# Internet Addiction and Its Relationship With Suicidal Behaviors:
## A Meta-Analysis of Multinational Observational Studies

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**ABSTRACT**

***Objective:*** To perform a systematic review and meta-analysis of observational studies that investigated the putative association between internet addiction and suicidality.

***Data Sources:*** Major electronic databases (PubMed, Embase, ClinicalKey, Cochrane Library, ProQuest, Science Direct, and ClinicalTrials.gov) were searched using the following keywords (internet addiction OR internet gaming disorder OR internet use disorder OR pathological internet use OR compulsive internet use OR problematic internet use) AND (suicide OR depression) to identify observational studies from inception to October 31, 2017.

***Study Selection:*** We included 23 cross-sectional studies (n = 270,596) and 2 prospective studies (n = 1,180) that investigated the relationship between suicide and internet addiction.

***Data Extraction:*** We extracted the rates of suicidal ideation, planning, and attempts in individuals with internet addiction and controls.

***Results:*** The individuals with internet addiction had significantly higher rates of suicidal ideation (odds ratio [OR] = 2.952), planning (OR = 3.172), and attempts (OR = 2.811) and higher severity of suicidal ideation (Hedges $g = 0.723$). When restricted to adjusted ORs for demographic data and depression, the odds of suicidal ideation and attempts were still significantly higher in the individuals with internet addiction (ideation: pooled adjusted OR = 1.490; attempts: pooled adjusted OR = 1.559). In subgroup analysis, there was a significantly higher prevalence rate of suicidal ideation in children (age less than 18 years) than in adults (OR = 3.771 and OR = 1.955, respectively).

***Conclusions:*** This meta-analysis provides evidence that internet addiction is associated with increased suicidality even after adjusting for potential confounding variables including depression. However, the evidence was derived mostly from cross-sectional studies. Future prospective studies are necessary to confirm these findings.

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Internet addiction disorder, although not included as a formal diagnosis in *DSM-5*,[1,2] has been attracting increasing attention due to its deleterious consequences to mental health and social functioning.[3,4] The reported prevalence of internet addiction disorder ranges from 0.3% to 38%.[5] This inconsistency in reported prevalence rates across studies may partly be due to a lack of universally accepted diagnostic criteria and differences in case definition across studies.[5] Moreover, there is still ongoing debate about whether internet addiction is merely a manifestation of other underlying mental disorders or should be considered a unique diagnostic entity.[2,6,7] Several terms have been used to define this condition, including *compulsive internet use, internet overuse, problematic computer use, pathological computer use, problematic internet use,* and *internet addiction disorder*.[6] Many criteria have been proposed for internet addiction disorder[8]; however, most encompass the following manifestations: preoccupation, negative mood management, tolerance, withdrawal, external conflicts, and a lack of control.[9] Various tools have been developed to assess internet addiction disorder, such as Young's Internet Addiction Test,[6] and several other assessment tools have been validated for use in different ethnic groups, such as the Chen Internet Addiction Scale and Korea Internet addiction scale.[10]

Several theories have been proposed for the development of internet addiction disorder[6]; however, evidence suggests that internet addiction is a result of the interplay between biological vulnerability and sociocultural factors.[11] Several psychiatric disorders such as attention-deficit/hyperactivity disorder have been associated with higher rates of internet addiction disorder,[4,12] and internet addiction has also recently been reported to be associated with higher rates of suicidality.[12,13] Hence, risk factors for both suicide and internet addiction disorder such as depression, poor impulse control, and anxiety disorders seem to overlap.[14,15] Furthermore, suicide remains a leading cause of death among adolescents,[16]

**Clinical Points**

- An increased risk of suicide, in the form of ideation, planning, or attempts, was associated with internet addiction; however, the strength of this association and the effect of other potential mediating factors such as depression remain unclear.
- Individuals with internet addiction should be screened for the risk of suicide, regardless of the presence of depression, especially adolescents.

and internet addiction may also lead to important health issues primarily in pediatric populations.[17]

Ryu et al[18] first reported an association between internet addiction, depression, and suicidal ideation in Korea. Several studies have since investigated the association between internet addiction and suicidality, some of which have only investigated the relationship between internet addiction and suicidal ideation,[18–28] while some of which have also included actual suicidal attempts.[12,13,23,24,26–35] The available evidence is derived from a wide range of different countries, and most studies have consistently shown that internet addiction is associated with higher rates of suicidal behaviors. However, after multivariate adjustments for the effect of depression on suicidal behaviors, this association has become nonsignificant in some studies.[30,33,35] In fact, the influence of online activities on suicidal behaviors may have both positive and negative effects, and a recent meta-analysis showed mixed results.[36] Since depression has been associated with both suicidal behaviors and internet addiction,[37,38] the independent association between internet addiction and suicidality remains unclear, although it may be partly mediated by depression.[35] In addition, many other factors such as age, sex, and socioeconomic factors may also modify this association. However, to our best knowledge, no meta-analysis has investigated the relationship between suicidal behaviors and internet addiction.

Furthermore, the *DSM-5* includes only internet gaming disorder, in section III "Conditions for Further Study," but not internet addiction disorder for other internet activities.[1] This may highlight the clinical importance of internet gaming disorder in particular,[7] and several studies have reported similarities in brain imaging studies and behavioral patterns between internet gaming disorder and addictive behaviors.[39] Moreover, the difference between internet addiction disorder and internet gaming disorder is still an area of ongoing research, and some studies have reported that patients with internet gaming disorder suffered from worse clinical outcomes.[40–42] Nevertheless, most studies investigating suicidal behaviors and internet addiction have not investigated differences in suicidal behaviors between individuals with internet gaming disorder and those with addiction to any type of internet activity. Therefore, in this meta-analysis, our aim was to investigate (1) the strength of association between suicidality and internet addiction; (2) any other associated factors that could modify the risk of suicide in those with internet addiction, including the presence of co-occurring psychiatric disorders, especially depression; and (3) differences in the risk of suicidal behaviors in those with addiction to any type of internet activity compared to those with internet gaming disorder.

## METHODS

This systematic review and meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement[43] (see Supplementary Table 1 and Supplementary Figure 1). An unpublished meta-analysis protocol, which was approved by the Institutional Review Board of Tri-Service General Hospital (TSGHIRB: B-105-12), was followed (available upon request from the authors).

### Search Strategy

Two independent authors (Drs Cheng and Tseng) searched the PubMed, Embase, ClinicalKey, Cochrane Library, ProQuest, Science Direct, and ClinicalTrials.gov databases up to October 31, 2017. Since many of the rating scales for depression include assessments of the risk of suicide and it may have been possible to extract suicidal risk items from these depression rating scales, keywords used in the current meta-analysis were (internet addiction OR internet gaming disorder OR internet use disorder OR pathological internet use OR compulsive internet use OR problematic internet use) AND (suicide OR depression). If there were any studies including depression rating scales that could potentially provide information about the risk of suicide, we contacted the authors by e-mail to ask for this information. Finally, our search strategy was augmented by hand searching the reference lists of specific review/original articles relevant to the current topic.[44–48]

Two independent authors (Drs Cheng and Tseng) screened the titles/abstracts of the retrieved references. The full-text articles of potentially eligible articles were then retrieved and independently verified for eligibility by the same authors. Disagreements were resolved through consensus. When a consensus could not be reached, a third reviewer (Dr M.-K. Wu) was consulted.

### Eligibility Criteria

The inclusion criteria were (1) observational studies (ie, cross-sectional, case-control, and prospective studies) and (2) peer-reviewed articles investigating the association between internet addiction and suicidality (including suicidal ideation, planning, and attempts). Suicidal plan was considered to be one of the most severe forms of suicidal ideation. Although some may consider it as suicidal ideation, we specifically extract suicidal plan as one of the targets. In order to expand our search to include the most potentially eligible studies, we did not set any limitations on language for this systematic review.

The exclusion criteria were (1) studies that were not observational, (2) studies in which the association between suicidality and internet addiction was not investigated, and (3) meeting abstracts.

### Methodological Quality Appraisal

We used the Newcastle-Ottawa Scale (NOS) for cohort studies and a modified version of the NOS for cross-sectional studies to assess the quality of the included studies. This modified version of the NOS was based on a version previously used in a meta-analysis published in the *British Journal of Psychiatry* in 2013.[49] The scores of the modified version of NOS range from zero to 6, and a score higher than 4 is classified as indicating a high-quality study (Supplementary Table 3). The NOS score for cohort studies ranges from zero to 9, and a score of 6 or more is classified as indicating a high-quality study.[50]

### Outcome Measures

The primary outcome was the difference in prevalence rates of suicidal ideation, planning, and attempts or the severity of suicidal ideation as indicated by suicide rating scale scores of the individuals with internet addiction versus those without internet addiction. The suicide rating scales included suicidal ideation questionnaires[51] and scores of any rating scales that provided information about the risk of suicide.

