Tech Gaming Designs, Neurodevelopmental Vulnerabilities, and Risks for Internet Gaming Disorder:

What Clinicians Need to Know

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Abstract

Importance: Digital gaming has surged in recent decades and is widely available to individuals of all ages. Although the construct of play and games is anthropologically linked to human development, the central question remains: Does the exponential technological advancement target vulnerabilities linked to the risk of addiction? A growing burden of individuals who blur the lines between use, misuse, and addiction adds to the list of many confounders linked to mental health crises. The growing body of literature led to the addition of internet gaming disorder (IGD) to the conditions that need further research section of the *DSM-5-TR*.

Observations: Results indicate that IGD has similar neurobiological changes to those of nicotine addiction and underscores how tech game designs are linked to gaming addiction. Additionally, a history of psychiatric diagnoses further increases the risk of developing IGD.

Conclusion and Relevance: With the rapidly evolving technological landscape, using broader terminologies and definitions would aid in understanding the scope of IGD. Besides more education on IGD, a readily accessible screening tool could assist with early detection and referral to experts. While there is a dearth of specific evidence-based interventions, applying the principles of motivational interventions and harm reduction models has shown some promise. The establishment of a standardized screening and treatment approach for IGD is necessary. Clinicians must address the neurobiological aspects of IGD for effective interventions. Awareness of risk factors is key for early identification and intervention.

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With the widespread reach of the internet globally, digital gaming has become a ubiquitous presence in every aspect of human connection and experience. It is anthropologically associated with a myriad of interlinked developmental activities, eg, the need for play and social relatedness.

Winnicott (1971) described the developmental aspects of play with its relationship to psychological well-being. While play encompasses a vast emotional landscape, it fosters the development of self-construct and creativity through the process of culminating interests into excitement with an element of surprise.[1] Tomkins provided an interesting hypothesis behind how the play turns into a ritual and then a game, "The child is encouraged and permitted to play with the parents, with peers, and by himself. Many interactions are converted into games and playful rituals that otherwise might be neutral, dull, or unpleasant. Play is regarded as an end in itself."[2(p170)]

While video games were introduced in the 1950s, it was not until the 1970s that they gained popularity in the form of arcade gaming stations. It was personal computer (PC) games that exponentially grew with the modifications in hardware technology and broadband internet access. In the late 20th century, digital games were deeply rooted in popular culture and were designed to be interwoven with its network's social architecture across different geographical landscapes and users from neurodiverse populations.[3] Figure 1 depicts the evolution of digital gaming over recent decades.[3] From the broader sociocultural context, the term *gamification* has been widely used. It encompasses strategies to enhance human motivations across faculties of economic game theory, behavioral economics, and work performance,

Clinical Points

- Research indicates that internet gaming disorder (IGD) has similar neurobiological changes to those of nicotine addiction and underscores how tech game designs are linked to gaming addiction.
- Awareness of risk factors for IGD is key for early identification and intervention.
- A standardized screening and treatment approach for IGD is needed; clinicians must address the neurobiological aspects of IGD for effective interventions.

suggesting its association and influence across disciplines. Our culture is intertwined with games beyond the standard element of entertainment. Societal gamification allows individuals to better remain focused on the task at hand. These strategies of gamification are used in corporate productivity through teams working toward a prized goal, exercise in an online community competing for distance runs or calories burned, and even education to see who has done their homework throughout the week. These ideas underscore the extent to which games are enmeshed into everyday lives.

