen a pre-existing psychosis (32, 33). Gaming disorder also appear together with the use of a variety of substances in the adult population [see the review by Burleigh et al. (34)]. Problematic gaming has further been shown to co-occur with cigarette smoking, nicotine use, alcohol, caffeine, and cannabis use (35–39) as well as more frequent substance use and polysubstance use (40). Interestingly, in contrast to the findings mentioned above, a heavy investment in gaming has also been found to be associated with lower alcohol use in adults (41). Studies further suggest that there are age differences in psychiatric co-morbidity, with older individuals with GD being more heavily burdened with co-morbidity (16, 26).

Other individual factors have also been linked to GD. For example, associations with personality traits have been reported, in particular, high neuroticism and low conscientiousness (42). Difficulties in identifying one's emotions, i.e., alexithymia, has been linked to the problematic use of the Internet in general (43) and more specifically to GD (44). Furthermore, having low self-esteem has as well been linked to GD (15). These individual factors may contribute to an increased risk of GD, but they may also be reinforced by extensive gaming in a bidirectional relationship. In addition, it has been found that specific motives for gaming are more strongly associated with GD than others, with escapism repeatedly being identified as having the strongest relationship (45–47). Similarly, spending more time online and also more time playing videogames has been described to increase during pandemic-related stress, possibly as a coping strategy (48).

Research about GD has mostly focused on younger populations. Adults are often omitted both in studies with clinical samples (49, 50) and in studies about GD and psychiatric co-morbidity in the general population (26, 27). Moreover, treatment studies have often excluded adults. In a brief oversight of the literature on treatments for GD, we found three reviews (49–51), one meta-analysis (52), and one mix of a review and a meta-analysis (53). These included almost 100 unique papers, and of these only 1/4 included adults (>25 years) as participants. Even though GD is more prevalent among the younger age groups (11), indications of age-dependent differences in co-morbidity (16, 26) as well as the increased prevalence of gaming in all age groups, highlight the importance of including individuals of all ages when conducting research about GD.

This study aimed to expand the knowledge about patients seeking treatment for GD and specifically to investigate possible differences in clinical profiles between adolescents and young adults (AYA) and adult patients. As most clinical studies focus on younger patients, this adds valuable knowledge for designing treatment options suitable for both AYAs and adults with GD. In line with previous research on alcohol, we hypothesize that an early debut of gaming leads to a faster progression of GD. We also hypothesize that the adults will have more psychiatric co-morbidity than the AYAs.

Materials and methods

Study design

This study was an observational cross-sectional study. The sampling method was a non-probability convenience sample, as patients were able to decline participation. The data was collected between February 2020 and March 2024, and the participants were continuously recruited as they sought treatment at the study site. The study sample was divided into two groups, based on age at seeking treatment, after the data had been collected. The information used in the study was obtained through semi-structured interviews and standardized questionnaires. The Swedish Ethical Review Authority, dnr 764-18, had approved the study, and it was conducted according to the 1964 Declaration of Helsinki.

Participants and procedure

The participants (n = 69) were recruited from the Clinic for Gambling disorder and Screen Health, Department of Addiction and Dependency, at Sahlgrenska university hospital in Gothenburg, Sweden. The clinic is the largest public health outpatient facility offering treatment for gaming disorder in Sweden and welcomes patients with GD from the year they turn 16, with no upper age limit set. The treatment offered is based on cognitive behavioral therapy. Patients are referred to the clinic either by self-referral or by referral from a physician or other healthcare professionals. To be included in the study patients had to fulfill diagnostic criteria for GD according to a diagnostic interview. No specific exclusion criteria were used in the study.

At their first visit to the clinic, the patients were informed about the study and approved participation. The participants were assessed with a semi-structured anamnestic interview, and the fulfillment of GD diagnosis was assessed through a semi-structured diagnostic interview for GD. The diagnostic assessments were made by a clinical psychologist, a social worker, or a nurse and were then validated at a treatment conference where a clinical psychologist made the final decision about diagnoses. In addition, sociodemographic data was collected, and several

questionnaires were administered to measure the severity of GD and symptoms of psychiatric co-morbidity. In addition, we assessed other clinically relevant factors such as progression into problematic gaming, reasons for gaming, and preferred gaming genres. During the study period, 142 patients were offered to participate in the study. Out of the 142 participants, 37 were excluded, as they did not fulfill the diagnostic criteria for GD. Furthermore, 36 participants declined to participate by not giving their consent. This left a total of n = 69 participants for analysis.