### Data Extraction and Management

Two independent authors (Drs Cheng and Tseng) extracted the data from the eligible articles following the Meta-Analysis of Observational Studies in Epidemiology (MOOSE) guidelines. The following variables were extracted from each study: mean age (years); gender distribution (% females); proportion of individuals with prior exposure to suicide-related content in the real world or on the internet; proportion of individuals living with their parents; depressive symptom scores according to the Child Bipolar Questionnaire, Children's Depression Inventory, Depression Anxiety Stress Scales, Beck Depression Inventory, Center for Epidemiologic Studies Depression Scale, or Korean version of the Diagnostic Interview Schedule for Children, Major Depression, Simple Questionnaire; proportion of those married; proportion of those with full-time occupations; proportion of those participating in internet activities in the form of gaming/adult sexual content/gambling/work; proportion of those living in rural regions; and percentage of individuals with Caucasian/African American/Asian ethnicity. When data were not available in the articles, we tried to contact the authors up to 2 times over a month to request additional data. Whenever available, we also extracted the adjusted odds ratios (ORs) provided in the original reports.

### Statistical Analysis

Due to the anticipated heterogeneity, a random-effects meta-analysis model rather than a fixed model was applied[52] using the Comprehensive Meta-Analysis software, version 3 (CMA version 3.0, Biostat; Englewood, NJ). For continuous data, we calculated Hedges *g* and 95% confidence intervals (CIs) as the effect sizes (ESs), because we anticipated a wide variation in the suicide scales used among the recruited studies; we calculated the OR and 95% CI for dichotomous data. In addition, because we could not directly adjust for potential confounding factors via CMA version 3.0, we calculated the pooled adjusted OR via extraction of the adjusted ORs from the recruited studies. Further, the adjusted ORs of interest included the studies that adjusted for both demographic data and depression. Statistical significance was considered at a $P$ value of .05.

Heterogeneity was assessed using the $Q$ statistic, with a corresponding $P$ value of less than .05 indicating high heterogeneity,[53] and the $I^2$ statistic for the proportion of heterogeneity among the study estimates.[54] Furthermore, to investigate publication bias, we visually inspected funnel plots when there were fewer than 10 datasets[55] and applied the Egger regression test when there were 10 or more datasets.[56] If there was evidence of publication bias, we used the Duval and Tweedie trim-and-fill test to adjust the effect size estimates.[57] Sensitivity analyses with 1 study removal test, which had been widely used in meta-analysis, were performed to verify whether a single outlier study could bias the pooled effect size estimates. In brief, we removed 1 study at a time and reanalyzed the result of meta-analysis of the other studies to see if there was any change in the results of meta-analysis. If the results of meta-analysis would change, then, this study might be the outlier or had larger sample sizes.[58]

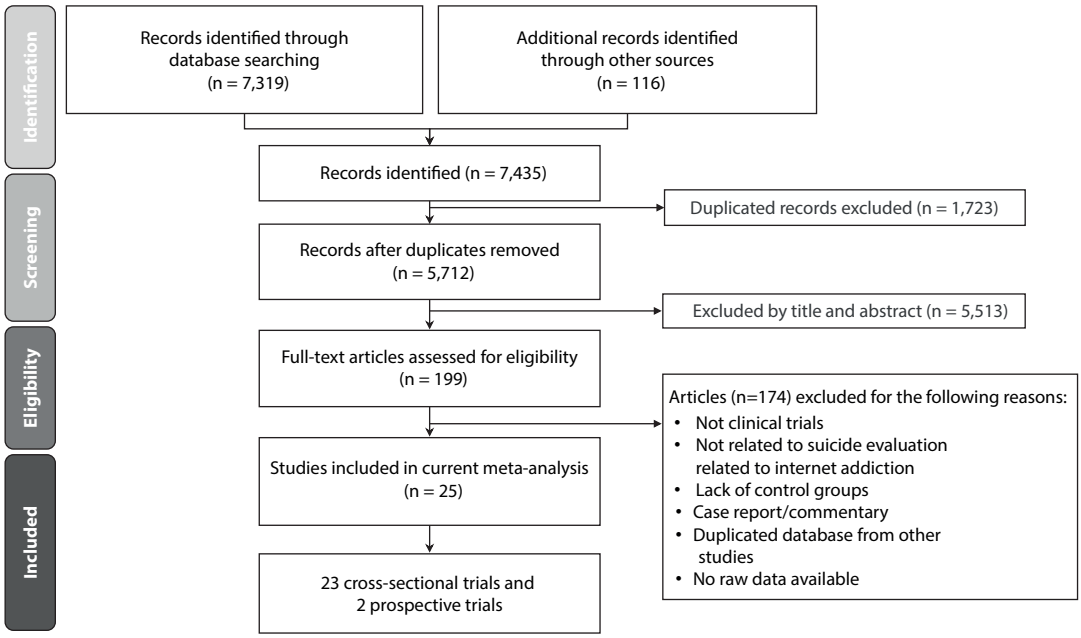
To investigate potential sources of heterogeneity and confounding effects, we conducted subgroup meta-analyses when there were at least 3 studies.[59] Specifically, we subdivided the recruited studies according to age distribution (children aged less than 18 years and adults aged at least 18 years), individuals with internet gaming disorder or internet addiction disorder with any type of internet activity, or different target surveillance periods for suicidal behaviors. The target surveillance periods were categorized into 3 groups: current without a specified time period (ie, "I have thoughts of killing myself," with no specified time period), lifetime (ie, any prior suicidal attempts), and non-lifetime including any time period less than 12 months (ie, any suicidal attempts occurring over the past 12 months). To detect potential differences in prevalence rate/severity of the risk of suicide among the different subgroups, we used interaction tests and corresponding $P$ values.[60] In addition, we also performed meta-regression analysis to investigate the potential confounding effects of clinical variables on the ESs with unrestricted maximum likelihood random effects. The meta-regression analyses were performed whenever data on a potential moderator were available in at least 5 datasets.

## RESULTS

### Study Selection

Figure 1 shows the flowchart of study selection. Reasons for study exclusion are provided in Supplementary Table 2. One hundred forty-nine articles provided information about internet addiction and depression, and 5 authors replied

**Figure 1. Flowchart of the Study Selection Strategy**




with useful information about suicide risk.[61–65] Finally, 25 articles were included in the current meta-analysis (Table 1).[12,13,18–35,61–65] The prevalence rates of internet addiction and internet gaming disorders ranged from 0.6% to 22.8% (mean = 7.07%, SD = 6.01%). Surveillance periods for suicidal behaviors in different studies are summarized in Table 1. We pooled the studies with a surveillance period of less than 12 months into a "non-lifetime" subgroup.

### Methodological Quality of the Included Studies

The details of the methodological quality of the included studies are provided in Supplementary Table 3. Most studies used validated assessment tools for internet addiction (Table 1). Across the 23 cross-sectional studies, the mean modified NOS score was 4.26 with a standard deviation of 0.96. Most of the studies seemed to have a fair sample selection; however, about as many studies did not provide adjustments for depression. Nevertheless, we conducted a separate meta-analysis for the studies that controlled for at least depression. Among the 2 cohort studies, 1 had a NOS score of 7,[19] and the other had a score of 6,[28] and therefore both were rated as high quality.

We provide only positive and important findings in our Results section. Please see Supplementary Table 4 for full results of sensitivity tests, meta-regression, and subgroup analyses.

### Meta-Analysis Investigating Differences in Suicidal Ideation in Participants With Internet Addiction and Controls: Dichotomous Data

Among 18 eligible articles (participants with internet addiction = 8,547, participants without internet addiction = 250,005) with 19 datasets comparing different prevalence rates of suicidal ideation, the meta-analysis revealed that the prevalence rate of suicidal ideation was significantly higher in the participants with internet addiction than in the controls ($k = 19$, OR = 2.952, 95% CI, 2.457–3.547; $P < .001$) (Figure 2A) with significant heterogeneity ($Q_{18} = 116.611$, $P < .001$, $I^2 = 84.564\%$) but not publication bias in Egger regression test ($t_{17} = 0.009$, 2-tailed $P$ value = .993).

