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Prevalence of gaming disorder: A meta-analysis

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ABSTRACT

Background: Gaming disorder (GD) has been listed in the International Classification of Diseases 11th Revision. Studies on GD prevalence have been highly heterogeneous, and there are significant gaps in prevalence estimates. Few studies have examined what methodological and demographic factors could explain this phenomenon. Therefore, this meta-analytic study quantifies globally reported GD prevalence rates and explores their various moderating variables.

Methods: Prevalence estimates were extracted from 61 studies conducted before December 3, 2020, which included 227,665 participants across 29 countries. Subgroup and moderator analyses were used to investigate the potential causes of heterogeneity, including region, sample size, year of data collection, age group, study design, sampling method, survey format, sample type, risk of bias, terminology, assessment tool, and male proportion.

Results: The overall pooled prevalence of GD was 3.3% (95% confidence interval: 2.6–4.0) (8.5% in males and 3.5% in females). By selecting only 28 representative sample studies, the prevalence estimate was reduced to 2.4% (95% CI 1.7–3.2), and the adjusted prevalence estimate using the trim-and-fill method was 1.4% (95% CI 0.9–1.9). High heterogeneity in GD prevalence rates was influenced by various moderators, such as participant variables (e.g., region, sample size, and age) and study methodology (e.g., study design, sampling method, sample type, terminology, and instrument). The moderator analyses revealed that the sample size, mean age, and study quality were negatively associated with GD prevalence.

Conclusions: This study confirms that GD prevalence studies were highly heterogeneous based on participant demographics and research methodologies. Various confounding variables, such as sampling methods, sample types, assessment tools, age, region, and cultural factors have significantly influenced the GD prevalence rates. Prevalence estimates are likely to vary depending on study quality. Further epidemiological studies should be conducted using rigorous methodological standards to more accurately estimate GD prevalence.

Abbreviations: CI, Confidence Interval; GD, Gaming Disorder; ICD, International Classification of Diseases; IGD, Internet Gaming Disorder; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; MOOSE, Meta-analysis of Observational Studies in Epidemiology; A-EQ, Addiction-Engagement Questionnaire; AICA-S, Assessment of Internet and Computer Addiction Scale-Gaming; CIUS, Compulsive Internet Use Scale; CSAS, Video Game Dependency Scale; DSM-IV, Diagnostic and Statistical Manual of Mental Disorders, fourth edition; GAIT, Game Addiction Identification Test; GAS-7, Game Addiction Scale-7 items; GAST, Game Addiction Screening Test; IGD-9, Internet Gaming Disorder Scale-9 items; IGDS9-SF, Internet Gaming Disorder Scale-9 Short Form; IGDT-10, Internet Gaming Disorder Test-10 items; POGQSF, Problematic Online Gaming Questionnaire-Short Form; PUVG, Problematic use of video games; PVP, Problematic Video game Playing Scale; VAT, Video Game Addiction Test; YDQ, Young Diagnostic Questionnaire; YIAT, Young Internet Addiction Test.

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1. Introduction

The World Health Organization has officially listed gaming disorder (GD) in the International Classification of Diseases (ICD) 11th Revision. GD has been included in the category of "Disorders due to addictive behaviors" alongside gambling disorder, which is a subitem of "Disorders due to substance use or addictive behaviors" of "mental, behavioral, or neurodevelopmental disorders." In addition, gaming addiction was described in the Diagnostic and Statistical Mental Disorders, Fifth Edition (DSM-5), in the section recommending conditions for further research. At the time, there was not enough evidence to determine whether the condition was a unique mental disorder or clarify the best criteria. Accordingly, the 11th Revision of the ICD was the first to recognize GD as an official disorder. The revision is expected to take effect in 2022, with final approval granted at the World Health Assembly in May 2019. However, whether internet gaming should be classified as a mental disorder is still a debated topic, which means it needs further supporting research (Aarseth et al., 2017; Van Den Brink, 2017).

Before the official announcement by the World Health Organization (WHO), there had been various discussions on whether there was a need for new diagnostic criteria regarding gaming or internet use (WHO, 2016). However, debates persist regarding whether excessive gaming should be viewed as a form of addiction and whether such classification is scientifically valid (Aarseth et al., 2017; Higuchi et al., 2017). Concerns have been raised in a statement opposing the WHO diagnosis due to the lack of clarity in the WHO's definition and diagnostic criteria for game addiction and its actual existence as an independent disorder (Society for Media Psychology and Special Interest Group in Media, Arts, & Cyberpsychology, 2018). Additionally, controversy remains over the clinical utility of the internet gaming disorder (IGD) diagnosis and the ability to clinically identify groups with gaming problems (Colder Carras & Kardefelt-Winther, 2018; Przybylski, Weinstein, & Murayama, 2017). Moreover, some have questioned the stability of diagnosing GD as a behavioral addiction (Jeong, Ferguson, & Lee, 2019) and the diagnostic criteria and evidence for its relationship with comorbid mental disorders and personal characteristics, for example, remain unclear (Andreassen et al., 2016; Ferguson, Coulson, & Barnett, 2011).

On the other hand, studies with contrasting opinions have noted that gaming problems should be considered as an important public health issue (Rumpf et al., 2018). Additionally, other studies have emphasized the need to respond to global concerns on the impact of problematic gaming and have reported that a considerable number of empirical studies and evidence on game use have accumulated to establish a diagnosis for gaming disorders (Saunders et al., 2017). Furthermore, studies claim that an official diagnosis could improve research quality and assist in clarifying debates by providing common grounds (Király & Demetrovics, 2017). Finally, it has been argued that diagnostic criteria are needed for appropriate treatment, intervention, and prevention (King et al., 2020). Recently, efforts have been made to develop clinically valid and representative international agreements with experts through the Delphi process to clarify the diagnostic uncertainty of GD (Castro-Calvo et al., 2021).

Through the years, many researchers have tried to explain the occurrence of GD and related issues, particularly by research teams in Europe and Asia (Stevens, Dorstyn, Delfabbro, & King, 2020). To date, studies on GD prevalence have been highly heterogeneous, and the literature has significant gaps in prevalence data. Feng et al. (Feng, Ramo, Chan, & Bourgeois, 2017) found that the GD prevalence was in the range 0.7%–15.6% between 1998 and 2016. Some studies showed prevalence estimates of 1%–2% (Haagsma, Pieterse, & Peters, 2012; Müller et al., 2015), whereas other estimates were around 15% (Lopez-Fernandez, Honrubia-Serrano, Baguley, & Griffiths, 2014; Tang, Koh, & Gan, 2017). The GD prevalence also varied by age and region: approximately 8.5% among U.S. youth 8–18 years old (Gentile, 2009), 5.4% among Dutch subjects 13–40 years old (Lemmens, Valkenburg, & Gentile, 2015), 1.2% among German youth 13–18 years old (Rehbein, Kliem, Baier, Mößle, & Petry, 2015), and 5.9% among South Korean youth aged 13–15 years old (Yu & Cho, 2016).