In the cutting-edge tech world driven by innovation and profitability, the knowledge of these inherent and implicit human variables in developing algorithms with reinforcing potential could explain the exponential growth of the gaming industry. However, the ethics of volitionally extending consumerism in the human psyche remain a matter of wider debate involving stakeholders given the dearth of studies on its long-term effects. The novel gaming design of the digital era has incorporated the missing "social interaction" component of 20th century PC games and provided experimentation with profiles, avatars, and the ability to enact roles with highly interactive audio-visual kinesthetic experiences involving a myriad of neurocircuitries. Fast forward many decades, the introduction of massively multiplayer online role-playing games (MMORPG) has exceeded all economic parameters, forcing tech companies to compete for profits. The games have increasingly exceeded the realm of entertainment and started to influence users in essentially every aspect of everyday life. The amount of time consumed in these gaming activities inspires pointed questions about how tech designs continue the interest or whether digital games serve a purpose that stimulates reality beyond our conventional understanding.

The reinforcing potential and neurobiological vulnerabilities among a myriad of developmental phenotypes underscore the key gaps in the phenomenology of internet gaming disorder (IGD). According to the *DSM-5-TR*, IGD's current proposed criteria are characterized as persistent use of the internet to engage in games, often with other players, leading to clinically significant impairment or distress as indicated by 5 or more of the symptoms in a 12-month period.[4]

Despite the guidance about limits on screen time to less than 2 hours a day, there is a lack of distinction between excessive use of social networking sites, IGD, and other digital mental health conditions. The association of IGD with co-occurring mental health conditions, other substance use disorders, and long-term outcomes is also critical in developing therapeutic pathways. Given the reported and published[5–10] serious, refractory, and pernicious nature of severe IGD psychopathologies, it is imperative to critique its theoretical basis, emerging trends, and plausible complex interacting risk factors to develop therapeutics for the future. The literature is promising, but much needs to be done to highlight an ignored mental health condition as the digital era continues to infiltrate our lives.

METHODS

A comprehensive search of several databases including PubMed, PsychINFO, Cochrane Library, Google Scholar, Scopus, MEDLINE, and Web of Science from inception to the date of the search (December 20,