Measures

Anamnestic interview

The anamnestic interview was created on site purposely for this clinical setting, and questions were asked about tobacco use, drug use, and other psychiatric diagnoses besides gaming. We also collected information related to gaming about age of gaming debut, duration of gaming problems, debut of gaming problems, days of gaming per week, hours of gaming per week, reasons for gaming, and preferred game genres.

Diagnostic interview

The diagnostic interview was based on the diagnostic criteria for Internet gaming disorder from the DSM-5 (6). The interview was adapted from a version developed by Vadlin et al. (54). It consists of structured questions in relation to each diagnostic criterion to aid in the decision on whether the diagnosis is fulfilled. According to the instructions in the DSM-5, the disorder is present if at least five of the nine criteria are fulfilled during the last 12 months.

Self-report questionnaires

Gaming addiction identification test (GAIT) is a screening tool for GD developed and validated in a Swedish population. GAIT contains 17 questions about gaming and covers all the diagnostic criteria for Internet gaming disorder from the DSM-5 with a very good internal consistency (Cronbach's alpha = 0.95). A version of the test covering gaming in the past 30 days was used. The test questions are about digital games not only on computer but also games on mobiles or TV (54). The suggested cutoff for GD is to fulfill at least five questions as "completely agree."

Patient Health Questionnaire (PHQ-9) contains nine questions screening for symptoms of depression in the last 2 weeks. The questionnaire is developed according to the diagnostic criteria in DSM-IV, and the scores assess the severity of depressive symptoms. The total score corresponds to the level of severity and is classified as none (0–4), mild (5–9), moderate (10–14), moderately severe (15–19), or severe (20–27) depression. The PHQ-9 has a high validity in detecting the severity of depression (Cronbach's alpha = 0.89) (55).

Generalised Anxiety Disorder Assessment (GAD-7) was developed to measure the symptoms of anxiety. The GAD-7 consists of seven questions screening for symptoms of anxiety in the last 2 weeks. The total score is 21, indicating minimal (0–4), mild (5–9), moderate (10–14), and severe (15–21) levels of anxiety (Cronbach's alpha = 0.92) (56).

NODS-PERC is a short screening instrument for pathological and problem gambling that consists of four yes or no questions measuring gambling problems the last 12 months. One yes or more indicates possible gambling problems (sensitivity of .997; specificity = .394; PPV = .885; NPV = .963; and diagnostic efficiency = .891) (57).

Alcohol Use Disorders Identification Test (AUDIT) is a screening instrument for alcohol-related problems (Cronbach's alpha = 0.82). The test consists of 10 items allocated in three areas: alcohol consumption, symptoms of dependence, and negative consequences of alcohol consumption. The cutoff score of 6 for women and 8 for men, respectively, indicates hazardous or harmful drinking. The maximum score is 40 (58).

Drug Use Disorders Identification Test (DUDIT) is a screening test for use of illicit drugs and drug-related consequences. It consists of 10 items with a maximum score of 40. The questionnaire is categorized in three drug use areas: drug use, drug dependence symptoms, and negative consequences of the drug. Scores of 1 or more for women and 3 or more for men indicate problematic drug use (Cronbach's alpha = 0.80) (59).

Adult ADHD Self-Report Scale-V1.1 (ASRS-V1.1) Screener is a screening instrument designed to identify adult individuals with symptoms of ADHD. The test consists of six questions describing different symptoms related to ADHD with a five-point response scale ranging from "never" to "very often". Each question is scored dichotomous, with each symptom considered prevalent if responding "sometimes", "often", or "very often" to the first three questions and "often" or "very often" to the remaining three questions. Four or more positive symptoms indicate possible ADHD. It is not a diagnostic tool but is meant to be used to identify individuals in need of a more thorough assessment for ADHD. The sensitivity is 68.7%, and the specificity is 99.5% (60). The ASRS screener was originally developed for and validated in adult samples of ages 18 years and above, but studies have since shown it to be a reliable and valid measure also in samples from adolescents (61).

Ritvo Autism and Asperger Diagnostic Scale Screen (RAADS-14 Screen) is a screening instrument for ASD in an adult population and is based on an original 80-item questionnaire. The test consists of 14 questions and has a four-item scale that ranges from "never true" to "true now and when I was young". A score of 14 or above is judged to be the optimal cutoff to identify possible ASD in a psychiatric outpatient sample (Cronbach's alpha = 0.80) (62).

The demographic data questionnaire assesses a number of demographic characteristics from the participants including age, gender, educational level, occupational status, living situation, and current occupation. This demographic questionnaire was specifically created for this study.