In a previous review on GD prevalence, Mihara and Higuchi, 2017 analyzed 50 cross-sectional and longitudinal studies and reported a 0.7–27.5% IGD prevalence. Feng et al. (2017) reviewed 27 studies, of which the majority were conducted on school-aged children, and they reported a prevalence estimate of 0.7–15.6% between 1998 and 2016. Another recent systematic review on GD in children and adolescents reported a wider IGD prevalence range of 0.60–50.00% (Paulus, Ohmann, von Gontard, & Popow, 2018; Paulus, Sinzig, Mayer, Weber, & von Gontard, 2018). A recent meta-analysis on IGD prevalence in adolescents found an overall prevalence of 4.6% across 16 studies and a 6.8% prevalence for males (Fam, 2018). Another recent meta-analysis comparing the prevalence of internet addiction and IGD reported a 2.47% weighted mean prevalence of IGD across 17 studies, from which a representative sample of 10 studies had a prevalence of 3.38% (Pan, Chiu, & Lin, 2020). A very recent meta-analysis including eight Southeast Asian studies found a pooled prevalence of 10.1% for GD (Chia et al., 2020). Finally, another recent meta-analysis found a pooled prevalence of 3.05%, which was reduced to 1.96% with strict sampling criteria (for example, random sampling) (Stevens et al., 2020). These divergent prevalence estimates could be explained by differences in the assessment tools and participant demographics among the studies (González-Bueso et al., 2018; King et al., 2020). Additionally, heterogeneity can be affected by methodological problems associated with self-report surveys or inaccurate diagnostic criteria used in prevalence studies (van Rooij et al., 2014).

It has been reported that estimates of pooled prevalence found in existing studies can be influenced by various factors. However, detailed reports on such variables are lacking. A recent meta-analysis described important factors that contribute to the pooled prevalence of GD and its variability in prevalence estimates (Stevens et al., 2020). However, at the same time, some subgroup analyses have reported potential limitations, such as underpowered studies. Accordingly, this meta-analysis investigated a total of 12 variables and more comprehensively evaluated factors potentially associated with GD prevalence than previous studies. We performed moderator analyses of various regional and demographic variables, as well as detailed methodological variables, enabling us to identify factors affecting inconsistent GD prevalence estimates. This analysis provides a pooled prevalence estimate of GD based on high-quality prevalence studies that targeted strictly representative samples, allowing for more accurate identification of influential variables. This study aimed to investigate the overall pooled prevalence effect size associated with GD and the effects of various moderators.

2. Materials and methods

2.1. Search strategy

The findings of all published studies reporting GD prevalence rates were collected. The following databases were searched until December 3, 2020: PubMed, Embase, ProQuest. The following search terminologies were used for PubMed: "video" OR "internet" OR "online" OR "computer" AND "game" OR "gaming" AND "excessive" OR "problematic" OR "problem" OR "pathological" OR "disorder" OR "addiction" OR "addicted" OR "disease" AND "prevalence" OR "epidemiology." (see Supplementary materials A.1). This search strategy was adapted for the rest of the databases. We conducted citation tracking of published systematic reviews and included studies. Pairs of reviewers independently assessed the studies and disagreements were resolved through consensus. This study was conducted according to the standard Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Liberati et al., 2009) and Meta-analysis of Observational Studies in Epidemiology (MOOSE) (Stroup et al., 2000). Our protocol was registered in the PROSPERO International prospective register of systematic reviews database (CRD42021227002) prior to the

study.

2.2. Inclusion and exclusion criteria

Studies were included if they were: (a) original research, (b) examined the prevalence rates of GD, (c) conducted in general populations, and (d) the abstract was available in English. Studies were excluded if they (a) were non-original research (such as a research review), (b) did not report prevalence rates of GD, (c) were conducted in psychiatric populations, and (d) the abstract was not available in English.

2.3. Data extraction

The title and abstract of the studies were identified from the databases using the above search strategy. Studies were first screened for relevancy to GD. The full-text articles of the remaining studies were assessed using the inclusion and exclusion criteria to determine the final pool of studies. The following information was extracted: the first author, year of data collection, publication year, country, study design, survey format, sample type, risk of bias, sampling method, population, sample size, gender, mean age, assessment tools, and prevalence rate. To ensure data accuracy, the extracted data was cross-checked by a second author.

2.4. Statistical analyses

The meta-analysis was calculated using a random effect model with a 95% confidence interval (CI) using RStudio® software and the meta packages. All prevalence estimates were analyzed by logit transformation to ensure that the data were normally distributed. We reported the aggregate prevalence, corresponding p value, 95% CI, Cochran's Q-statistic, and estimated effect size. A forest plot was also generated to provide visual representation of the prevalence data from the included studies. Heterogeneity across studies was assessed through significance testing of the I^2 statistic, with a null hypothesis assuming homogeneity. Subgroup analyses were conducted considering study features such as participant variables (region, sample size, year of data collection, and age group) and study methodology variables (study design, sampling method, survey format, sample type, risk of bias, gaming problem terminology, and instrument). Meta-regression analyses were performed to explore the association between heterogeneity and study year, average age, sample size, study quality score, or proportion of males in the studies. Publication bias was evaluated by Egger's regression test and a visual inspection of the funnel plot. The cutoff value was set at $p < 0.05$. If bias existed, the trim-and-fill method was used to adjust the publication bias (Duval & Tweedie, 2000). Additionally, a sensitivity analysis was performed to test the influence of each study on the pooled estimate.

2.5. Quality assessment

The risk of bias (RoB) of individual studies was assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Studies Reporting Prevalence Data (Institute, 2018; Munn, Moola, Lisy, Riitano, & Tufanaru, 2015). The two authors (H.K.; G.S.) independently evaluated each study's RoB and cross-checked the information. RoB was categorized as "high" if the percentage of "yes" scores reached 49%, "moderate" if the percentage of "yes" scores was between 50% and 69%, and "low" if the percentage of "yes" scores was more than 70% (Islam et al., 2020). The checklist includes the following: (1) appropriate sample to address the target population, (2) appropriate participant sampling, (3) sample size adequate, (4) detailed descriptions of study subjects and setting, (5) analysis conducted with sufficient coverage of the identified sample, (6) valid identification methods, (7) standardized and reliable measurements, (8) appropriate statistical analyses, and (9) adequate response rate. Each item was evaluated using yes/no/unclear or not applicable (Supplementary Table 4). The quality assessment results were used for moderator analyses.

3. Results

3.1. Study selection

Our study selection process is illustrated in Fig. 1. The initial search identified a total of 4,877 articles from the electronic databases (PubMed, 1334; Embase, 657; ProQuest 2886). After reviewing the titles and abstracts, we selected 88 relevant articles for full-text analysis. Of these, 27 studies were further eliminated, as 7 studies were unrelated to GD, 11 were duplicate studies on the same population, 6 had no full text, and 3 were not based on the general population. Finally, 61 studies met our selection criteria and 71 individual prevalence estimates were included in the meta-analysis (see Supplementary materials A.3).