After subdividing the participants into age groups, the main results of the meta-analysis revealed that the prevalence rate of suicidal ideation was still significantly higher in those with internet addiction than in the controls in the child subgroup (aged less than 18 years) ($k = 9$, OR = 3.771, 95% CI, 2.802–5.075; $P < .001$) and in the adult subgroup (aged 18 years or older) ($k = 5$, OR = 1.955, 95% CI, 1.312–2.915; $P = .001$). In addition, there was a significant difference in the ORs between these 2 subgroups via the interaction test ($P = .010$).

After subdividing the participants into internet gaming addiction only and internet addiction disorder with any type of internet activity groups, the main results of the meta-analysis revealed that the prevalence rate of suicidal ideation was still significantly higher in the patients than in the controls in the internet gaming addiction only subgroup ($k = 4$, OR = 3.033, 95% CI, 2.515–3.657; $P < .001$) and in the internet addiction disorder with any type of internet activity subgroup ($k = 15$, OR = 2.952, 95% CI, 2.361–3.691; $P < .001$). In addition, there was no significant difference in the ORs between these 2 subgroups in the interaction test ($P = .857$).

### Meta-Analysis Investigating the Differences in Suicidal Ideation in Participants With Internet Addiction and Controls: Continuous Data

Among 10 eligible articles (participants with internet addiction = 509, participants without internet

**Table 1. Summary of Characteristics of Studies Included in the Meta-Analysis[a,b]**

| Study (Year) | Diagnosis of Internet Addiction | Design | Comparison | n | Suicidal Events: Type of Event | Suicidal Events: Prevalence (Assessment Method) | Gender (% Female) | Mean ± SD Age (y) | Adjusted Odds Ratio (95% CI) | Country |
|---|---|---|---|---|---|---|---|---|---|---|
| Kim et al (2017)[23] | Scale of "problematic game playing" ≥ 4 symptoms<br>Prevalence: 7.71% | Cross-sectional | Internet game addiction | 108 | Suicidal ideation<br>Suicide plan<br>Suicide attempt | 37.0%<br>18.5%<br>14.8% | 32.4 | 27.5 ± 8.3 | NA | Korea |
| | | | Normal | 1,293 | Suicidal ideation<br>Suicide plan<br>Suicide attempt<br>(lifetime) | 16.4%<br>2.2%<br>3.1%<br>(by interviewer) | 29.9 | 33.6 ± 11.8 | | |
| Kim et al (2017)[24] | YIAT > 50<br>Prevalence: 6.35% | Cross-sectional | Internet addiction | 204 | Suicidal ideation<br>Suicide plan<br>Suicide attempt | 22.4%<br>7.0%<br>5.5% | 41.2 | 26.9 ± 8.8 | NA | Korea |
| | | | Normal | 3,008 | Suicidal ideation<br>Suicide plan<br>Suicide attempt<br>(lifetime) | 15.1%<br>2.6%<br>2.7%<br>(by interviewer) | 56.6 | 35.0 ± 9.9 | | |
| Bousoño Serrano et al (2017)[25] | YQD ≥ 5 symptoms<br>Prevalence: 4.3% | Cross-sectional | Internet addiction | 44 | Suicidal ideation<br>(past 2 wk) | 34.1% | 48.3 | 14.5 ± 0.7 | NA | Spain |
| | | | Normal | 846 | | 4.4%<br>(by PSS) | | | | |
| Seyrek et al (2017)[62] | YIAT > 40<br>Prevalence: 1.6% | Cross-sectional | Addictive/borderline internet use | 76 | Suicidal ideation<br>Suicide severity | 60.5%<br>0.7 ± 0.6 | 16.1 | 13.6<br>(median) | NA | Turkey |
| | | | Normal | 353 | Suicidal ideation<br>Suicide severity<br>(past 2 wk) | 23.5%<br>0.3 ± 0.5<br>(by CDI) | 83.9 | | | |
| Pearcy et al (2017)[63] | Personal Internet Gaming Disorder Evaluation<br>Prevalence: 8.2% | Cross-sectional | Internet game disorder | 34 | Suicidal ideation<br>Suicide severity | 44.1%<br>0.9 ± 1.2 | 30.0 | 23.8 ± 7.2 | NA | Australia |
| | | | Normal | 370 | Suicidal ideation<br>Suicide severity<br>(past 2 wk) | 21.6%<br>0.3 ± 0.7<br>(by PHQ-9) | | | | |
| Kim et al (2016)[30] | YIAT > 40<br>Prevalence: 0.6% | Cross-sectional | Problematic internet use | 604 | Suicidal ideation<br>Suicide plan<br>Suicide attempt | 21.6%<br>5.5%<br>4.2% | 47.5 | NA | Suicidal ideation: 1.4 (1.1–1.9)<br>Suicide plans: 2.0 (1.1–3.5)<br>Suicide attempts: 0.9 (0.5–1.7) | Korea |
| | | | Non-problematic internet use | 2,968 | Suicidal ideation<br>Suicide plan<br>Suicide attempt<br>(lifetime) | 14.0%<br>2.3%<br>2.6%<br>(by interviewers) | 55.1 | | | |
| Alpaslan et al (2016)[13] | YIAT > 50<br>Prevalence: 17.7% | Cross-sectional | Problematic internet use + MDD | 36 | Suicidal ideation | 19.1 ± 7.0 | 62.5 | 15.2 ± 1.6 | NA | Turkey |
| | | | Non-problematic internet use + MDD | 84 | Suicidal ideation<br>(past 2 wk) | 18.8 ± 6.9<br>(by CDI) | | | | |
| Liu et al (2016)[33] | CIAS > 64<br>Prevalence: 17.1% | Cross-sectional | Internet addiction with self-harm | 77 | Suicide attempt | 44.2% | 67.2 | 15.5 ± 0.6 | Suicide attempts: 1.4 (1.0–2.0) | Taiwan |
| | | | No internet addiction with self-harm | 173 | Suicide attempt<br>(past 12 mo) | 28.3%<br>(by questionnaire) | | | | |
| Lee et al (2016)[31] | KS scale > 53<br>Prevalence: 2.6% | Cross-sectional | High risk for internet addiction | 5,762 | Suicidal ideation<br>Suicide attempt | 39.6%<br>12.8% | 47.6 | NA | Suicidal ideation: 1.9 (1.8–2.1)<br>Suicide attempts: 1.9 (1.7–2.1) | Korea |
| | | | No or mild risk for internet addiction | 210,488 | Suicidal ideation<br>Suicide attempt<br>(past 12 mo) | 18.2%<br>4.4%<br>(by questionnaire) | | | | |