Figure 1.
Timeline of Gaming

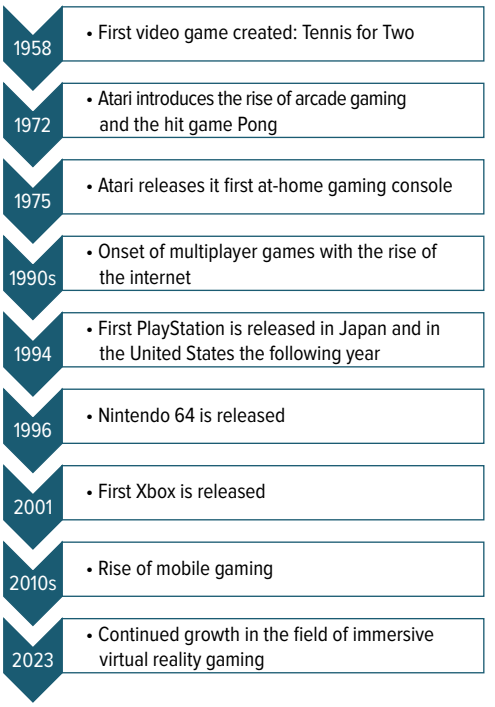
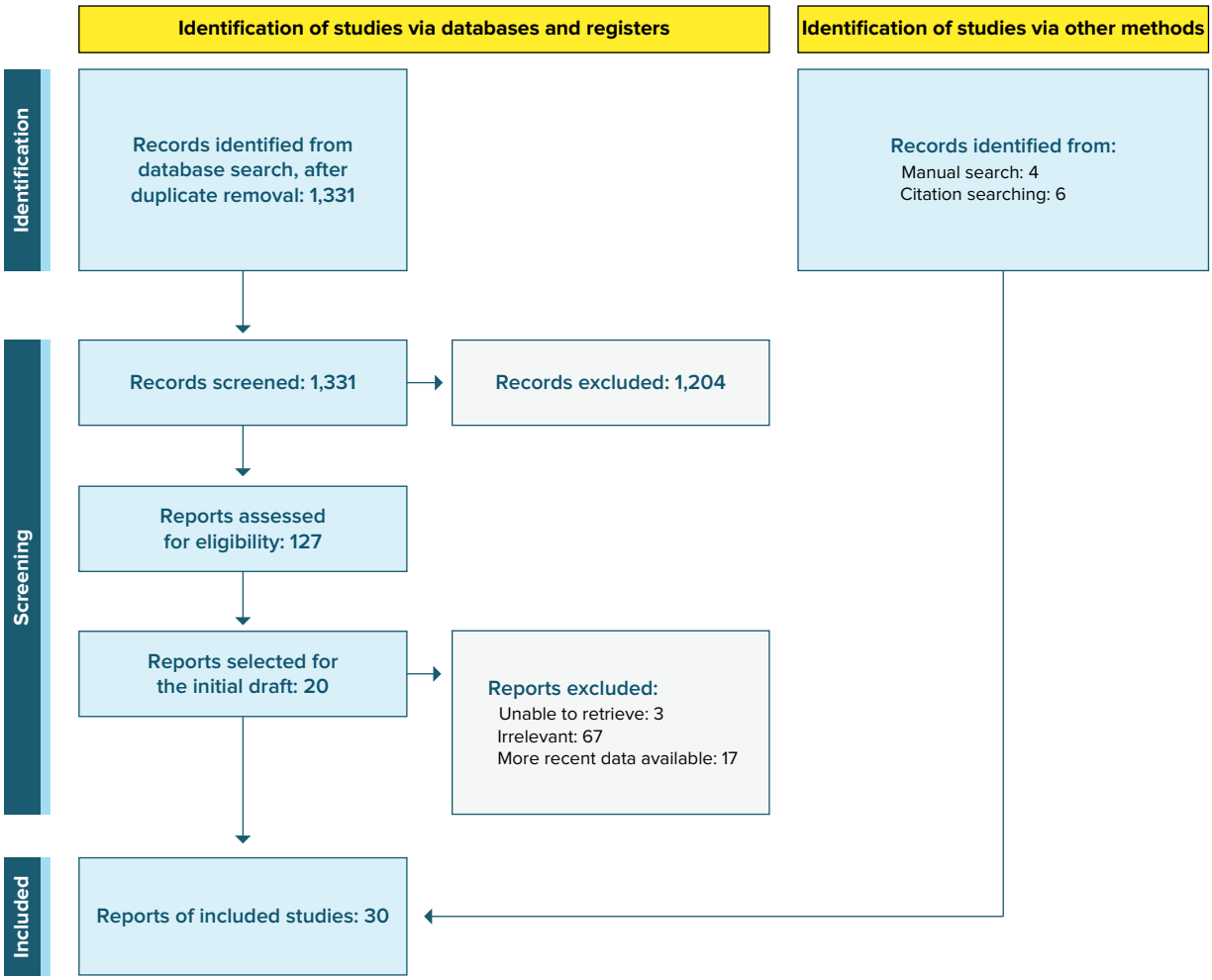


Figure 2.
Detailed Overview of the Search Methodology



2023) was conducted. We also searched the databases in PubMed Central, as the nature of the subject would require book chapters and expert opinions. The search was designed using controlled vocabulary and the keywords *internet gaming disorder*, *internet addiction disorders*, *video games*, and *gaming*. The search was performed in all languages. The inclusion criteria were any published material focused on IGD including but not limited to the prevalence, screening, risk factors, clinical findings, clinical assessment, tools used, pathophysiology, treatment, and prognosis or on any other issues associated with IGD. The search strategy was intentionally broad, as the authors aimed to identify evidence available on IGD. A total of 1,331 articles were initially identified after the removal of duplicates, and 127 articles met the initial screening criteria. Upon further review, 20 of the articles screened were used for the initial draft, as agreed upon by the 3 authors. The authors chose to select articles published over the last 5 years, although important landmark articles from 2013, 2017, and 2019 were also included. Ten articles were added later, both through manual search and reverse citations, toward the completion of the final version of the review. Figure 2 provides a detailed overview of the search methodology.