3.2. Study characteristics

A summary of the characteristics of the 61 studies included in the meta-analysis is shown in Table 1. The total number of participants was 227,665 (mean age = 19.9 years, SD = 9.5). There were 29 countries included in the study, with Europe accounting for 55% ($k = 39$) and Asia 28% ($k = 20$). Among age groups, the adolescent sample (12–18 years) was the most common with 54% ($k = 38$), followed by the young adult group (18–40 years) with 13% ($k = 9$). Regarding date ranges of data collection, 2010–2014 accounted for 44% ($k = 31$), and 2015–2019 was 34% ($k = 24$). As for sample size, "1000–5000" was the most common with 61% ($k = 43$), whereas 15% ($k = 11$) had less than 1000. Regarding methodological variables, cross-sectional studies were 87% ($k = 62$) and self-report studies were 87% ($k = 62$). The sampling methods were the convenience sampling, 23% ($k = 16$), and the non-convenience sampling, 77% ($k = 55$), with the non-convenience sampling containing

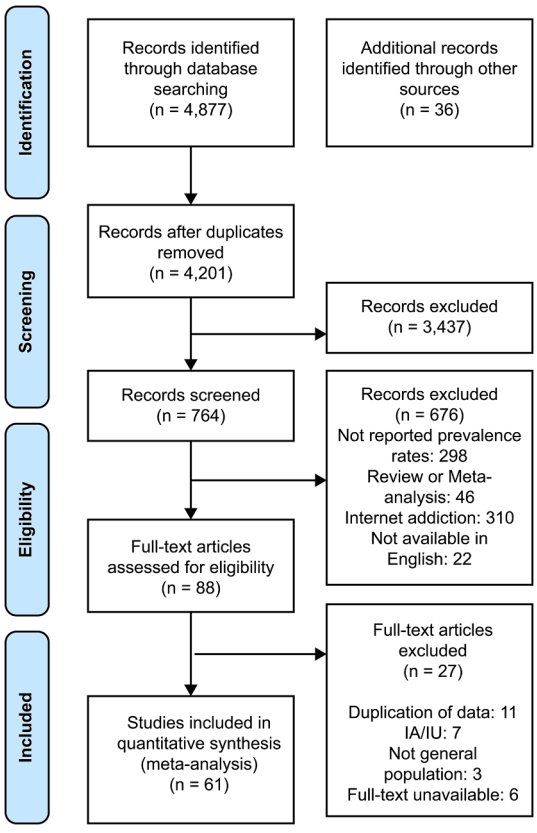

Fig. 1. Flow diagram for study selection.

Table 1
Characteristics of the studies included in the meta-analysis ($N = 71$).

No	First author(year)	Country	Study year	Study design	Survey format	Sampling method	Used terms	Instrument	Sample size	Mean Age	Male (%)	Prevalence (%)	Sample type
1	Ahmadi (2014)	Iran	2008/2009	cross-sectional	offline	non-conv.	addiction	DSM-IV	1020	NA	50	1.27	2
2	Andre (2020)	Sweden	2017	cross-sectional	online	non-conv.	addiction	GAS-7	2075	NA	49.6	1.2	2
3	Apisitwasana (2017)	Thailand	2015	cross-sectional	offline	non-conv.	addiction	GAST	295	9.87	52.9	7.5	2
4	Asqah (2020)	Saudi Arabia	2019/2020	cross-sectional	online	non-conv.	disorder	IGD-9	228	21.15	64.9	8.8	2
5	Borges (2019)	Mexico	2018/2019	cross-sectional	online	conv.	disorder	IGD-9	7022	NA	44.3	5.2	3
6	Brunborg (2013)	Norway	2009	cross-sectional	offline	non-conv.	addiction	GAS-7	1320	13.6	47.9	4.24	1
7	Chiu (2018)	Taiwan	2016/2017	cross-sectional	offline	conv.	disorder	IGDT-10	8110	13.17	63.3	3.14	3
8	Choo (2010)	Singapore	NR	cross-sectional	offline	non-conv.	pathological	Pathological video-game use	2998	11.2	72.7	8.7	2
9	Chupradit (2019)	Thailand	NR	cross-sectional	offline	conv.	addiction	GAST	242	13.78	33.5	5.8	3
10	Coeffec (2015)	France	NR	cross-sectional	offline	conv.	problematic	PUVG	1192	NA	NA	17.7	3
11	Colder Carras (2017)	Netherlands	2009/2012	cross-sectional	offline	non-conv.	problematic	VAT	9733	NA	48.8	1.3	2
12	Desai (2010)	USA	NR	cross-sectional	offline	non-conv.	problematic	3-item	4028	NA	45.8	2.6	1
13	Dreier (2017)	Germany	NR	cross-sectional	offline	non-conv.	addiction	AICA-S	3967	NA	54.5	1.94	1
14	Faulkner (2015)	Canada	2010/2011	cross-sectional	offline	non-conv.	problematic	PVP	3338	15.9	51	1.9	2
15	Festl (2013)	Germany	2011	cross-sectional	online	non-conv.	problematic	GAS-7	4382	37.8	58.4	3.7	1
16	Fisher (1994)	UK	1990	cross-sectional	offline	conv.	pathological	DSM-IV-JV	460	NA	52	6	3
17	Gentile (2009)	USA	2007	cross-sectional	online	non-conv.	pathological	Pathological video-game use	1178	NA	49.9	8.5	1
18	Gentile et al. (2011)	Singapore	2007/2009	longitudinal	offline	non-conv.	pathological	Pathological video-game use	2532	NA	72.7	7.6	2
19	Haagsma et al. (2012)	Netherlands	2009	cross-sectional	online	non-conv.	problematic	GAS-7	902	44.54	47.1	1.3	1
20	Henchoz (2016)	Switzerland	2010/2013	longitudinal	offline	non-conv.	addiction	GAS-7	5223	21.25	100	2.3	1
21	Hui (2019)	China	2017	cross-sectional	online	non-conv.	disorder	IGD-9	1200	19.48	68.8	7.5	2
22	Johansson (2004)	Norway	1999	cross-sectional	online	non-conv.	pathological	YDQ	3237	NA	NA	2.7	1
23	Khazaal (2016)	Switzerland	2010/2011	cross-sectional	offline	non-conv.	problematic	GAS-7	5983	20	100	2.3	1
24	Kim (2017)	South Korea	2011	cross-sectional	offline	non-conv.	addiction	PVP	1401	33.13	69.9	7.71	2
25	King (2013)	Australia	2012	cross-sectional	offline	non-conv.	pathological	PTU	1214	14.8	49.6	1.89	2
26	King (2016)	Australia	2014	cross-sectional	offline	conv.	disorder	IGD-9	824	14.1	48.8	3.15	3
27	Kiraly (2014)	Hungary	2011		offline	non-conv.	problematic	POGQSF	1923	16.4	68.4	4.26	1