*(continued)*

**Table 1 (continued).**

| Study (Year) | Diagnosis of Internet Addiction | Design | Comparison | n | Suicidal Events: Type of Event | Suicidal Events: Prevalence (Assessment Method) | Gender (% Female) | Mean ± SD Age (y) | Adjusted Odds Ratio (95% CI) | Country |
|---|---|---|---|---|---|---|---|---|---|---|
| Strittmatter et al (2016)[28] T0 | YQD ≥ 5 symptoms Prevalence: 4.4% | Cohort | Internet addiction | 22 | Suicide behaviors (past 12 mo) | 63.6% | 62.1 | 14.5 ± 0.71 | NA | Europe |
| | | | Normal | 492 | | 26.4% (by PSS) | | | | |
| Strittmatter et al (2016)[28] T1 | YQD ≥ 5 symptoms Prevalence: 2.9% | Cohort | Internet addiction | 14 | Suicide behaviors (past 12 mo) | 42.9% | 62.1 | 14.5 ± 0.71 | NA | Europe |
| | | | Normal | 489 | | 19.3% (by PSS) | | | | |
| Strittmatter et al (2015)[26] | YQD ≥ 5 symptoms Prevalence: 3.1% | Cross-sectional | Internet addiction | 593 | Suicide behaviors (past 12 mo) | 48.9% | 55.5 | 15.0 ± 1.3 | NA | Germany |
| | | | Normal | 8,214 | | 21.3% (by PSS) | | | | |
| Wu et al (2015)[12] | CIAS > 67 Prevalence: 10.6% | Cross-sectional | Internet addiction | 99 | Suicidal ideation (current) Suicide attempt (past year and lifetime) | 47.0% 5.1% and 23.1% | 73.5 | NA | NA | Taiwan |
| | | | Control | 983 | Suicidal ideation Suicide attempt (past year and lifetime) | 22.1% 2.3% and 14.1% (by questionnaire) | 87.3 | | | |
| Kaess et al (2014)[29] | YQD ≥ 5 symptoms Prevalence: 4.2% | Cross-sectional | Pathological internet use | 477 | Suicidal ideation Suicide attempt | 42.3% 3.1% | 57.2 | 14.9 ± 0.9 | NA | Europe |
| | | | Normal | 9,355 | Suicidal ideation Suicide attempt (past 2 wk) | 12.7% 0.3% (by PSS) | | | | |
| Şenormancı et al (2014)[64] | IAS ≥ 90 Prevalence: 7.2% | Cross-sectional | Internet addiction | 52 | Suicidal ideation Suicide severity | 65.0% 0.9 ± 0.9 | 50.3 | 19.0 (median) | NA | Turkey |
| | | | Normal | 665 | Suicidal ideation Suicide severity (current) | 61.2% 0.7 ± 0.8 (by BDI) | | | | |
| Estévez Gutiérrez et al (2014)[65] | MULTICAGE CAD-4 Prevalence: 22.8% | Cross-sectional | Internet addiction | 62 | Suicide severity | 0.3 ± 0.8 | 42.6 | 17.3 ± 2.7 | NA | Spain |
| | | | Normal | 1,243 | Suicide severity (past 1 wk) | 0.4 ± 0.9 (by SCL-90-R) | | | | |
| Lin et al (2014)[32] | CIAS > 64 Prevalence: 18.7% | Cross-sectional | Internet addiction | 1,778 | Suicidal ideation (odds ratio) Suicide attempt (odds ratio) | 1.3 (95% CI, 1.1–1.4) 1.6 (95% CI, 1.3–2.0) | 51.7 | 14.7 ± 1.7 | Suicidal ideation: 1.3 (1.1–1.4) Suicide attempts: 1.6 (1.3–2.0) | Taiwan |
| | | | Control | 7,732 | Suicidal ideation Suicide attempt (past 1 mo) | Reference Reference (by Kiddie-SADS-E) | | | | |
| King et al (2013)[61] | Adopted from PTU checklist ≥ 5 Prevalence: 6.4% | Cross-sectional | Pathological internet use | 76 | Suicidal ideation Suicide severity | 81.6% 1.5 ± 1.1 | 50.4 | 14.8 ± 1.5 | NA | Australia |
| | | | Pathological internet and video game use | 36 | Suicidal ideation Suicide severity | 80.6% 1.6 ± 1.2 | | | | |
| | | | Normal | 1,007 | Suicidal ideation Suicide severity (current) | 57.1% 0.9 ± 1.0 (by RCADS) | | | | |
| Park et al (2013)[21] | KS scale > 53 Prevalence: 9.4% | Cross-sectional | Problematic internet use | 75 | SIQ-JR | 39.6 ± 36.2 | 58.7 | 13.9 ± 1.6 | NA | Korea |
| | | | Control | 720 | SIQ-JR (past 1 mo) | 16.9 ± 26.8 (by SIQ) | 68.6 | 13.9 ± 1.5 | | |

*(continued)*

**Table 1 (continued).**

| Study (Year) | Diagnosis of Internet Addiction | Design | Comparison | n | Suicidal Events: Type of Event | Suicidal Events: Prevalence (Assessment Method) | Gender (% Female) | Mean ± SD Age (y) | Adjusted Odds Ratio (95% CI) | Country |
|---|---|---|---|---|---|---|---|---|---|---|
| Fischer et al (2012)[27] | YQD ≥ 5 symptoms<br>Prevalence: 4.8% | Cross-sectional | Internet addiction | 69 | Suicidal ideation<br>Suicide attempt | 69.6%<br>1.5% | 52.1 | NA | NA | Germany |
| | | | Normal | 1,158 | Suicidal ideation<br>Suicide attempt<br>(past 2 wk) | 37.2%<br>0.7%<br>(by PSS) | 50.6 | | | |
| Tsouvelas and Giotakos (2011)[34] | YIAT > 70<br>Prevalence: 3.5% | Cross-sectional | Pathological internet engagement | 18 | Suicidal ideation<br>Suicide attempt | 11.1%<br>0.0% | 54.1 | 22.5 ± 3.3 | NA | Greece |
| | | | Healthy internet use | 361 | Suicidal ideation<br>Suicide attempt<br>(current) | 8.0%<br>1.1%<br>(by questionnaire) | | | | |
| Yang et al (2010)[35] | YQD ≥ 5 symptoms<br>Prevalence: 5.2% | Cross-sectional | Internet addiction | 182 | Suicidal ideation<br>Suicide plans<br>Suicide attempt | 36.9%<br>16.8%<br>4.9 | 48.2 | 15.4 ± 1.6 | Suicidal ideation: 1.4 (1.0–2.0)<br>Suicide plans: 1.5 (1.0–2.4)<br>Suicide attempts: 1.2 (0.6–2.8) | China |
| | | | Control | 3,325 | Suicidal ideation<br>Suicide plans<br>Suicide attempt<br>(past 12 mo) | 26.7%<br>9.0%<br>2.4%<br>(by questionnaire) | | | | |
| Fu et al (2010)[19] | YQD ≥ 5 symptoms<br>Prevalence: 6.7% | Cohort | Pathological internet use | 14 | SIQ-JR | 24.2 ± 1.21 | 28.6 | NA | NA | Hong Kong |
| | | | Adaptive internet use | 149 | SIQ-JR<br>(past 1 mo) | 4.5 ± 0.3<br>(by SIQ) | 42.3 | | | |
| Bakken et al (2009)[22] | YQD ≥ 5 symptoms<br>Prevalence: 1% | Cross-sectional | Internet addiction | 35 | Suicidal ideation | 6.3% | 52.9 | NA | NA | Norway |
| | | | Control | 2,741 | Suicidal ideation<br>(past 12 mo) | 1.0%<br>(by questionnaire) | | | | |
| Kim et al (2006)[20] | YIAT > 70<br>Prevalence: 1.6% | Cross-sectional | Internet addiction | 25 | SIQ-JR | 35.4 ± 26.9 | 56.0 | NA | NA | Korea |
| | | | Control | 951 | SIQ-JR<br>(past 1 mo) | 11.9 ± 13.7<br>(by SIQ) | 65.1 | | | |
| Ryu et al (2004)[18] | YIAT > 70<br>Prevalence: 1.5% | Cross-sectional | Internet addiction | 25 | SIQ-JR | 35.4 ± 26.9 | 56.0 | NA | NA | Korea |
| | | | Control | 1,006 | SIQ-JR<br>(past 1 mo) | 11.9 ± 13.6<br>(by SIQ) | 65.0 | | | |

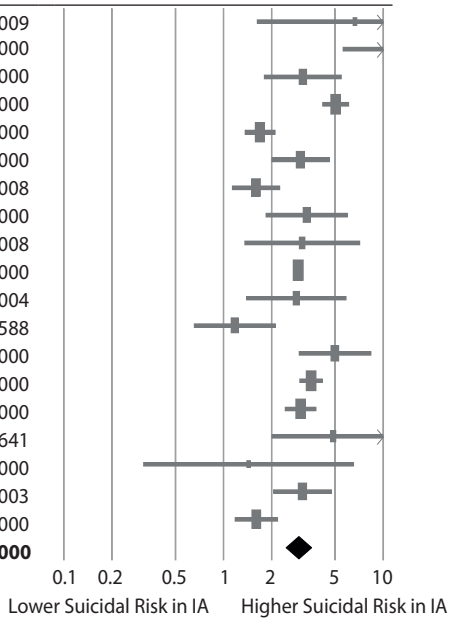
[a]Summary of assessment tools for different studies: 8 used YDQ, 7 used YIAT, 3 used CIAS, 2 used KS scale, 1 used the IAS, 1 used PTU checklist, 1 used the Personal Internet Gaming Disorder Evaluation, 1 used a scale of "problematic game playing," and 1 used MULTICAGE CAD-4. [b]Summary of surveillance periods for different studies: 1 investigated suicidal behaviors over the past week, 6 investigated suicidal behaviors over the past 2 weeks, 5 studies investigated suicidal behaviors over the past month, 7 studies investigated suicidal behaviors over the past 12 months, 4 studies investigated lifetime suicidal behaviors, and 3 studies investigated current suicidal behaviors without a specified time period (ie, "I have thoughts of killing myself," without a specified time period).

Abbreviations: BDI = Beck Depression Inventory, CDI = Children's Depression Inventory, CI = confidence interval, CIAS = Chen Internet Addiction Scale, IAS = Internet Addiction Scale, Kiddie-SADS-E = Kiddie Schedule for Affective Disorders and Schizophrenia, KS-scale = Internet Addiction Proneness Scale for Youth–Short Form, MDD = major depressive disorder, NA = not available, PHQ = Patient Health Questionnaire, PSS = Paykel Suicide Scale, PTU = pathological technology use, RCADS = Revised Children's Anxiety and Depression Scale, SCL-90-R = Symptom Checklist-90-Revised (item 15), SIQ = Reynolds Suicidal Ideation Questionnaire, SIQ-JR = Suicidal Ideation Questionnaire Junior, YIAT = Young's Internet Addiction Test, YQD = Young Diagnostic Questionnaire.