Data analysis

The data analysis was performed using IBM SPSS Statistics version 28. All the hypotheses were tested with a significance level of $\alpha = 0.05$. The participants were divided in two groups: a younger group consisting of AYAs and an adult group. The age span for AYA was defined as ages up to 25 (63–65), and the adult group consisted of those who were 26 years of age or older.

The information received in the anamnestic interview about the participants' reasons for gaming was clustered in four categories (escape and coping, habit, improve ranking, and social), and the types of games that the participants preferred were clustered into six genres (MMORPG, FPS, MOBA, sport games, mobile games, and other). The participants were allowed to answer with several reasons and game genres, and therefore the total frequency exceeds 100%.

A large proportion of the answers about hours gaming on a typical day and number of gaming days per week were on the highest possible option in the GAIT questionnaire (10 h a day and 4 days per week, respectively), indicating a possible ceiling effect. These variables were thus analyzed as dichotomous variables. For gaming hours on a typical day, we made three separate calculations, dividing the participants in groups depending on time spent gaming per day (up to 5 h, 6 to 7 h, and 8 h or more). For gaming days per week, two groups were constituted of those indicating the highest option, 4 days or more, and the ones indicating less than 4 days per week.

Differences between AYA and adults in categorical variables (time spent gaming per day and week, ASRS, RAADS-14, NODS-PERC, tobacco use, family history of addiction, education, occupational status, living situation, reasons for gaming, and gaming genres) were tested with Fisher's exact test as this gives more exact statistics for cross-tabulations with 2 × 2 cells and works in larger cross-tabulations where the expected count in >20% of the cells is less than five, which was the case for all of our larger cross-tabulations (66).

Histograms of the continuous variables age, age of gaming onset, debut of problem gaming, years to develop gaming problems, duration of problem, number of DSM-5 criteria, GAIT, PHQ-9, GAD-7, AUDIT, and DUDIT were examined to analyze skewness. The distributions were judged to be approximately normally distributed, and therefore we continued the analyses with parametric statistics. A two-tailed *t*-test was used for the continuous variable *age* to test for a difference between the groups. In the remaining tests, AYA and adults were used as the dependent variables. Possible ADHD was, on a theoretical basis, judged to be a possible confounder for both the gaming variables and the measures of other types of psychiatric symptoms (29, 67) and was included as a covariate. The participants were coded as having possible ADHD if they screened positively for ADHD on the ASRS scale. To analyze possible differences between the groups and control for confounders, analysis of covariance (ANCOVA) was used. As the study was exploratory in nature, no correction was made due to multiple testing, and no power calculation was carried out to determine the sample size.

For clinical reasons, the battery of questionnaires was changed during the collection of data, and therefore $n = 24$ is missing on DUDIT. The number of missing data points was between 0% and 17% per variable, on average 6.2%, not counting the missing information regarding DUDIT.

We also calculated Cohen's *d* for all continuous variables and odds ratios for the dichotomous variables. Cohen's *d* was calculated with estimated marginal means and original standard deviations. The odds ratios are reported as the odds of the event among AYAs divided by the odds among adults.

Results

Sociodemographic characteristics

Sociodemographic characteristics of the total group of participants ($n = 69$) as well as for the young ($n = 35$) and the old ($n = 34$) groups together with test statistics and *p*-values are presented in Table 1. The mean age of the AYA group was 21.2 (SD = 3.1; age range 15–25), and the adult group had a mean age of 33.5 years (SD = 7.9; age range 26–56). Fisher's exact test ($p = .001$) showed a significant association between age group and education level. The AYAs more frequently had less than high school education, while the adults more often had university level education. There was also a difference between the groups regarding occupational status according to Fisher's exact test ($p = .001$), with the adults more often working and the AYAs more often studying. According to Fisher's exact test, a significant difference was found in living situation ($p = .001$). The adults lived more often alone or with a partner compared to the AYAs who more often lived with relatives or friends.

Gaming-related measures

The results from the ANCOVAs assessing the differences in gaming related measures between the younger and the older group, controlling for the confounder ADHD, *F*-values, and *p*-values, are reported in Table 2.