(*continued on next page*)

Table 1 (*continued*)

No	First author(year)	Country	Study year	Study design	Survey format	Sampling method	Used terms	Instrument	Sample size	Mean Age	Male (%)	Prevalence (%)	Sample type
				cross-sectional									
28	Lemmens et al. (2015)	Netherlands	2013	cross-sectional	online	non-conv.	disorder	IGD-9	2444	NA	49.6	5.4	1
29	Lopez-Fernandez_1 (2014)	Spain	2014	cross-sectional	offline	conv.	pathological	PVP	1132	14.55	53.4	7.7	3
30	Lopez-Fernandez_2 (2014)	UK	2014	cross-sectional	offline	conv.	pathological	PVP	1224	13.56	67.3	14.6	3
31	Mannikko (2015)	Finland	2014	cross-sectional	online	non-conv.	problematic	GAS-7	263	18.7	51	9.1	2
32	Mannikko (2019)	Finland	NR	cross-sectional	online	conv.	problematic	IGDT-10	773	17.5	58.86	1.3	3
33	Mentzoni (2011)	Norway	2009	cross-sectional	both	non-conv.	problematic	GAS-7	816	NA	NA	4.1	1
34	Müller et al. (2015)	Germany	2011/2012	cross-sectional	offline	non-conv.	disorder	AICA-S	2,315	NA	NA	1.59	1
35	Müller et al. (2015)	Greece	2011/2012	cross-sectional	offline	non-conv.	disorder	AICA-S	1,897	NA	NA	2.5	1
36	Müller et al. (2015)	Iceland	2011/2012	cross-sectional	offline	non-conv.	disorder	AICA-S	1924	NA	NA	1.76	1
37	Müller et al. (2015)	Netherlands	2011/2012	cross-sectional	offline	non-conv.	disorder	AICA-S	1188	NA	NA	1.09	1
38	Muller_5 (2015)	Poland	2011/2012	cross-sectional	offline	non-conv.	disorder	AICA-S	1892	NA	NA	2.11	1
39	Muller_6 (2015)	Romania	2011/2012	cross-sectional	offline	non-conv.	disorder	AICA-S	1790	NA	NA	1.34	1
40	Muller_7 (2015)	Spain	2011/2012	cross-sectional	offline	non-conv.	disorder	AICA-S	1931	NA	NA	0.62	1
41	Myrseth (2018)	Norway	NR	cross-sectional	online	non-conv.	disorder	GAS-7	2055	NA	47.1	1.2	1
42	Papay (2013)	Hungary	2011	cross-sectional	offline	non-conv.	problematic	POGQSF	5045	16.4	51	4.6	1
43	Pontes (2016)	Slovenia	2015	cross-sectional	offline	non-conv.	disorder	IGDS9-SF	1071	13.44	50.2	2.5	1
44	Przybylski_1 (2017)	Multi	2015	cohort	online	non-conv.	disorder	IGD-9	10,009	NA	50.1	0.7	2
45	Przybylski_2 (2017)	USA	2015	cohort	online	non-conv.	disorder	IGD-9	5777	46.59	42.4	0.3	2
46	Przybylski_3 (2017)	UK	2015	cohort	online	non-conv.	disorder	IGD-9	1899	NA	50.4	0.5	2
47	Przybylski_4 (2017)	USA	2015	cohort	online	non-conv.	disorder	IGD-9	1247	NA	57.7	1	2
48	Qin (2020)	China	2019/2020	cross-sectional	offline	conv.	disorder	IGDS9-SF	3724	20.31	44	2.4	3
49	Rehbein (2010)	Germany	2007/2008	cross-sectional	offline	non-conv.	addiction	CSAS	15,168	15.3	51.3	1.7	1
50	Rehbein (2015)	Germany	2013	cross-sectional	offline	non-conv.	disorder	CSAS	11,003	14.9	51.1	1.16	2
51	Sanders (2017)	Canada	2015	cross-sectional	online	non-conv.	disorder	IGD-9	1238	41.7	61	3.2	1
52	Seok (2012)	South Korea	2011	cross-sectional	offline	non-conv.	addiction	A-EQ	1332	NA	84	2.7	2
53	Shiue (2015)	Japan	2010	cohort	offline	non-conv.	addiction	JGSS	5003	NA	42.26	5.5	2
54	Strittmatter (2015)	Europe	2010	cross-sectional	offline	non-conv.	pathological	YDQ	8807	15	44.5	3.62	1
55	Subramaniam (2016)	Singapore	2014	cross-sectional	online	conv.	problematic	IGD-9	1236	23.6	63.2	13.9	3
56	Taechoyotin (2020)	Thailand			offline	non-conv.	disorder	IGD-20	5497	NA	44.9	5.4	2

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Table 1 (*continued*)

No	First author(year)	Country	Study year	Study design	Survey format	Sampling method	Used terms	Instrument	Sample size	Mean Age	Male (%)	Prevalence (%)	Sample type
			2017/ 2018	cross-sectional									
57	Tang (2017)	Singapore	2015	cross-sectional	offline	conv.	addiction	POGQSF	1107	21.45	37.4	15.4	3
58	Thomas (2010)	Australia	2004/ 2005	cross-sectional	offline	non-conv.	addiction	YDQ	2031	NA	42.6	4.8	2
59	Turner (2012)	Canada	2006/ 2007	cross-sectional	offline	non-conv.	problematic	PVP	2832	15	49.2	9.4	2
60	Vadlin (2015)	Sweden	2012	cohort	offline	non-conv.	problematic	GAIT	1783	NA	45.2	1.3	2
61	Van Rooij (2011)	Netherlands	2008/ 2009	cross-sectional	offline	non-conv.	addiction	CIUS	8299	14.34	52	1.04	2
62	Van Rooij (2014)	Netherlands	2009/ 2011	cross-sectional	offline	non-conv.	problematic	VAT	8478	14.2	49	2.41	2
63	Wang (2015)	Hong Kong	2013	cross-sectional	offline	non-conv.	addiction	GAS-7	920	15.03	36.6	13	2
64	Wang (2018)	South Korea	2016	cross-sectional	online	conv.	disorder	IGD-9	7200	24.51	44.4	10.8	3
65	Wartberg (2017)	Germany	2016/ 2017	cross-sectional	online	non-conv.	disorder	IGD-9	1531	18.86	51.4	5.75	1
66	Wartberg (2019)	Germany	2016	longitudinal	online	non-conv.	disorder	IGD-9	985	13.89	50.7	11.7	2
67	Wartberg (2020)	Germany	2017	cross-sectional	online	non-conv.	disorder	IGD-9	1001	14.58	51.8	3.5	2
68	Wittek (2016)	Norway	2013	cohort	online	non-conv.	addiction	GAS-7	10,081	32.6	NA	0.53	1
69	Wu (2018)	Macao	2016	cross-sectional	offline	non-conv.	disorder	IGD-9	1000	40	44	2	1
70	Yang (2020)	China	NR	cross-sectional	offline	conv.	disorder	IGD-9	2666	12.77	51.9	13	3
71	Yu and Cho (2016)	South Korea	2011	cross-sectional	offline	non-conv.	disorder	IGD-9	2024	14.5	50.6	5.9	2

representative studies, cohort studies, and randomly selected samples. The terms used in the GD were classified into four categories, appearing with the following frequency: disorder 42% ($k = 30$), addiction 16% ($k = 16$), problematic 23% ($k = 16$), and pathological 13% ($k = 9$). There were 23 instruments for GD used in this study with IGD-9 accounting for 25% ($k = 18$).