RESULTS

Digital Games, Screen Time, and Addictive Potential

About 71% of children and adolescents aged 2–17 years reported playing video games in 2022.[11] However, a vulnerable group is at higher risk of developing IGD. According to the ICD-11, IGD is described as "A pattern of gaming behavior ('digital gaming' or 'video gaming') characterized by impaired control over gaming, increasing priority given to gaming

over other activities to the extent that gaming takes precedence over other interests and daily activities, and continuation or escalation of gaming despite the occurrence of negative consequences."

However, as a note of caution, in the *DSM-5-TR*, IGD is included in the section of conditions needing further study, along with caffeine use disorder and other conditions. The debate regards what could be considered normative or excessive but nonproblematic gaming behavior. The distinction between passionate engagement (someone enthusiastic and focused on gaming) and disorder (someone with an illness/addiction) is critical. It is also of note that IGD should not be limited to digital games played online, as offline digital games can also cause similar addictive effects,[12] which brings to light that the wording regarding the condition should be more along the lines of *digital gaming disorder* rather than purely IGD. Lastly, IGD could be a symptom of an underlying problem, such as depression or anxiety, and not a disorder or addiction itself.

While billions of individuals play video games worldwide, what factors may have predisposed these select groups to become clinically addicted to video games and meet the criterion of IGD? This is a loaded question influenced by the gamification of one's life and the underlying game design used to capture and maintain a hold on a player's time and attention in addition to societal, biological, and cultural factors.

Digital Game Designs

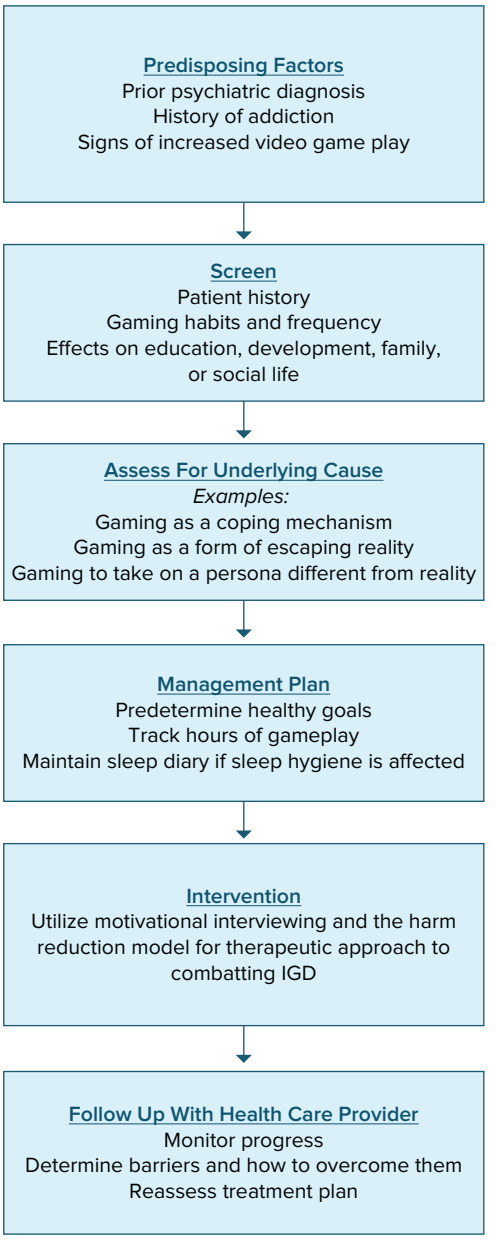
Videogames are often designed to be just challenging enough to keep the player on edge while not too challenging to be distressing. These opportunities can give rise to flow-like phenomena[13] that can result in a distorted perception of time and an experience of a "high" on video games. Crossing beyond this intersection with reality is part of the draw to gaming. Additionally, games are built on positive feedback mechanisms such as achieving a new level that provides a new skill to continue the play. This positive feedback keeps the individual playing until further achieving a new level and unlocks a new additional skill to continue playing. Furthermore, the recent inclusion of social factors in MMORPG, often having the strongest effect on IGD, draws on players who may otherwise feel lonely and now have a sense of belonging.