**Figure 2. Meta-Analysis of Different Risks of Suicide in Patients With Internet Addiction (IA) and Controls With Regard to Suicidal Ideation, Planning, and Attempts**

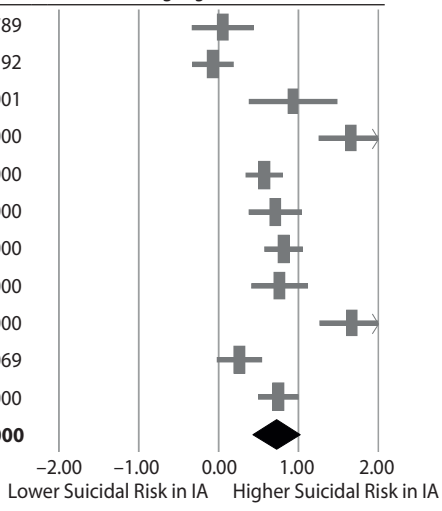
**A. Risk of Suicidal Ideation in IA Compared to Controls[a]**

| Study | Odds Ratio | Lower Limit | Upper Limit | *P* Value |
|---|---|---|---|---|
| Bakken et al (2009)[22] | 6.656 | 1.618 | 27.388 | 0.009 |
| Bousoño Serrano et al (2017)[25] | 11.309 | 5.588 | 22.890 | 0.000 |
| Fischer et al (2012)[27] | 3.140 | 1.794 | 5.497 | 0.000 |
| Kaess et al (2014)[29] | 5.039 | 4.161 | 6.103 | 0.000 |
| Kim et al (2016)[30] | 1.692 | 1.358 | 2.108 | 0.000 |
| Kim et al (2017)[23] | 3.034 | 1.998 | 4.606 | 0.000 |
| Kim et al (2017)[24] | 1.600 | 1.133 | 2.261 | 0.008 |
| King et al (2013)[61] | 3.327 | 1.838 | 6.022 | 0.000 |
| King et al (2013)[61] IA + IGA | 3.113 | 1.351 | 7.172 | 0.008 |
| Lee et al (2016)[31] | 2.947 | 2.792 | 3.110 | 0.000 |
| Pearcy et al (2017)[63] | 2.862 | 1.392 | 5.884 | 0.004 |
| Şenormancı et al (2014)[64] | 1.177 | 0.652 | 2.126 | 0.588 |
| Seyrek et al (2017)[62] | 4.988 | 2.961 | 8.403 | 0.000 |
| Strittmatter et al (2015)[26] no IGA | 3.540 | 2.989 | 4.194 | 0.000 |
| Strittmatter et al (2015)[26] also IGA | 3.044 | 2.426 | 3.819 | 0.000 |
| Strittmatter et al (2016)[28] | 4.873 | 1.998 | 11.884 | 0.641 |
| Tsouvelas and Giotakos (2011)[34] | 1.436 | 0.314 | 6.558 | 0.000 |
| Wu et al (2015)[12] | 3.126 | 2.049 | 4.769 | 0.003 |
| Yang et al (2010)[35] | 1.605 | 1.177 | 2.190 | 0.000 |
| **Overall** | **2.952** | **2.457** | **3.547** | **0.000** |




**B. Severity of Suicidal Ideation in IA Compared to Controls[b]**

| Study | Hedges *g* | Lower Limit | Upper Limit | *P* Value |
|---|---|---|---|---|
| Alpaslan et al (2016)[13] | 0.053 | −0.335 | 0.441 | 0.789 |
| Estévez Gutiérrez et al (2014)[65] | −0.071 | −0.330 | 0.188 | 0.592 |
| Fu et al (2010)[19] | 0.933 | 0.378 | 1.487 | 0.001 |
| Kim et al (2006)[20] | 1.657 | 1.253 | 2.061 | 0.000 |
| King et al (2013)[61] IA | 0.572 | 0.338 | 0.806 | 0.000 |
| King et al (2013)[61] IA + IGA | 0.711 | 0.377 | 1.044 | 0.000 |
| Park et al (2013)[21] | 0.815 | 0.575 | 1.056 | 0.000 |
| Pearcy et al (2017)[63] | 0.764 | 0.410 | 1.119 | 0.000 |
| Ryu et al (2004)[18] | 1.668 | 1.265 | 2.071 | 0.000 |
| Şenormancı et al (2014)[64] | 0.262 | −0.021 | 0.544 | 0.069 |
| Seyrek et al (2017)[62] | 0.748 | 0.496 | 1.001 | 0.000 |
| **Overall** | **0.723** | **0.427** | **1.019** | **0.000** |




*(continued)*

addiction = 7,555) with 11 datasets comparing different severities of suicidal ideation, the meta-analysis revealed that the severity of suicidal ideation was significantly higher in the participants with internet addiction than in the controls ($k = 11$, Hedges $g = 0.723$, 95% CI, 0.427–1.019; $P < .001$) (Figure 2B) with significant heterogeneity ($Q_{10} = 98.818$, $P < .001$, $I^2 = 89.980\%$) but not publication bias in Egger regression test ($t_9 = 1.312$, 2-tailed $P$ value = .222).

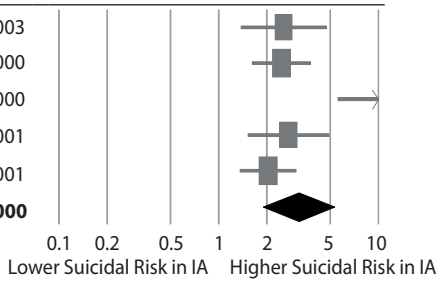
### Meta-Analysis Investigating the Differences in Suicidal Planning in Participants With Internet Addiction and Controls

Among 5 eligible articles (participants with internet addiction = 1,167, participants without internet addiction = 11,752) with 5 datasets comparing different prevalence rate of suicidal planning, the most severe form of suicidal ideation, the meta-analysis revealed that the

**Figure 2 (continued).**

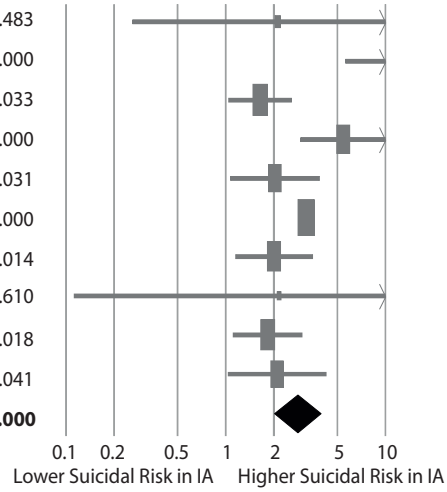
**C. Risk of Suicidal Plan in IA Compared to Controls[c]**

| Study | Odds Ratio | Lower Limit | Upper Limit | *P* Value |
|---|---|---|---|---|
| Fischer et al (2012)[27] | 2.553 | 1.373 | 4.746 | 0.003 |
| Kim et al (2016)[30] | 2.472 | 1.618 | 3.779 | 0.000 |
| Kim et al (2017)[23] | 10.268 | 5.561 | 18.957 | 0.000 |
| Kim et al (2017)[24] | 2.732 | 1.519 | 4.913 | 0.001 |
| Yang et al (2010)[35] | 2.042 | 1.360 | 3.065 | 0.001 |
| **Overall** | **3.172** | **1.894** | **5.311** | **0.000** |




**D. Risk of Suicidal Attempt in IA Compared to Controls[d]**

| Study | Odds Ratio | Lower Limit | Upper Limit | *P* Value |
|---|---|---|---|---|
| Fischer et al (2012)[27] | 2.114 | 0.261 | 17.146 | 0.483 |
| Kaess et al (2014)[29] | 10.632 | 5.625 | 20.097 | 0.000 |
| Kim et al (2016)[30] | 1.642 | 1.040 | 2.595 | 0.033 |
| Kim et al (2017)[23] | 5.448 | 2.939 | 10.099 | 0.000 |
| Kim, K. (2017)[24] | 2.034 | 1.066 | 3.880 | 0.031 |
| Lee et al (2016)[31] | 3.189 | 2.944 | 3.455 | 0.000 |
| Liu et al (2016)[33] | 2.007 | 1.148 | 3.507 | 0.014 |
| Tsouvelas and Giotakos (2011)[34] | 2.161 | 0.112 | 41.700 | 0.610 |
| Wu et al (2015)[12] | 1.830 | 1.109 | 3.019 | 0.018 |
| Yang et al (2010)[35] | 2.095 | 1.031 | 4.256 | 0.041 |
| **Overall** | **2.811** | **2.011** | **3.928** | **0.000** |




[a]The risk of suicidal ideation was significantly higher in the patients with IA than in the controls ($P < .001$).
[b]The severity of suicidal ideation was significantly higher in the patients with IA than in the controls ($P < .001$).
[c]The risk of suicidal planning was significantly higher in the patients with IA than in the controls ($P < .001$).
[d]The risk of suicide attempts was significantly higher in the patients with IA than in the controls ($P < .001$).
Abbreviation: CI = confidence interval.

prevalence rate of suicidal planning was significantly higher in the participants with internet addiction than in the controls ($k = 5$, OR = 3.172, 95% CI, 1.894–5.311; $P < .001$) (Figure 2C) with significant heterogeneity ($Q_4 = 19.940$, $P = .001$, $I^2 = 79.939\%$) and significant publication bias via inspection of a funnel plot (Supplementary Figure 3A). The adjusted ESs via Duval and Tweedie trim-and-fill test were still significant (OR = 3.598, 95% CI, 2.179–5.942).