3.3. Overall pooled prevalence of gaming disorder

Fig. 2 shows the forest plot of the GD prevalence, which varied from 0.3% to 17.7% in the 71 prevalence estimates. The random effect model revealed an overall pooled GD prevalence estimate of 3.3% (8.5% in males and 3.5% in females). The CI of 95% had lower and upper limits of 0.026 and 0.040, respectively, which was significant. With a methodologically rigorous approach of selecting only representative samples ($k = 28$), the pooled prevalence estimate was reduced to 2.4%, which was lower than the overall pooled prevalence estimate of 3.3%. Additionally, there was significant heterogeneity between the effect sizes of all individual studies ($I^2 = 98.7\%$, $Q = 6161.16$, $p < 0.001$). Accordingly, subgroup analysis was conducted to determine the cause of interstudy heterogeneity.

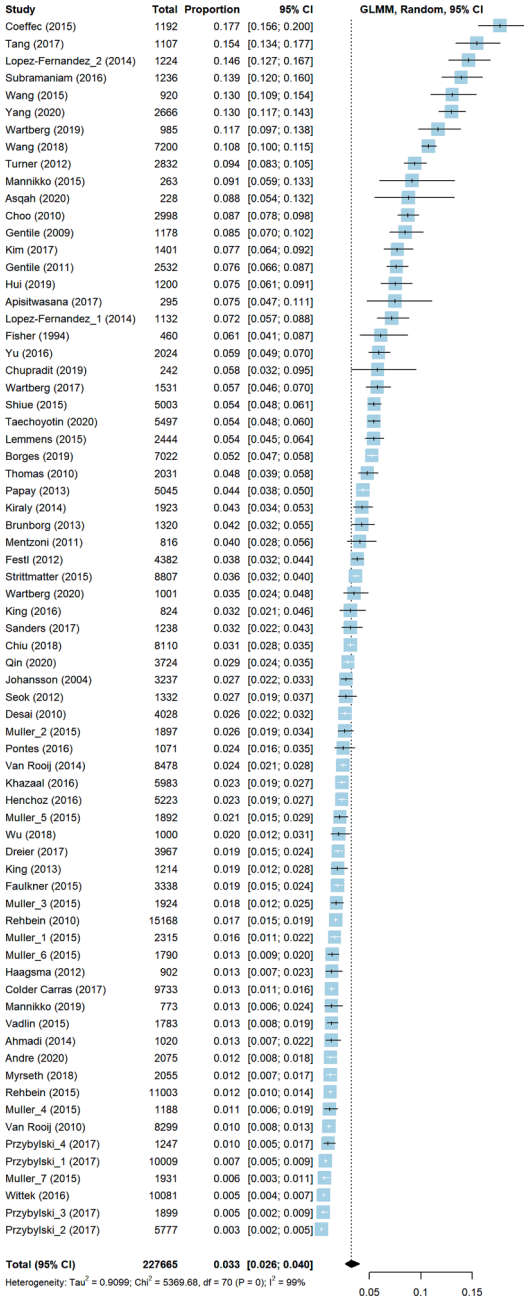

Fig. 2. Forest plot of studies included in meta-analysis.

3.4. Subgroups analyses

3.4.1. Participant variables

First, the subgroup analysis of demographic variables showed significant differences in GD prevalence estimates according to continental region, age group, and sample size (see Supplementary materials A.2).

As shown in Table 2, individual study regions by continent were categorized into Asia ($k = 20$), Europe ($k = 39$), Oceania ($k = 3$), multi-region ($k = 2$), and North America ($k = 7$). Asia had the largest effect size (6.3%), followed by North America (3.6%), Oceania (3.0%), Europe (2.7%), and multi-region (0.5%). The Q_b value, which is the difference in the effect size, was significant (28.31, df = 4, $p < 0.001$), confirming that region (by continent) is a moderator of prevalence.

The years that data were collected in individual studies were divided into the 1990′s ($k = 2$), 2000′s ($k = 12$), 2010–2014 ($k = 31$), 2015–2019 ($k = 24$), and 2020′s ($k = 2$). The highest prevalence was the 2020′s (5.0%), followed by the 1990′s (4.0%), 2000′s (3.6%), 2010–2014 (3.3%), and 2015–2019 (3.2%). The Q_b value was not significant (5.4, df = 3, $p > 0.05$).

Sample sizes were classified into studies with less than 1000 participants ($k = 11$), studies with 1000–5000 participants ($k = 43$), and studies with more than 5000 participants ($k = 17$). Studies with less than 1000 participants yielded the highest prevalence estimate of 5.3%, followed by studies with 1000–5000 participants (3.6%) and studies with more than 5000 participants (2.1%). The Q_b value was significant (7.37, df = 2, $p < 0.05$).

The age groups in individual studies were categorized into children and adolescents ($k = 5$), adolescents ($k = 38$), adolescents and young adults ($k = 8$), young adults ($k = 9$), adolescents and adults ($k = 5$), and all adults ($k = 6$). The highest prevalence was children and adolescents (6.6%), followed by adolescents and young adults (6.3%), young adults (3.4%), adolescents (3.3%), all adults (1.9%), and adolescents and adults (1.3%). The Q_b value was significant (16.52, df = 5, $p < 0.01$).

3.4.2. Methodology variables

The subgroup analysis of methodological variables showed significant differences in study designs, sampling methods, sample type, risk of bias, GD terminology, and instrument types (see Supplementary materials A.2).

The study designs were divided into cross-sectional ($k = 62$), longitudinal ($k = 3$), and cohort ($k = 6$) designs. Longitudinal studies (6.0%) had the largest effect size, followed by cross-sectional (3.7%) and cohort (0.8%) studies. The Q_b value (18.81, df = 2, $p < 0.001$) was significant.

The recruitment method was divided into convenience sampling ($k = 16$) and nonconvenience sampling ($k = 55$), and in the subgroup analysis, studies using convenience sampling (6.4%) were significantly higher than those using nonconvenience sampling (2.8%) ($Q_b = 7.79$, df = 1, $p < 0.01$).

Furthermore, individual studies were categorized into problematic ($k = 16$), pathological ($k = 9$), addiction ($k = 16$), and disorder ($k = 30$), according to GD terminology. The studies that used pathological terminology (5.8%) showed the highest prevalence, followed by problematic (4.0%), addiction (3.2%), and disorder (2.6%). The Q_b value was significant (9.49, df = 3, $p < 0.05$).