Epidemiologic Trend Analysis and Neurobiological Basis

The prevalence of IGD can vary by population, culture, and age among other categories, though is understood to affect 1.2%–10% of adolescents in the Northwestern hemisphere[14] with significantly more males affected than females.[15] These discrepancies are thought to be due to a multitude of factors both societal and physiological. Most popular internet games are action-adventure, role-playing, or first-person shooter games that are more often marketed to a male-dominated audience, contributing to the higher prevalence of males with IGD. When these games are played by individuals with a diagnosis of IGD, similar areas of the brain are activated as those with a nicotine addiction.[5] Additionally, compared to females, post-gaming males had increased activation-related neural pathways making them more susceptible to IGD.[5]

Figure 3.

Approach to Identifying and Managing Patients With IGD



Abbreviation: IGD = internet gaming disorder.

Table 1.

Summary of Major Findings of Relevant Research in the Field of IGD

Study	Methods	Findings	Interpretation
Hull et al[13]	Survey	Decreases in general happiness and altered perceptions of time during play predict gaming addiction. Increased sociability correlates with addictive-like experiences. Treatment strategies should focus on time management	Structural characteristics and social elements of video games contribute to gaming addiction
Griffiths and Nuyens[21]	Review article	Features requiring significant time investment in games are associated with problematic gaming	Time-consuming game designs contribute to problematic gaming behaviors
Paik et al[22]	Online survey	Combined use of computer and smartphone gaming is associated with higher prevalence of IGD and other disorders	Gaming device usage patterns influence the occurrence and severity of IGD
Paulus et al[12]	Parent questionnaire	Children with ASD exhibit longer gaming durations and a preference for solo play. Offline gaming should be included in the definition of gaming disorder	Gaming behavior in children with ASD may require specific considerations in diagnosis and treatment
Ma et al[16]	Functional MRI study	Neural activity during gaming correlates with IGD severity. Altered brain regions resemble those seen in substance addictions	IGD shares neurobiological similarities with substance addictions
Chang et al[23]	Self-report questionnaire	Emotional dysregulation is common in gaming-addicted ADHD youth. Controlling ADHD symptoms improves IGD treatment efficacy	Emotional regulation plays a significant role in gaming addiction
Weinstein and Lejoyeux[10]	Review article	Neurobiological correlates of addictive internet use include reward center activation and impaired impulse control	IGD shares neurobiological alterations with other addictions
Marino et al[24]	Online survey	Social anxiety correlates with motives, preference for online social interaction, and metacognitions about gaming. Metacognitions mediate the link between anxiety and IGD	Social and cognitive factors influence the relationship between anxiety and IGD
Darvesh et al[15]	Scoping review	Consensus on diagnostic criteria is necessary for accurate prevalence estimation of gaming disorders	Standardized diagnostic criteria are crucial for assessing gaming disorder prevalence
Stavropoulos et al[25]	Online survey	Individualistic tendencies influence IGD behaviors. Collectivism-averse gamers show higher IGD behaviors	Cultural orientation may impact susceptibility to gaming addiction
Yen et al[26]	University-based study	Genetic factors and personality traits influence IGD development. Impulsivity and fun-seeking mediate genetic effects on IGD	Genetic predispositions interact with personality traits in IGD development
Yao et al[20]	Meta-analysis	IGD is associated with deficits in reward-related decision-making, irrespective of task type or severity	Reward-related decision-making deficits are a core feature of IGD
von Deneen et al[5]	Review article	Neural circuits in IGD resemble those in substance addictions. This supports the classification of IGD as a true addiction	IGD shares neural circuitry similarities with substance addictions
Luo et al[14]	Cross-sectional study	Specific criteria like "give up other activities" and "continuation" are valid for diagnosing IGD and should be included in diagnostic frameworks	Inclusion of specific criteria is crucial for accurate IGD diagnosis
Giustiniani et al[27]	Online gaming forum study	IGD shares personality traits with individuals in substance dependence treatment. Trait intensity varies with addiction severity	Personality traits play a role in addiction severity and treatment response
Murray et al[28]	Cross-sectional study	ASD is associated with increased gaming disorder symptoms. Peer attachment and emotional regulation predict gaming symptoms in ASD	Social and emotional factors influence gaming disorder symptoms in ASD
Warburton et al[7]	Survey	Self-control and social exclusion are strong predictors of problematic gaming. Personal and social factors contribute to gaming disorder severity	Personal and social factors interact to influence gaming disorder severity
Masklavanou et al[8]	Self-report questionnaire study	IGD is associated with reduced exercise and increased ADHD symptoms. Coexistence of symptoms should be considered in treatment	Lifestyle factors and comorbidities should be addressed in IGD treatment
Gomez et al[9]	Online self-report questionnaire study	Symptoms of IGD are independent, with loss of control, continuation, and withdrawal being the most influential	Specific symptoms may be more indicative of IGD and should be prioritized in assessment
Gao et al[29]	Meta-analysis	Prevalence of IGD among adolescents and young adults is approximately 9.9%. Stress, long gaming hours, and mental health issues are significant risk factors	Identifying and addressing risk factors is crucial for preventing and managing IGD