First, in ANCOVA, when controlling for ADHD, the groups did not differ in age of gaming debut $F(1,53) = 3.4$, $p = .07$ and ADHD $F(1,53) = 0.06$, $p = .80$. However, if not controlling for ADHD, the groups differed in age of gaming debut $F(1,64) = 4.27$, $p = .04$ (6.7 vs 9.9 years). We believe that this could be due to a power problem because of the lower *n* when ADHD was considered in the model. Second, in ANCOVA, when controlling for ADHD, the groups significantly differed in debut age of problem gaming [$F(1,57) = 17.1$, $p < .001$; ADHD $F(1,57) = 0.12$, $p = .73$], showing that AYAs were on average 14 years old and the adults were almost 22 years old when they started having problems with gaming. Third, ANCOVA revealed, when controlling for ADHD, that the groups also differed in time to develop gaming problems. It was demonstrated that AYAs developed problems about 7 years after gaming debut and the adults after 11 years [$F(1,53) = 8.8$, $p = .005$; ADHD $F(1,53) = 0.12$, $p = .74$]. Additionally, in ANCOVA, when controlling for ADHD, the groups also differed in duration of problems. It was found that AYAs had a shorter duration of problems compared to the older

TABLE 1 Demographic information.

Variables	Total (n=69)	Younger/AYA (n=35)	Older/Adult (n=34)	*p*-value	Effect size (Odds ratio)
Age M (SD)	27.3 (8.6)	21.2 (3.1)	33.5 (7.9)		
Age range	15-56	15-25	26-56		
Gender (% male)	95.7	97.1	94.1	–	–
Education %*				<0.001	
Less than high school	28.8	47.1	9.4		OR = 8.59
High School	40.9	41.2	40.6		OR = 1.02
Occupational training	12.1	5.9	18.8		OR = 0.27
University	18.2	5.9	31.3		OR = 0.14
Occupational status %*				<0.001	
Working	27.5	11.4	44.1		OR = 0.16
Studying	34.8	57.1	11.8		OR = 10.0
Sick-leave	11.6	11.4	11.8		OR = 0.97
Unemployed	21.7	17.1	26.5		OR = 0.57
Other	4.3	2.9	5.9		OR = 0.47
Living situation %*				<0.001	
Alone	29.4	20.0	39.4		OR = 0.38
With partner	10.3	0.0	21.2		–
With partner and children	13.2	0.0	27.3		–
Single parent	1.5	0.0	3.0		–
With relatives/friends	45.6	80.0	9.7		OR = 40.0

Difference in age was calculated with a t-test.
Data is presented as means and standard deviations *M* (*SD*), in range and in percent (%).
Education, occupation status and living situation were calculated with Fishers exact test.
Effect size is reported as odds ratios for the categorical variables.
OR, Odds ratios are reported for AYAs to adults.
*Statistically significant.

TABLE 2 Gaming related measures.

Variables		Total (n=69)	Younger/AYA (n=35)	Older/Adult (n=34)	*p*-value	Effect size (Cohen's *d* / Odds ratio)
Age of gaming debut	Unadjusted	8.4 (6.3)	6.7 (2.7)	9.9 (8.0)		
	Adjusted	8.6 (6.8)	6.9 (2.8)	10.3 (8.9)	0.07	*d* = 0.58
Debut of problem gaming (age in years)*	Unadjusted	17.4 (7.7)	13.9 (3.7)	21.0 (9.1)		
	Adjusted	17.7 (8.1)	14.0 (3.9)	21.8 (9.5)	<0.001	*d* = 1.14
Years to develop problems*	Unadjusted	9.1 (6.0)	6.9 (3.8)	11.1 (6.9)		
	Adjusted	9.2 (6.3)	6.8 (4.0)	11.6 (7.2)	0.005	*d* = 0.88
Duration of problem (years) *	Unadjusted	9.9 (6.1)	7.3 (4.8)	12.6 (6.3)		
	Adjusted	9.8 (5.9)	7.5 (4.8)	12.4 (6.0)	0.001	*d* = 0.90
GAIT (Gaming addiction identification test)	Unadjusted	41.4 (8.7)	40.0 (8.4)	43.0 (8.9)		
	Adjusted	41.5 (9.0)	39.9 (8.7)	43.3 (9.1)	0.18	*d* = 0.38

(Continued)