The sample type was classified into three types, and there was a significant difference between the groups ($p < 0.001$). Studies with Type 3 (6.9%) had the highest prevalence, followed by Type 2 (3.1%) and Type 1 (2.4%) (Table 2). Additionally, the group with a high risk of bias had the highest prevalence (5.6%), followed by the moderate-risk group (5.9%) and the low-risk group (2.7%) ($p < 0.01$). Study quality

Table 2
Meta-regression and meta-ANOVA analysis

Variable	Coefficient	*k*		95% CI		*p*
Age (mean)	−0.001	43		−0.002	−0.000	<0.001***
Proportion of males	0.001	60		−0.017	0.020	0.884
Year of publication	−0.010	71		−0.067	0.047	0.726
Sample size	−0.000	71		−0.000	−0.000	<0.001***
Study quality score	−0.099	71		−0.146	−0.052	<0.001***
Variable	**Subgroup**	***k***	**Prevalence**	**95% CI**		***p***
Region continent	Asia	20	0.063	0.047	0.083	<0.001***
	Europe	39	0.027	0.020	0.035	
	Oceania	3	0.031	0.020	0.048	
	Multi	1	0.007	0.006	0.009	
	North America	8	0.026	0.012	0.055	
Sample size	<1000	11	0.053	0.031	0.087	
	1000–5000	43	0.036	0.027	0.047	<0.05*
	>5000	17	0.021	0.014	0.033	
Collected year	1990′s	2	0.040	0.011	0.138	0.967
	2000′s	12	0.036	0.021	0.060	
	2010–2014	31	0.033	0.023	0.045	
	2015–2019	24	0.032	0.022	0.047	
	2020′s	2	0.050	0.013	0.167	
Age group	Children and adolescents	5	0.066	0.032	0.133	<0.01**
	Adolescents	38	0.033	0.025	0.043	
	Adolescents and young adults	8	0.063	0.035	0.109	
	Young adults	9	0.034	0.019	0.059	
	Adolescents and adults	5	0.013	0.006	0.028	
	All adults	6	0.019	0.009	0.038	
Terminology	Problematic	16	0.040	0.027	0.061	<0.05*
	Pathological	9	0.058	0.039	0.086	
	Addiction	16	0.032	0.020	0.051	
	Disorder	30	0.026	0.018	0.037	
Study design	Cross-sectional	62	0.037	0.030	0.046	<0.001***
	Longitudinal	3	0.060	0.024	0.143	
	Cohort	6	0.008	0.004	0.016	
Sampling method	Convenience sampling	14	0.069	0.047	0.102	<0.001***
	Non-convenience sampling	57	0.027	0.022	0.034	
Survey format	Offline	47	0.034	0.026	0.045	0.461
	Online	23	0.029	0.019	0.042	
Sample type[a]	Type 1	28	0.024	0.017	0.032	0.0004***
	Type 2	29	0.031	0.023	0.042	
	Type 3	14	0.069	0.045	0.105	
Risk of bias	High	4	0.056	0.023	0.126	0.005**
	Moderate	13	0.059	0.037	0.093	
	Low	54	0.027	0.021	0.034	

Note. [a]Sample type: Type 1: Representative sampling; Type 2: Stratified random sampling, or randomized cluster sampling; population or cohort registry; Type 3: Convenience or purposive sampling; online marketing or advertising; non-representative sample via crowdsourcing platform; selective sample based on male or gamer. $^{**}p < 0.01$, $^{***}p < 0.001$

variables, such as risk of bias and sample type, were identified as moderator variables that influenced prevalence. The variation in prevalence by survey format included in this subgroup analysis was not statistically significant (Table 2).

The six instrument types used in individual studies are presented in Table 3. The pooled prevalence of studies using the six instrument types was 2.8%. The prevalence using the IGD-9 instrument was 3.7%; similarly, the prevalence for the YDQ tool was 3.6%, followed by the IGDS9-SF (2.8%), GAS-7 (2.6%), IGDT-10 (2.2%), and AICA-S (1.6%) tools. The Q_b value was significant (1199.35, df = 22, $p < 0.001$).

Table 3
Subgroup analysis of prevalence according to instrument type

Instrument type	*k*	Prevalence	95% CI		*p*
IGD-9	18	0.037	0.022	0.062	0.0003***
GAS-7	11	0.026	0.015	0.045	
AICA-S	8	0.016	0.012	0.020	
YDQ	3	0.036	0.028	0.046	
IGDS9-SF	2	0.028	0.024	0.033	
IGDT-10	2	0.022	0.012	0.041	
Random effects model	44	0.0277	0.021	0.037	

Note. AICA-S: Assessment of Internet and Computer Addiction Scale-Gaming; GAS-7: Game Addiction Scale-7 items; IGD-9: Internet Gaming Disorder Scale-9 items; IGDS9-SF: Internet Gaming Disorder Scale-9 Short Form; IGDT-10; Internet Gaming Disorder Test-10 items; YDQ: Young Diagnostic Questionnaire. $^{***}p < 0.001$.

3.5. Moderator analyses

Table 2 presents an overview of the moderator analyses. Meta-regression analysis revealed that the sample size ($\beta = -0.000$, $p < 0.001$; including all 71 studies), mean age ($\beta = -0.001$, $p < 0.001$; including 43 studies with available data), and study quality score (%) ($\beta = -0.099$, $p < 0.001$) were negatively associated with GD prevalence. However, the proportion of males ($\beta = 0.001$, $p = 0.88$) and the year of publication ($\beta = -0.010$, $p = 0.73$) were not associated.

3.6. Study quality Appraisal

A detailed quality assessment of the included studies is shown in the Supplementary Materials (Supplementary Table 4). Of the 61 studies, four were rated as poor, 13 were rated as moderate, and 44 were rated as good using the JBI assessment tool. The studies with a high risk of bias had the highest prevalence (5.6%), followed by the moderate-risk group (5.9%) and the low-risk group (2.7%) ($p = 0.005$). The study quality

variable was identified as a moderator that significantly influenced prevalence (Table 2).

3.7. Publication bias and sensitivity analysis

Visual inspection of the funnel plot showed bias asymmetry (Fig. 3), and Egger's regression test revealed significant publication bias ($t = -3.97$, df = 69, $p < 0.001$). When adjusting for bias using the trim-and-fill method, the adjusted prevalence estimate by randomly adding 33 studies was 1.39% (95% CI 0.9–1.9). After omitting each study sequentially, the repooled estimates were similar to the previous figures, indicating that no studies had a significant effect on the overall results.