(continued)

Table 1 (continued).

Study	Methods	Findings	Interpretation
Qin et al[6]	Case-control study	Individuals with IGD exhibit enhanced PIT effects, correlating with addiction severity. PIT effects contribute to the maintenance of IGD symptoms	Enhanced PIT effects may perpetuate IGD symptoms and severity
Zhuang et al[30]	Meta-analysis	Intrapersonal factors are stronger predictors of IGD than interpersonal and environmental factors	Individual characteristics play a significant role in IGD development

Abbreviations: ADHD = attention-deficit/hyperactivity disorder, ASD = autism spectrum disorder, IGD = internet gaming disorder, PIT = Pavlovian-to-instrumental transfer.

In one study[16] comparing depression and gameplay, compared to healthy controls who indicated 0.92 ± 0.20 hours of game time per week, the IGD population had 21.86 ± 9.82 hours. Additionally, these individuals with IGD had a significantly larger depression severity, with a Beck Depression Inventory score of 7.86 ± 5.67 versus 2.91 ± 3.04 in the healthy controls.[16] Delving further into the psychosocial risk factors, associations of IGD with other comorbidities such as attention-deficit/hyperactivity disorder (ADHD), suicidal ideation, substance use, sleep problems, and posttraumatic stress disorder have been explored. However, it is largely postulated that gaming is more likely a coping strategy used in the context of the comorbidity, which can lead to IGD,[17] rather than IGD contributing to psychosocial problems.

It is also critical to understand how IGD affects the developing brain. Functional magnetic resonance imaging (fMRI) studies in IGD have shown 3 classes of neurobiological alterations that are typical of other addictions.[10] First, there is decreased dopamine transporter density on the striatum with lower D_2 receptor occupancy. Second, there is reduced grey matter in the prefrontal cortex (PFC) and amygdala, which is associated with higher impulsivity on the Barrat Impulsiveness Scale.[10] Third, there is decreased functional neural networking in the PFC, dorsolateral PFC, orbitofrontal cortex, striatum, and amygdala, which are involved in cognitive control, executive decision-making, motivation, and reward. Some of these changes, especially those essential for motivation, craving, and reward, show a more concrete association with addiction.[10] Behavioral changes can be attributed to the neural changes seen in fMRI. More specifically, changes in grey matter, grey matter volume, and white matter density affect areas of the brain involved in memory, attention, impulse control, emotional regulation, and motor function in IGD.[10]