### Meta-Analysis Investigating the Differences in Suicide Attempts in Participants With Internet Addiction and Controls

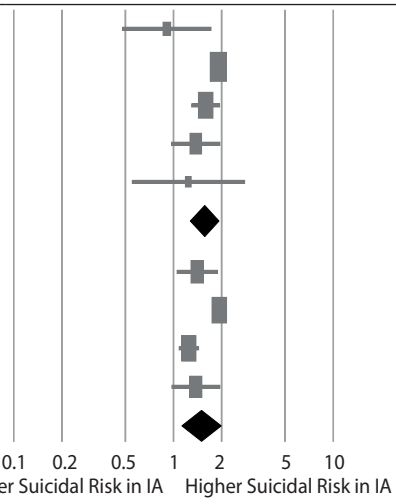
Among 10 eligible articles (participants with internet addiction = 7,600, participants without internet addiction = 233,112) with 10 datasets comparing different prevalence rates of suicide attempts, the meta-analysis revealed that the prevalence rate of suicide attempts was significantly higher in the participants with internet addiction than in the controls ($k = 10$, OR = 2.811, 95% CI, 2.011–3.928; $P < .001$) (Figure 2D) with significant heterogeneity ($Q_9 = 35.070$, $P < .001$, $I^2 = 74.337\%$) but not publication bias in Egger regression test ($t_8 = 0.606$, 2-tailed $P$ value = .561).

### Meta-Analysis Investigating the Adjusted OR of the Risk of Suicide in Participants With Internet Addiction and Controls

If we focused on the studies that adjusted the OR by both demographic data and depression, there were only 5 eligible articles[30–33,35] with 5 datasets that provided adjusted ORs of suicide attempts and 4 eligible articles[30–32,35] with 4 datasets that provided adjusted ORs of suicidal ideation. The adjusted covariates ranged from 5 to 19 items. The meta-analysis of pooled adjusted ORs revealed that the pooled adjusted ORs of suicide attempts ($k = 5$, pooled adjusted OR = 1.559, 95% CI, 1.266–1.920; $P < .001$) and suicidal ideation ($k = 4$,

**Figure 3. Meta-Analysis of Adjusted Risks of Suicide in the Patients With Internet Addiction (IA) and Controls With Regard to Suicide Attempts and Ideation[a]**

| Suicidal Risk | Study | Odds Ratio | Lower Limit | Upper Limit | *P* Value |
|---|---|---|---|---|---|
| Attempt | Kim et al (2016)[30] | 0.910 | 0.479 | 1.728 | 0.773 |
| Attempt | Lee et al (2016)[31] | 1.910 | 1.707 | 2.137 | 0.000 |
| Attempt | Lin et al (2014)[32] | 1.590 | 1.290 | 1.960 | 0.000 |
| Attempt | Liu et al (2016)[33] | 1.380 | 0.971 | 1.962 | 0.073 |
| Attempt | Yang et al (2010)[35] | 1.240 | 0.549 | 2.803 | 0.605 |
| **Attempt** | **Attempt Overall** | **1.559** | **1.266** | **1.920** | **0.000** |
| Ideation | Kim et al (2016)[30] | 1.410 | 1.048 | 1.897 | 0.023 |
| Ideation | Lee et al (2016)[31] | 1.940 | 1.791 | 2.101 | 0.000 |
| Ideation | Lin et al (2014)[32] | 1.250 | 1.083 | 1.443 | 0.002 |
| Ideation | Yang et al (2010)[35] | 1.380 | 0.971 | 1.962 | 0.073 |
| **Ideation** | **Ideation Overall** | **1.490** | **1.123** | **1.978** | **0.006** |




[a]Odds ratios adjusted for demographic data and depression. The adjusted risk of suicide was significantly higher in the patients with IA than in the controls with regard to suicide attempts ($P < .001$) and ideation ($P = .006$).
Abbreviation: CI = confidence interval.

pooled adjusted OR = 1.490, 95% CI, 1.123–1.978; $P = .006$) were significantly higher in the participants with internet addiction than in the controls (Figure 3) with significant heterogeneity (attempts: $Q_4 = 9.562$, $P = .048$, $I^2 = 58.167\%$; ideation: $Q_3 = 30.867$, $P < .001$, $I^2 = 90.281\%$). In addition, inspection of funnel plots showed that there was also significant publication bias in suicidal attempts and ideation (Supplementary Figure 3B and 3C). The ESs after adjusting for publication bias using the Duval and Tweedie trim-and-fill test remained significant (suicidal attempts: ES = 1.672, 95% CI, 1.365–2.047; suicidal ideation: ES = 1.612, 95% CI, 1.292–2.011).

## DISCUSSION

### Summary of Study Findings

Our meta-analysis included 23 cross-sectional studies (n = 270,596) and 2 cohort studies (n = 1,180). The results of this meta-analysis revealed that the severity of suicidal ideation as indicated by suicide rating scale scores was significantly higher in the participants with internet addiction than in the controls (Hedges $g = 0.723$). Similarly, our meta-analysis showed that prevalence rates of suicidal ideation, planning, and attempts were all significantly higher in the participants with internet addiction than in the controls (ORs of 2.952, 3.172, and 2.811, respectively). Furthermore, if we included only data with ORs adjusted for both demographic data and depression, the results still showed that the prevalence rates of suicide attempts and ideation were significantly higher in the participants with internet addiction than in the controls (attempts: pooled adjusted OR = 1.559; ideation: pooled adjusted OR = 1.490). Therefore, the results of our meta-analysis suggest that the association between internet addiction and risk of suicide cannot be solely explained by depression. Finally, in our subgroup analysis, we found a significantly higher prevalence rate of suicidal ideation in the children subgroup (aged less than 18 years) than in the adult subgroup (OR = 3.771 and OR = 1.955, respectively). There was also a trend of a higher prevalence rate of suicidal ideation in the internet gaming addiction only subgroup (OR = 3.033) than in the internet addiction disorder with any type of internet activity subgroup (OR = 2.952), although this did not reach statistical significance in the interaction test.

### Strength of the Evidence and Study Quality

To the best of our knowledge, this is the first meta-analysis to investigate the relationship between suicidal behaviors and internet addiction. There was a wide range of prevalence rates of internet addiction or internet gaming disorders in our included studies (mean = 7.07%, SD = 6.01%; range, 0.6%–22.8%). The highest prevalence rate of internet addiction among the recruited studies was 22.8%[65]; however, some of the data in that study came from a gambling rehabilitation center in Spain.[65] Therefore, the participants in that particular study may not be representative of the general population. The second to fourth highest prevalence rates (range from 17.1% to 18.7%) of internet addiction were observed in adolescents (aged 12–18 years) from community samples,[13,32,33] and the lowest prevalence rate of internet addiction was observed in adults (aged 18–64 years).[30] This finding suggests that internet addiction is more prevalent in adolescents, which is consistent with most previous studies.[17] The risk of suicide is an important issue in internet addiction, which can potentially lead to serious consequences, especially in adolescents. Furthermore,

internet addiction is still underresearched and is not included in the *DSM-5* due to a lack of sufficient evidence of clinically significant impairment.[7] The results of our meta-analysis may provide a direction for further studies to investigate internet addiction and may also provide evidence about the potentially negative effects of internet addiction. Another major strength of this meta-analysis is the large sample size (N = 271,776) from a wide range of different countries and ethnic groups. Moreover, the majority of studies in our meta-analysis seemed to have fair quality according to the NOS and modified version of the NOS for observational studies, and most of the studies used validated assessment tools for internet addiction. Finally, by including 25 articles, we were able to conduct subgroup analysis of different age groups and different types of internet addiction. However, our study results were still mostly derived from cross-sectional studies, and therefore the causal relationship could not be determined.