4. Discussion

The current meta-analytic study aimed to quantify the overall pooled prevalence of GD reported worldwide and identify variables that influence the prevalence estimate. The results showed that the overall prevalence of GD was 3.3% (8.5% in males and 3.5% in females), ranging from 0.3% to 17.7%. High heterogeneity in the GD prevalence rates was found to be influenced by various moderators such as participant variables (e.g., region, sample size, and age) and study methodology (e.g., study design, sampling method, sample type, risk of bias, terminology, and instrument). The prevalence rates reported in this study are consistent with the overall prevalence of 3.1% reported in a previous meta-analysis (Ferguson et al., 2011). However, the prevalence reported in this study was slightly lower than that reported in the children's group (4.2%) (Ferguson et al., 2011) and relatively lower than that of the adolescents' group (4.6%) in a previous meta-analysis (Fam, 2018).

Of the 61 studies included in the quality assessment, four had a high risk of bias, and 13 showed a moderate risk of bias. This was related to the failure to perform data analysis with recruitment in representative settings, adequate sample size, sufficient coverage, and valid identification methods. Additionally, some studies were rated as unclear in terms of response rate or measurement reliability. While the number of nationally representative studies ($n = 28$) was limited, these studies produced a lower prevalence (2.4%). Similarly, another recent meta-analysis reported that the pooled prevalence of GD was 3.05%, decreasing to 1.96% when strict sampling criteria (e.g., random sampling) were selected (Stevens et al., 2020). This suggests that GD prevalence is associated with selection and participation bias inherent to sampling that is less stringent and less representative. Additionally, in the meta-regression analysis of this study, a higher risk of bias was associated with a higher prevalence, so study quality was identified as a significant moderator variable. These findings show variability regarding which prevalence estimates may be inflated or lowered depending on study quality. The current heterogeneity in GD prevalence rates reflects not only changes in the definition and key symptoms of GD over time but also a lack of high-quality clinical studies (Gentile et al., 2011; Király, Griffiths, & Demetrovics, 2015; Kuss, Griffiths, & Pontes, 2017).

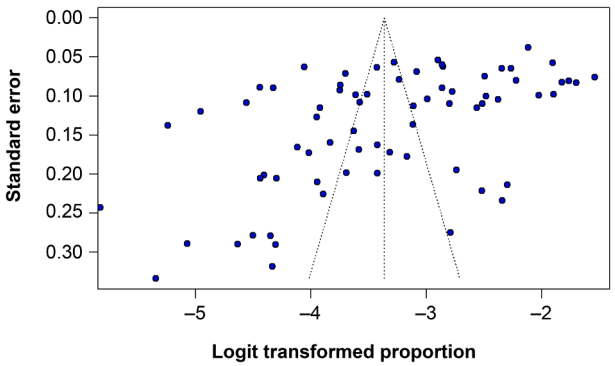

Fig. 3. Funnel plot of studies included in meta-analysis.

The subgroup analysis showed significant differences in the GD prevalence estimates by region, age group, and sample size. First, in terms of the prevalence by region, Asian countries showed a prevalence of 6.3%, the highest worldwide. This result was similar to that of a previous meta-analysis conducted in Southeast Asia (Chia et al., 2020) as well as several other studies (Chia et al., 2020; Fam, 2018; Stevens et al., 2020). However, the GD prevalence in Asia may be overestimated due to cultural factors, such as the considerable gaming market in Asia, and environmental factors, such as technological development, which are reflected in the evaluation (Rumpf et al., 2019). In particular, in South Korea, a country with an intense and pervasive gaming culture, it has been difficult to accurately identify the prevalence of game addiction and high involvement through existing screening tools (Seok & DaCosta, 2012). In a prevalence study on Korean adolescents, the GD prevalence ranged between 1.7% and 25.5% according to the classification system; when only the core criteria were applied, 2.7% were classified as addicted (Seok & DaCosta, 2012). Such high prevalence rates of 15%–20% or more raise concerns about validity issues of the assessment tools and the risk of false positives (King et al., 2020). Furthermore, a longitudinal study involving Korean adolescents indicated that cultural and environmental factors, such as excessive parental interference and communication problems with parents, had a significant influence on academic stress and consequently increased pathological gaming (Jeong et al., 2019). However, in another systematic review, a higher prevalence of GD in Asian countries was not identified (Mihara and Higuchi, 2017). It is speculated that measurements used in some prevalence studies conducted in Hong Kong, Singapore, and China did not directly match the DSM-5 criteria (Gentile et al., 2011; Wang et al., 2014; Yu, Li, & Zhang, 2015). The non-random sampling methods applied to these Asian studies might explain the higher prevalence rates (King, Haagsma, Delfabbro, Gradisar, & Griffiths, 2013).

Among all age groups, the children and adolescent groups (8–18 years) (6.7%) and the adolescent and young adults groups (12–40 years) (6.3%) were higher than other age groups in this study. These findings are similar to the higher prevalence estimates in adolescent samples shown in previous meta-analyses (Stevens et al., 2020). In addition, existing literature has repeatedly reported that the GD prevalence in adolescents is high (King et al., 2013; Müller et al., 2015). However, despite high prevalence estimates in the children's group, in elementary school, few studies involve average ages of under 10 years old (Chiu, Pan, & Lin, 2018). In addition, the difference in prevalence by age may not be a permanent phenomenon because impulse control capabilities, such as self-regulation in children, are not yet mature (Giedd et al., 1999; Rothmund, Klimmt, & Gollwitzer, 2018; Thege, Woodin, Hodgins, & Williams, 2015). Therefore, the stability of prevalence in adolescents should be further investigated based on natural history studies, with data such as actual incidence, persistence, and recovery rates (Han, Yoo, Renshaw, & Petry, 2018). In a systematic review of longitudinal studies, a stable tendency was only found in adolescent age groups, not adult age groups, even though the results should also be considered tentative due to an insufficient follow-up period, the limited number of included studies, and data diversity (Mihara and Higuchi, 2017). In future research, the stability of prevalence by age and additional epidemiologic studies should be investigated in a longitudinal study.

The subgroup analysis by sample size showed significant differences in prevalence estimates of GD. That is, studies with less than 1000 participants had the highest prevalence of 5.2%, whereas studies with medium-sized samples of 1000–5000 participants and those with over 5000 participants reported prevalence rates of 3.6% and 2.1%, respectively. A similar trend was reported in the results of a previous meta-analysis among younger adolescents. The prevalence was highest (8.6%) in the small sample and gradually decreased as the sample size increased from a mid- to large-size (Fam, 2018). Without employing a simple random sampling method, a large sample size is needed (Suresh

& Chandrashekara, 2012). Thus, a sample size of at least 1000 participants is necessary to calculate a small prevalence of approximately 5% for GD (Fam, 2018; Naing, Winn, & Rusli, 2006).