TABLE 2 Continued

Variables		Total (n=69)	Younger/AYA (n=35)	Older/Adult (n=34)	*p*-value	Effect size (Cohen's *d* / Odds ratio)
Number of DSM-criteria*	Unadjusted	7.0 (1.3)	6.7 (1.3)	7.3 (1.2)		
	Adjusted	7.0 (1.3)	6.7 (1.3)	7.4 (1.2)	0.018	d = 0.66
Gaming days at least 4 days/week (%)		84.7	82.1	87.1	0.72	OR = 0.68
Gaming time at least 8 hours/day (%)		44.1	50.0	38.7	0.44	OR = 1.58
Gaming time 6-7 hours/day (%)		27.1	25.0	29.0	0.78	OR = 0.81
Gaming time up to 5 hours/day (%)		28.8	25.0	32.3	0.58	OR = 0.70
Reasons for gaming %						
Escape/coping		80.9	76.5	85.3	0.54	OR = 0.56
Habit		35.8	39.4	32.4	0.62	OR = 1.36
Improve ranking		45.6	44.1	47.1	1.0	OR = 0.89
Social		44.9	48.6	41.2	0.63	OR = 1.35
Gaming genre %						
MMORPG		51.5	51.4	51.5	1.0	OR = 1.0
FPS*		39.7	57.1	21.2	0.003	OR = 4.95
MOBA		20.6	25.7	15.2	0.37	OR = 1.94
Sport games		4.4	0.0	9.1	0.11	–
Mobile games*		11.8	2.9	21.2	0.025	OR = 0.11
Other		1.5	0.0	3.0	0.49	–

Data is presented as means and standard deviations *M* (*SD*), in percent (%).
Gaming days, gaming time (8, 6-7, 5 hr/day) gaming reasons and gaming genre were calculated with Fisher's exact test.
Age of gaming debut, debut of problem gaming, time to develop problem, duration, GAIT, number of DSM-criteria was calculated with ANCOVA and presented in the table with adjusted and unadjusted means and standard deviations *M* (*SD*).
Effect size is reported as odds ratios for categorical variables and Cohen's *d* for continuous variables.
OR, Odds ratios are reported for AYAs to adults.
*Statistically significant.

group (on avarage 7.3 versus 12.6 years) [F(1,57) = 12.0, p = .001; ADHD F(1,57) = 0.09, p = .77]. Debut age in gaming, debut of problem gaming, and the time to develop problems are shown in Figure 1.

An analysis of the symptoms of gaming disorder, with ANCOVA, showed that when controlling for ADHD, there was no difference between the groups in symptoms of GD according to the GAIT scale [F(1,57) = 1.85, p = .18; ADHD F(1,57) = 0.17, p = .69]. Furthermore, when comparing the groups regarding the number of DSM criteria in ANCOVA, when controlling for ADHD, it was found that the adults fulfilled, on average. 0.6 criteria more than the AYAs did [F(1,57) = 5.92, p = .018; ADHD F(1,57) = 0.95, p = .34].

When analyzing gaming days per week, Fisher's exact test showed no association between gaming days per week and age group (p = 0.72). Furthermore, 82.1% of the AYAs and 87.1% of adults reported gaming at least 4 days per week. In addition, Fisher's exact test showed no association between gaming time on a typical day and age groups (at least 8 h per day, p = 0.44; between 6 and 7 h per day, p = 0.78; up to 5 h per day, p = 0.58). We found that 50% of the AYAs and 38.7% of the adults reported gaming more than 7 h a day on a typical day.

We also assessed the reasons for gaming, and no associations were found between age groups on reasons for gaming according to Fisher's exact test (escape/coping, p = .54; habit, p = .61; improve ranking, p = 1.0; social, p = .63). We also investigated differences in preferred gaming genres. Fisher's exact test showed a significant association between age group and FPS (p = .002), with FPS being more prevalent among the AYAs, and mobile games (p = .025) that were more common among the adults. There were no associations between age and any of the other genres (MMORPG, p = 1.0; MOBA, p = .28; sport games, p = .11; other, p = 0.49).

Clinical measures

Results from the ANCOVAs (controlling for the confounder ADHD regarding PHQ-9, GAD-7, AUDIT and DUDIT) assessing the differences in psychiatric co-morbidity between the younger and the older group with *F*-values and *p*-values are reported in Table 3.

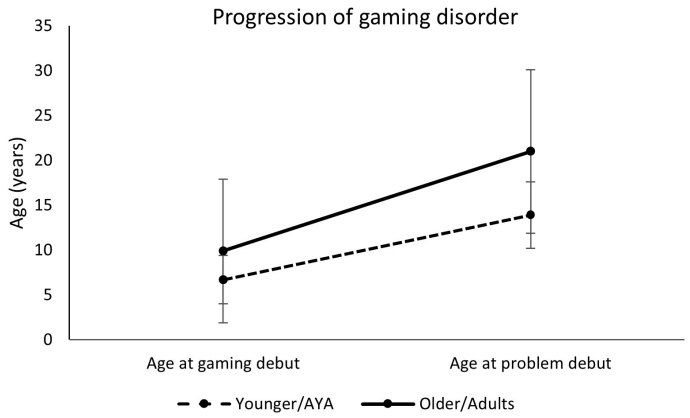

FIGURE 1
Progression of gaming disorder in AYA and adults, shown as the time between debut age of gaming and debut of problem gaming.