### Rates of Suicidal Ideation, Planning, or Attempts in Those With Internet Addiction

Our meta-analysis showed that the severity of suicidal ideation as indicated by suicide rating scale scores was significantly higher in the participants with internet addiction than in the controls ($k = 11$, Hedges $g = 0.723$, 95% CI, 0.427–1.019; $P < .001$). This finding suggests a strong association between internet addiction and the severity of suicidal ideation. This result was further confirmed by significantly higher prevalence rates of suicidal ideation in the participants with internet addiction than in the controls ($k = 19$, OR = 2.952, 95% CI, 2.457–3.547; $P < .001$). In fact, all of the included studies except 2[34,64] showed significantly elevated prevalence rates of suicidal ideation among the participants with internet addiction, in whom the ORs of suicidal ideation ranged from 1.177 to 11.309. Similarly, elevated rates of suicidal planning and attempts were also found in those with internet addiction in our meta-analysis (planning, $k = 5$, OR = 3.172, 95% CI, 1.894–5.311; attempts, $k = 10$, OR = 2.811, 95% CI, 2.011–3.928). Among individual studies, the OR of suicidal planning in those with internet addiction ranged from 2.042 to 10.268, and that of suicide attempts ranged from 1.642 to 10.632. Only 2 studies failed to show significantly elevated rates of suicide attempts in those with internet addiction.[27,34] In summary, our meta-analysis showed that the prevalence rates of suicidal ideation, planning, and attempts were approximately 3 times higher in those with internet addiction, slightly higher than the increase in risk caused by anxiety disorder (OR = 2.2).[66] Although other risk factors such as depression increased the risk of suicide by a much higher degree (up to 20 times),[67] suicide remains an important health issue in adolescents and young adults. In addition, the risk of suicide may be even higher if combined with other psychiatric comorbidities,[68] and internet addiction is frequently associated with other psychiatric disorders.[47] Without controlling for other psychiatric comorbidities, the wide range in the OR of the risk of suicide observed in our meta-analysis in the internet addiction group (eg, suicide attempts: OR ranged from 1.642 to 10.632) may be partly explained by an elevated risk of suicide in other psychiatric disorders. Nevertheless, although clinical evidence of significant harm is still insufficient in internet addiction disorder,[7] the evidence with regard to an elevated risk of suicide seems robust in our meta-analysis. Therefore, we suggest screening individuals with internet addiction for the risk of suicide and also other psychiatric comorbidities.

### Rates of Suicidal Ideation, Planning, or Attempts Among Those With Internet Addiction After Adjusting for Depression

Many theories have been proposed for the increased risk of suicide in individuals with internet addiction, including poor impulse control and hostility/aggression, but most importantly comorbidities with other psychiatric disorders, and especially its association with depression.[14,15,48] Although there seems to be a strong association between internet addiction and increased suicidality, some studies have suggested that this association may be mediated by depression. Furthermore, some studies have even reported a positive influence of the internet through social support on suicide or self-harm websites despite most viewing them as negative.[69,70] Therefore, we further conducted meta-analysis of the studies that provided adjusted ORs for depression. Although almost all of the studies showed significantly elevated risks of suicide in those with internet addiction, some of the results became insignificant after adjusting for depression in the original study. Among the 5 studies included in our meta-analysis that included adjusted ORs for both demographic data and depression, 3 still showed significantly elevated rates of suicidal ideation,[30,31,33] but only 2 showed significantly elevated rates of suicide attempts in those with internet addictions after adjustments.[31,32] Nevertheless, after we pooled all of these adjusted ORs together, the meta-analysis showed significantly elevated rates of suicide attempts and ideation in those with internet addiction (attempts: $k = 5$, pooled adjusted OR = 1.559, 95% CI, 1.266–1.920; $P < .001$; ideation: $k = 4$, pooled adjusted OR = 1.490, 95% CI, 1.123–1.978; $P = .006$). This finding suggests that the increased risk of suicide in those with internet addiction may be partly mediated by depression, but that other factors are also involved. The most popular theory is that individuals with internet addiction may have greater exposure to suicidal ideas or experience through websites and that this may result in imitations of suicidal behaviors based on a social learning model.[69,71–73] This influence could be even more prominent in those with psychiatric disorders, as a previous report suggested that the internet could be a communication platform for those with similar mindsets to arrange group suicide.[74] Furthermore, both internet addiction and suicidal behaviors have been associated with experiential avoidance, which is a tendency to escape from painful reality.[75,76] Other possible explanations for the association between suicidal behaviors and internet addiction include the more impulsive nature of those with

internet addiction,[77] some overlap in psychiatric disorders between internet addiction and the risk of suicide such as attention-deficit/hyperactivity disorder[78] and substance use disorder,[30] and a low socioeconomic status.[31] Overall, our results showed that the rates of suicide attempts and ideation were still elevated in those with internet addiction after adjusting for the effects of depression, and we suggest that further studies are needed to investigate other possible factors that could explain the association between internet addiction and the risk of suicide. Furthermore, we suggest screening individuals with internet addiction for the risk of suicide even if they do not have depression, as other factors may increase the risk of suicide in those with internet addiction.

### Subgroup Analysis and Meta-Regression of Suicidal Behaviors in Those With Internet Addiction

The results of our subgroup analysis showed a significantly higher OR of suicide ideation in the children subgroup (aged less than 18 years) than in the adult subgroup ($k = 9$, OR = 3.771 and $k = 5$, OR = 1.955 respectively, interaction test $P = .010$). Among individual studies, the highest OR of suicide ideation was observed in the children subgroup with internet addiction (OR = 11.3).[25] The first peak of the risk of suicide was reached in midadolescence,[79] and internet addiction also seemed to occur more often in adolescents.[17] Moreover, the studies included in our meta-analysis also showed that the prevalence rate of internet addiction was highest in adolescents (18.7%)[32] and lowest in adults (0.6%).[30] There are some common characteristics of adolescents that may be linked to both the risk of suicide and internet addiction, such as poorer impulse control, poorer self-regulation, poorer emotional regulation, and greater vulnerability to environmental stress.[80–82] Therefore, adolescents with internet addiction may be at a higher risk of suicide than those with internet addiction in other age groups. The results of our subgroup analysis suggest that clinicians should pay more attention to the risk of suicide among adolescents with internet addiction. Furthermore, the results of our subgroup analysis showed a trend of a higher OR of suicide attempts in the children subgroup (OR = 3.547) than in the adult subgroup (OR = 3.251). However, this result did not achieve statistical significance in the interaction test ($P = .899$), and further studies are required to confirm this association.

Another important finding in our subgroup analysis is a trend of a higher prevalence rate of suicidal ideation in the internet gaming addiction only subgroup ($k = 4$, OR = 3.033) than in the internet addiction with any type of activity subgroup ($k = 15$, OR = 2.952), although this difference did not reach statistical significance in the interaction test ($P = .857$). Previous studies have found that patients with internet gaming disorder suffered more severe consequences including lower remission rates and a higher risk of addiction.[40,41] Moreover, exposure to violent video games may increase aggression,[83] and prolonged video game use has also been associated with impulsiveness.[84] Both of these factors may increase the risk of suicide regardless of internet use. However, we could only include 4 datasets for internet gaming addiction to compare with 16 datasets for internet addiction with any type of activity. This discrepancy in the number of studies between the 2 groups may have diluted the potential difference in prevalence rates of suicidal ideation between internet gaming disorder and internet addiction with any online activity. Furthermore, we were unable to conduct meta-analysis for suicidal planning or suicide attempts, which are more severe forms of suicidal behaviors, due to insufficient data. Therefore, patients with internet gaming addiction may still be at a higher risk of suicide than those with internet addiction with other online activity. However, this result did not reach statistical significance, and further studies are needed to confirm this association.

With regard to meta-regression analysis, we found no significant association between the prevalence rates of suicidal behaviors and clinical variables of interest, including mean age, female proportion, or percentage of internet gaming activities. This suggests that the associations between suicidal behaviors and interactions were not affected by these factors. Our subgroup analysis of different surveillance periods showed that the significant association between suicidal behaviors and internet addiction were still present after classifying the surveillance periods into 3 subgroups. There were no differences in ORs between the different subgroups, which suggests that differences in targeted surveillance periods did not affect the association between suicidal behaviors and internet addiction.