Second, significant prevalence differences were found by the use of different instruments, study designs, sampling methods, and GD terms. This suggests that confounding factors, such as the absence of reliable and valid diagnostic tools for epidemiological studies, representative samples, and accurate definitions, impact prevalence. The instruments used in the included studies were diverse, and the prevalence outcomes, stratified by the tool used, showed significant differences. Among the instruments included in this study, the prevalence measured by the PUVG was the highest at 17.7%, and studies using GAIT, Pathological video game use, PVP, POGQSF, and GAST yielded high prevalence values of approximately 7%–10%. In contrast, CIUS, DSM-IV, CSAS, AICA-S, and VAT yielded low prevalence estimates ranging from 1.0% to 1.6%, demonstrating considerable differences among instruments.

In particular, the study using PUVG, which reported a significantly high prevalence of 17.7%, had several limitations (Coeffec et al., 2015). The questionnaire used for measuring PUVG is based on the criteria for substance dependence in the DSM-IV-TR, and the cut-off score (over 3 out of 7 points) was the same as that used for diagnosing substance dependency. Furthermore, only 1.1% of the studies met the maximum of 7 points. Particularly, this study enrolled a convenience sample from schools that voluntarily participated in the study. Thus, the results should be interpreted with caution since the prevalence rate may be overestimated due to the limitations of the assessment tool and the problem of convenience sampling.

Additionally, the three-item scale was based on questions for evaluating impulsive behaviors from the Minnesota Impulse Disorder Inventory. Accordingly, it was identified that neither the verification of psychometric properties nor research on the tool's optimal cut-off value was performed (Desai et al., 2010). Screening tools, such as the A-EQ, YIAT, YDQ, and IGDT-10 tools, have been validated and cited by many researchers (King et al., 2020). However, the YIAT and YDQ tools were developed based on the DSM-IV criteria for pathological gambling, while the A-EQ tool measures two factors of addiction and engagement together. Thus, these tools differ substantially. Currently, more than 40 assessment tools have been developed. However, no gold-standard assessment tool exists. There have been tools (e.g., GAS-7, Lemmens IGD-9, AICA-S, and IGDT-10) that support relatively stronger evidence in distinct domains, but none have been remarkably superior to the others with psychometric and practical benefits (King et al., 2020).

In this analysis, the tools used in studies that reported high prevalence estimates do not provide total coverage of both the DSM-5 and ICD-11 criteria and are screening tools that are not commonly used in GD prevalence studies (King et al., 2020). In a recent review study, only 3 out of 32 assessment tools covered 3 criteria for ICD-11 and 4 areas of functional impairment. The accurate assessment of functional impairment in five main areas of the ICD-11 guidelines associated with clinical significance can prevent over pathologizing and false positives (Billieux, Flayelle, Rumpf, & Stein, 2019). However, few studies have sufficiently reflected the ICD-11 diagnostic criteria in the prevalence studies reported to date. In addition, when a self-report assessment tool that can overestimate prevalence is used, prevalence estimates may vary significantly. Furthermore, this can impact prevalence when different cutoff values are applied or when varying population groups or periods are used (Jeong et al., 2018; Maraz, Király, & Demetrovics, 2015).

GD prevalence stratified by study design was the highest (6.0%) in studies with a longitudinal design and the lowest (0.8%) in those with a cohort design. Three longitudinal studies were included in this study; however, this number is insufficient for comparison. In contrast, 62 cross-sectional studies were included. In addition, longitudinal studies with a small sample size of<1,000 subjects included in the follow-up evaluation may increase the random error (Rumpf et al., 2019). Although there have been considerably fewer longitudinal studies than cross-sectional studies so far, additional longitudinal studies should be conducted to identify the risks, protective factors, and courses of GD (Mihara and Higuchi, 2017).

This study found that studies using convenience sampling had higher prevalence estimates of GD compared to those not using convenience sampling. These results suggest that the prevalence of GD is affected by sampling methods, such as representative samples, cohort study, or random selection. In previous meta-analyses, pooled prevalence figures for clearly identified representative or random samples proved to be lower than those based on convenience or purposive sampling (Stevens et al., 2020). In addition, although 77% of the studies included in this study chose the non-convenience sampling, 35% of them used the self-report method through online surveys. In a review study by King et al. (2013), 13 of 63 studies used the self-selection method through advertisements, and they reported that this method's ability to develop generalized norms may be limited. Samples recruited through media solicitation methods, such as online surveys, may differ from the general population and affect the results due to sample selection bias (Greenacre, 2016; Rumpf, Bischof, Hapke, Meyer, & John, 2000). To prevent sampling error and increase the possibility of generalization of the evidence, confounding variables, such as recruitment procedures and sampling methods, should be controlled (Rumpf et al., 2019).

This study also confirmed significant differences in prevalence according to the type of GD terminology employed. Studies using the term disorder showed the lowest prevalence, whereas studies using the terms problematic and pathological showed relatively high prevalence. Terms such as internet addiction, pathological video gaming, computer addiction, game overuse, video game addiction, excessive, problematic, pathological, and addicted gamers were used interchangeably to describe the pathological use of computer technology due to the lack of definitional consensus prior to the introduction of the DSM-5 IGD criteria (Paulus, Ohmann et al., 2018; Paulus, Sinzig et al., 2018; Wood, 2008). Moreover, several studies included in this meta-analysis failed to accurately explain the terms used, inferring their meanings instead through the related instruments. However, it is crucial to establish clear, consensual concepts that are accurate and used uniformly to reduce systematic errors in epidemiological studies (Király et al., 2015; Kuss et al., 2017; Rumpf et al., 2019). In future epidemiological studies, the level of disability and spectrum of severity should be considered.

To our knowledge, this study's strength lies in including the largest number of participants among existing related studies. Additionally, we performed a qualitative summary analysis by considering various aspects related to prevalence studies, such as gender, age, cultural and geographical area, methodological considerations (such as survey format, sample type, or sampling method), assessment tools, and study quality. Nevertheless, the results of this meta-analysis should be interpreted with consideration of some limitations. First, information on comorbidity variables among moderator factors was not included in the analysis as few studies have targeted clinical samples that accurately diagnose comorbid diseases. In the future, research using clinical samples to identify the relationship with comorbidities would be necessary. Also, as with all meta-analyses, our study was limited by existent studies. The results reflect only what is available for existing literature. Additionally, due to the high heterogeneity across studies, the actual prevalence rate may be higher or lower depending on study quality. Lastly, since our meta-analysis included studies utilizing non-standardized diagnostic tools, the scope of GD prevalence should be interpreted with caution. It will be important to develop and use standardized assessment tools based on agreed diagnostic criteria for future epidemiological research.

5. Conclusions

This meta-analytic study quantified GD prevalence rates reported in studies across diverse regions and time points and explored various moderating variables. GD prevalence studies were highly heterogeneous based on participant demographics and research methodology. Changes

in consensual concepts, diagnostic criteria, and instruments over time influenced GD prevalence. Although the GD classification code was created in the ICD-11, it is our conclusion that epidemiological evidence for GD as a disease would be unreliable. Further epidemiological studies with rigorous methodological standards should be conducted to accurately estimate the prevalence among countries and regions and to predict changes over time and future developments as well as GD prevalence trends globally.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Not applicable.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.addbeh.2021.107183.

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