AYAs and the older group only differed on the AUDIT scores. It was found that the adults scored higher than the AYAs on the AUDIT scale [F(1,57) = 6.7, p = .01; ADHD F(1,57) = 0.10, p <.76].

ANCOVA revealed that the two groups did not differ on any of the following measures of psychiatric co-morbidity [PHQ-9 F(1,56) = 1.21, p = .28; ADHD F(1,56) = 0.22, p = .64; GAD-7 F(1,57) = 0.29, p = .59; ADHD F(1,57) = 2.43, p = .13; DUDIT F(1,39) = 0.23, p = .63, ADHD F(1,39) = 1.62, p = .21]. Fisher's exact test revealed no association between age and ASRS (p = .43), RAADS-14 (p = .61), NODS-PERC (p = .15), family history of addiction (p = .20), or tobacco use (p = .30).

Discussion

This cross-sectional study identifies three key findings. First and in line with our hypothesis, we found that the younger treatment-seeking group reported a faster progression into problematic gaming than the adults did. Second and contrary to our hypothesis, we found that both age groups had similar levels of psychiatric symptoms including possible ADHD, ASD, and problematic gambling. Third, notably half of our patient population consisted of adults, 26 years or older.

TABLE 3 Measures of psychiatric co-morbidity.

Variables		Total (n=69)	Younger/AYA (n=35)	Older/Adult (n=34)	p-value	Effect size (Cohen's d / Odds ratio)
PHQ-9	Unadjusted	12.2 (5.2)	12.6 (4.6)	11.8 (5.9)		
	Adjusted	12.2 (5.3)	12.9 (4.6)	11.4 (6.1)	0.28	d = 0.30
GAD-7	Unadjusted	8.3 (5.3)	8.9 (5.9)	7.8 (4.7)		
	Adjusted	8.8 (5.4)	9.0 (6.1)	8.6 (4.6)	0.59	d = 0.14
AUDIT *	Unadjusted	4.1 (4.2)	2.9 (2.8)	5.3 (5.0)		
	Adjusted	3.9 (4.0)	2.7 (2.7)	5.3 (4.7)	0.01	d = 0.64
DUDIT	Unadjusted	1.2 (2.7)	1.1 (2.8)	1.3 (2.7)		
	Adjusted	1.1 (2.5)	1.2 (3.0)	1.0 (2.1)	0.63	d = 0.15
ASRS (above cut-off) %		56.1	50.0	63.0	0.43	OR = 0.59
RAADS-14 (above cut-off) %		39.7	43.8	35.5	0.61	OR = 1.41
NODS-PERC (above cut-off) %		27.9	37.9	18.8	0.15	OR = 2.65
Family history of addiction %		40.0	31.0	48.4	0.20	OR = 0.48
Tobacco use %		34.8	27.3	42.4	0.30	OR = 0.51

Data is presented as means and standard deviations M (SD), in percent (%).
ASRS, RAADS-14, NODS-PERC, Family history of addiction and Tobacco use were calculated with Fisher's exact test.
PHQ-9, GAD-7, AUDIT and DUDIT was calculated with ANCOVA and presented in the table with adjusted and unadjusted means and standard deviations M (SD).
Effect size is reported as odds ratios for categorical variables and Cohen's d for continuous variables.
OR, Odds ratios are reported for AYAs to adults.
*Statistically significant.

The faster progression into problematic gaming among the AYAs was one of the most evident differences between the groups in our study. The younger group developed problematic gaming about 7 years after intitiation of gaming while it took 11 years for the adult group to develop problems. Although not significant when controlling for ADHD, the AYAs also reported initiating gaming when they were, on average, 7 years old compared to the adults who began gaming when they were 10 years old. Possible reasons for these differences could be changes in the gaming environment, developmental factors, or a combination thereof. The gaming environment has changed considerably during the last decades. Accordingly, the younger group in our sample have had considerably more access to digital games during childhood and adolescence and access to online games with more addictive potential (13). It is possible that these changes have contributed to the earlier initiation and faster progression to GD in the younger group. Starting gaming at an early age could also in itself be a possible risk factor for developing GD. Our brain undergoes extensive development from childhood to adolescence, making it more susceptible for the development of addiction (21). Previous research has shown that starting gaming at a younger age is associated with GD at older ages (14, 68) and an increased risk of a more severe GD (15). Similar findings have also been reported regarding Internet use (19, 20). This relationship is also well known in the field of substance use disorders. Starting drinking at an early age is associated with an increased risk of faster progression into AUD (23) and a higher risk of ever developing AUD (22). Taken together, this suggests that starting gaming at a younger age may not only increase the risk of developing GD per se but also contribute to a faster progression into GD. From our cross-sectional data, we cannot conclude a causal relationship. Still the observation of a faster progression into GD in the younger group indicates that it could be advisable to be mindful of signs of problematic gaming in early ages as GD might more rapidly develop at that time in life. The continuous changes of the gaming environment also call for further monitoring of how gaming debut and progression into gaming disorder develop as the types of games change and evolve.