Screening for IGD was previously done via self-reporting, which raises questions regarding the validity of the diagnosis. However, studies have suggested that the self-reports correlated well with standardized measures.[18] Subsequently, criteria for pathological gambling were used in psychometric measures studying gaming addiction.[18] Although there are similarities, these are 2 different clinical pictures requiring 2 different methods of analysis.[18] Thus, there is still a need for a universal, validated screen for IGD risks that aligns with *DSM-5-TR* criteria for diagnosis. Incorporating more digital gaming vocabulary and gaming-related questions can help objectively discriminate between those who use, misuse, and abuse digital gaming. If an individual's use is excessive and they are at risk for developing IGD, then comprehensive mental health assessments should be considered. Among many evidence-based interventions, the harm reduction model and applying principles of motivational interviewing remain the core strategy. A stepwise approach to identifying and managing IGD is provided in Figure 3.

Finally, certain video games are developed and approved by the US Food and Drug Administration for the treatment of certain conditions. Video-game–based therapy has been shown to decrease symptoms of ADHD.[19] As children with ADHD have lower intrinsic motivation and can become bored earlier, they rely on external stimuli. Therapeutic gamification and video games provide the external stimulation that has been shown to not only be beneficial to the child but also to have higher engagement and compliance to therapeutic treatment.[19]

Scientific Questions and Empirical Designs

As it stands, further research is required before the inclusion of IGD in the *DSM-5-TR*, and the question remains as to whether IGD is an addiction. Table 1 provides the most recent empirical findings on IGD. It has been found in replicated research that individuals with IGD have not only neural restructuring,[5,10,16] often mirroring those of substance use disorder, but also behavioral changes[6,14,16,20] with reward-seeking behavior, loss of control, and giving up on other activities.

DISCUSSION

Limitations

The goal of this review was to assess the current literature on IGD and its evolving understanding from an epidemiologic, neurophysiologic, and behavioral perspective. As this is a relatively new area of research, the studies were limited in number. The inclusion criteria were intentionally broad to allow discussion of as many of the various findings as possible. The most recently published studies were also included. Additionally, to best delineate if IGD is an addiction, there is a need for

further research into other attributes of addiction such as tolerance and withdrawal.

Future Directions

As research is further evolving to better understand the various aspects of IGD, there are still gaps in knowledge of how best to combat or treat IGD. Additionally, as gaming is commonplace in society, it may be beneficial to find an optimal regimen of gaming to use in the treatment of IGD, as gaming is already used for those with ADHD.[19] Currently, this is an area of limited research and may require gaps of knowledge to be filled before establishing effective treatment protocols via structured gaming. Additionally, there is limited research on other aspects of addiction associated with IGD such as withdrawal and tolerance. These areas should be better explored to develop an understanding of the potentially addictive effects of IGD and to better understand if individuals with IGD are susceptible to developing anything else such as substance use disorder. Finally, further data need to be collected for those under the age of 12 years for a fuller appreciation of the various effects that IGD can have on different age groups.

CONCLUSION

With the amount of time consumed on screen including social networking sites and video games, there have been concerns from various stakeholders including public policymakers, researchers, parents, and clinicians. Cultural gamification, modifications in the tech designs, and lack of empirical data on long-term effects are a few among many variables that affect clinical guidance, development of diagnostics, and therapeutics. While there is an increase in awareness of digital process addictions, there is a gap in the development of easy-to-administer sensitive screening tools for IGD. While accurate scientific terminologies and definitions are critical to broadening the scope of understanding these clinical entities, *digital gaming disorder* may be a more appropriate term instead of IGD. Additionally, the emerging empirical literature on neural and behavioral changes linked with IGD further supports the need for action, which includes the inclusion of IGD in the *DSM-5-TR* beyond needing more research.

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Notice of correction 10/31/24: Author Maneesh Chidambaram's degree has been corrected.

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