Both of our age groups had the same high levels of psychiatric co-morbidity. They reported, on average, a moderate level of depression, and over 50% screened above cut-off for possible ADHD and almost 40% for possible ASD. Symptoms of underlying psychiatric disorders are common in GD, with anxiety, depression, and ADHD being the most prominent (26, 29). Unlike our findings of equal levels of psychiatric symptoms in the younger and older groups, the opposite was seen in a clinical study by Granero et al. (16). They identified an older group of GD patients with higher levels of psychiatric co-morbidity in comparison to a younger group. These differences might be caused by not only differences in methodology but also differences between the samples. The participants in our study reported having had problematic gaming for, on average, 10 years, which is about more than double as long as in the Granero study. It is possible that more psychiatric co-morbidity developed in both of our groups during that amount of time, erasing differences that might have been there at earlier stages. Unfortunately, participants with co-occurring psychiatric symptoms are often excluded in studies investigating treatments for GD (49, 50), which leads to an incomplete picture of this clinical population. More research about psychiatric co-morbidity in representative treatment-seeking samples, covering all age groups, is needed.

Furthermore, substance-related addictions have also been reported in relation to GD, indicating a cross-sensitivity for substance use and behavioral problems (40, 69, 70). In contrast to previous studies, our participants reported a low intake of both alcohol and other substances measured by the AUDIT and DUDIT. Even though we saw that the adult group scored significantly higher on the AUDIT than the AYAs did, the levels were low and several points below the cutoff for problematic use of alcohol (0–7 points) (71). We can only speculate that gaming might have been a protective factor for other addictions in this population, similar to the findings of Erevik et al. (41), or that those with GD in combination with problematic alcohol or substance use seek treatment elsewhere.

Notably, as much as half of our sample consisted of adults. This could seem counterintuitive, as the prevalence of GD is higher among AYAs than in adults (11). One reason for this could be that the age group of adults is larger than the group of AYAs in the general population (72), thus making it possible that an equal or even higher number of adult treatment-seekers could appear even with a lower prevalence rate among adults. This underscores the importance of including older gamers in research. As mentioned in the "Introduction", only 25% of the treatment studies in five of the most recent systematic reviews and meta-analyses (49–53) included adults over 25 years old. This may lead to an inaccurate representation of the adults in need of treatment for GD. With digital games becoming increasingly available, it is also possible that the age patterns in both prevalence and progression rate into GD can change over time. Irrespectively of age, all our participants had developed GD when seeking treatment. Though the progression rate in young ages might be faster and the risk to develop GD higher, this underscores that GD also can develop after adolescence and in older ages. This makes it necessary to design treatments suitable for adults and make efforts to reach people in need of treatment for GD in all different age groups.

Overall, the preferred genres and reported motives for gaming were similar to the findings in earlier studies. The most common game genres were MMORPGs, FPS, and MOBA games among our participants, genres that often have been reported in combination with GD (12). These types of games often require a heavy investment of time (73), which affects other activities not related to gaming. Previous research has found that spending excessive time playing games like MMORPGs at young ages can impact the development of GD (15, 74). We did, however, see some differences between the age groups, with the younger participants more often preferring FPS while the adults more often played mobile games. Furthermore, a clear majority (80%) reported escapism/coping as an important motive for gaming, which is in line with previous research showing that escapism is strongly associated with GD (45). It has been hypothesized that the association between GD and the

escape motive could be understood through the self-medication hypothesis (75) originally suggested in relation to substance use disorders (76). Using gaming as a dominating coping strategy, perhaps to cope with individual vulnerabilities including psychiatric co-morbidities, might be a key factor in maintaining the behavioral addiction (77). This highlights the importance of taking motives for gaming into account in treatment, for example, by offering new emotion regulation strategies when escape is a dominating motive.

Our results should be interpreted with caution. This was an explorative study in a relatively small sample. To start with, we found a near-significant result together with a moderate effect size regarding age differences in gaming debut, indicating that the study could have been underpowered in this aspect. It was further a cross-sectional study, which means that we cannot make any causal conclusions, and the self-report information about such information as age when starting gaming or developing problems could be flawed by, for example, difficulties remembering exact years or periods in one's life. In addition, the high proportion of male patients in our study sample differs considerably from the gender distribution reported in population studies (11). On the other hand, this mirrors the small number of women in other clinical studies (16, 78, 79) as well as the gender distribution in the total patient population at our clinic. Although this makes the gender distribution skewed, we believe that it is important to include both men and women in studies to accumulate knowledge about who seeks treatment for GD. However, since male patients dominated our patient population, it introduced a bias in the study and therefore limits the generalizability in relation to female gamers. We also had possible ceiling effects in our measurements about the time spent in gaming, which can have obscured possible differences between the groups.

Overall, we used self-reported assessments, which is a common way to collect clinical data in psychological and psychiatric research, yet the method is fallible, and the percentages of different psychiatric conditions are probably higher, after using self-reports, than would be the case after a full diagnostic assessment. Several steps were taken to mitigate these biases. First, we have used well-validated self-report questionnaires, and second, the patients have been able to ask questions about the questionnaires to the clinicians. Third, specifically regarding the GD diagnosis, we have used self-report data in combination with a structured clinical interview to establish a diagnosis as correctly as possible. We have focused on psychiatric co-morbidities but have not included measures of personality traits or personality disorders. Since this study is based on clinical data, the results should first and foremost be interpreted as applying to treatment seekers and not the wider population with GD. The results also need to be confirmed in longitudinal studies.

Increased awareness of GD would be of great importance to both the health sector and the general public. The younger group with a faster progression still reported that it took almost 7 years before they developed problems. This suggests that there is a considerable timeframe where it would be possible to identify at-risk individuals and offer prevention programs before the problems develop into GD. This requires instruments and routines to identify at-risk individuals, preferably in non-medical settings such as schools, to be able to reach them at an early stage. To be able to identify at-risk individuals more effectively, there is also a need to accumulate more knowledge about risk factors such as psychiatric co-morbidities for developing GD at different ages. It would also be valuable with more research about the effects of an early debut of gaming and if interventions that delay gaming onset can reduce the risks of developing GD.

In conclusion we found an association between young age when seeking treatment and a faster progression into GD. This issue is increasingly important as digital games nowadays are available for children of very young ages. At the same time, the large proportion of adults in our clinical sample also underscores the importance of designing treatments for all age groups. From a clinical perspective, the findings that both age groups had similar clinical profiles when seeking treatment indicate that it could be possible to offer treatments with comparable types of interventions to both AYAs and adult patients. With the increasing use of gaming in all age groups, it is timely to be well equipped with both preventive strategies and treatment interventions [e.g., (80)] to counteract the negative effects of excessive gaming.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by The Swedish Ethical Review Authority. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided written informed consent to participate in this study.

Author contributions

AH: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Visualization, Writing – original draft, Writing – review & editing. AG: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Resources, Supervision, Visualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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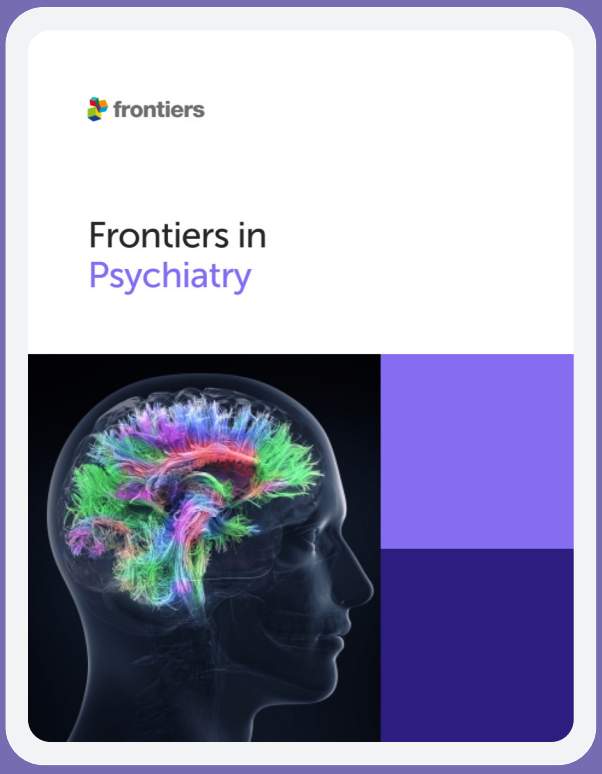

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