## LIMITATIONS

There are several limitations to this meta-analysis. First, all of the included studies except for 2[19,28] were cross-sectional observational studies. Therefore, our results only suggest an association between internet addiction and suicidal behaviors but cannot determine the causal relationship. Second, most studies did not control for depressive state in their results. We tried to include depressive state in our subgroup analysis, but only 1 study[13] provided prevalence rates of suicide attempts and ideation in both depressed and nondepressed groups. Most studies only provided depressive rating scale scores, but we were also unable to conduct meta-regression or subgroup analysis due to an insufficient number of studies using the same rating scale for depression. Nevertheless, to better understand the relationship between depression, risk of suicide, and internet addiction, we further conducted meta-analysis for the studies that provided ORs adjusted for depression, and the results showed that the prevalence rates of suicide attempts and ideation in the internet addiction groups were still higher than in the controls. Third, although some studies tried to control for certain confounding factors such as depression, other potential confounding factors such as impulsivity or economic status were not controlled in most of the included studies, and so we cannot rule out the possibility that other potential confounding factors may have increased the rates of suicidal behaviors rather

than internet addiction itself. Fourth, although our meta-analysis included a wide variety of diverse ethnic groups including European and Asian countries, we did not have data from America or Africa. In addition, our data came primarily from certain Asian countries including Korea, Taiwan, and China. Therefore, the study results may not be generalizable to countries or ethnic groups not included in our data source. Fifth, as the study participants were mostly young adults or adolescents, the results of our meta-analysis may be more representative of adolescents and young adults than all age groups. Sixth, many depression rating scales also included suicidal items. However, we were able to extract useful information from only 5 authors out of 149 articles even though we tried to contact them for the original data. This may have contributed to potential bias of the results of the current meta-analysis. Finally, the definitions and assessment tools used for internet addiction and suicidal behaviors were different in different studies. This may partly account for the wide range of prevalence rates of internet addiction among the different studies. We are unsure how this difference in the use of assessment tools may have influenced the strength of association between suicidal behaviors and internet addiction. Nevertheless, most of the studies showed some association between suicidal behaviors and internet addiction, and this was confirmed by the results of our meta-analysis and remained unchanged after removing the results of any 1 study.

## CONCLUSION

In conclusion, our meta-analysis showed a positive association between internet addiction and suicidal behaviors, and the rates of suicidal ideation, planning, and attempts were increased by about 3 times in those with internet addiction. The higher rates of suicidal behaviors remained but were reduced from 3 times to about 1.5 times after adjusting for potential confounding factors including at least depression. Moreover, our subgroup analysis showed higher rates of suicidal behaviors in adolescents compared with adults and also showed a trend of higher prevalence rates of suicidal ideation in those with internet gaming disorder compared to those with internet addiction including any type of internet activity. Therefore, we suggest screening those with internet addiction for the risk of suicide, especially adolescents. We also encourage further studies to investigate the difference between suicidal behaviors in those with internet gaming disorder and internet addiction with other types of internet activity. As the evidence in this study was mostly derived from cross-sectional studies, future prospective studies are necessary to confirm our findings.



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***Supplementary material:*** Available at PSYCHIATRIST.COM.

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*Editor's Note:* We encourage authors to submit papers for consideration as a part of our Focus on Suicide section. Please contact Philippe Courtet, MD, PhD, at pcourtet@psychiatrist.com.

See supplementary material for this article at PSYCHIATRIST.COM.

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# Supplementary Material

**Article Title:** Internet Addiction and Its Relationship With Suicidal Behaviors: A Meta-Analysis of Multinational Observational Studies

**Author(s):** Yu-Shian Cheng, MD; Ping-Tao Tseng, MD; Pao-Yen Lin; Tien-Yu Chen, MD; Brendon Stubbs; Andre F. Carvalho; Ching-Kuan Wu, MD; Yen-Wen Chen, MD; and Ming-Kung Wu, MD

**DOI Number:** 10.4088/JCP.17r11761

## List of Supplementary Material for the article



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This Supplementary Material has been provided by the author(s) as an enhancement to the published article. It has been approved by peer review; however, it has undergone neither editing nor formatting by in-house editorial staff. The material is presented in the manner supplied by the author.

**Supplementary Table 1:** PRISMA checklist of current meta-analysis

| Section/Topic | # | Checklist Item | Reporte<br>Page # |
|---|---|---|---|
| **TITLE** | | | |
| Title | 1 | Identify the report as a systematic review, meta-analysis, or both. | 1 |
| **ABSTRACT** | | | |
| Structured summary | 2 | Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number. | 4-5 |
| **INTRODUCTION** | | | |
| Rationale | 3 | Describe the rationale for the review in the context of what is already known. | 6-7 |
| Objectives | 4 | Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS). | 8-9 |
| **METHODS** | | | |
| Protocol and registration | 5 | Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration | 10-1 |

| | | | |
|---|---|---|---|
| | | information including registration number. | |
| Eligibility criteria | 6 | Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale. | 10-1 |
| Information sources | 7 | Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched. | 10-1 |
| Search | 8 | Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated. | 10 |
| Study selection | 9 | State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis). | 10-1 |
| Data collection process | 10 | Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators. | 10-1 |
| Data items | 11 | List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made. | 12-1 |
| Risk of bias in individual studies | 12 | Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis. | 10-1 |
| Summary measures | 13 | State the principal summary measures (e.g., risk ratio, difference in means). | 11-1 |
| Synthesis of results | 14 | Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., $I^2$) for each meta-analysis. | 11-1 |
| Risk of bias across studies | 15 | Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within | 13-1 |

| | | | |
|---|---|---|---|
| | | studies). | |
| Additional analyses | 16 | Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified. | 12-1 |
| **RESULTS** | | | |
| Study selection | 17 | Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram. | 15-1 |
| Study characteristics | 18 | For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations. | 15-17 t 1 |
| Risk of bias within studies | 19 | Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12). | 15-1 |
| Results of individual studies | 20 | For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot. | 16-18, t 1 |
| Synthesis of results | 21 | Present the main results of the review. If meta-analyses done, include for each, confidence intervals and measures of consistency. | 16-18, fi 2 |
| Risk of bias across studies | 22 | Present results of any assessment of risk of bias across studies (see Item 15). | 19-2 |
| Additional analysis | 23 | Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]). | 15-17, fi 3 |
| **DISCUSSION** | | | |
| Summary of evidence | 24 | Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups | 23-2 |

| | | | |
|---|---|---|---|
| | | (e.g., healthcare providers, users, and policy makers). | |
| Limitations | 25 | Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias). | 29-3 |
| Conclusions | 26 | Provide a general interpretation of the results in the context of other evidence, and implications for future research. | 31 |
| **FUNDING** | | | |
| Funding | 27 | Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review. | 32 |

*From:* Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(6): e100

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**Supplementary Table 2:** The excluded articles and reasons

Commentary (n=1)

1. Tam P. Commentary on 'The association between problematic internet use and depression, suicidal ideation and bipolar disorder in Korean adolescents'. *The Australian and New Zealand journal of psychiatry* 2013;47(2):185-6. doi: 10.1177/0004867412469690

Duplicated data samples from the recruited study (Kaess, M. (2014)) (n=2)

2. Strittmatter E, Kaess M, Parzer P, et al. Pathological Internet use among adolescents: Comparing gamers and non-gamers. *Psychiatry Res* 2015;228(1):128-35. doi: 10.1016/j.psychres.2015.04.029
3. Fischer G, Brunner R, Parzer P, et al. [Depression, deliberate self-harm and suicidal behaviour in adolescents engaging in risky and pathological internet use]. *Prax Kinderpsychol Kinderpsychiatr* 2012;61(1):16-31. doi: 10.13109/prkk.2012.61.1.16

Duplicated data samples from the recruited study (Kim, B.S. (2016)) (n=1)

4. Kim K, Lee H, Hong JP, et al. Poor sleep quality and suicide attempt among adults with internet addiction: A nationwide community sample of Korea. *PLoS One* 2017;12(4):e0174619. doi: 10.1371/journal.pone.0174619

Lack of control (n=1)

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No definite diagnosis of internet addiction (n=1)

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**Supplementary Table 3:** Newcastle-Ottawa Scales of recruited studies

| Author (year) | Country | Design | Newcastle-OttawaScale | | | |
|---|---|---|---|---|---|---|
| | | | Selection | Comparability | Outcome | Total (quality) |
| Kim, D.J. (2017) | Korea | Cross-sectional questionnaire study | 2 | 2 | 1 | 5(high quality) |
| Kim, K. (2017) | Korea | Cross-sectional questionnaire study | 2 | 2 | 1 | 5(high quality) |
| Seyrek, S. (2017) | Turkey | Cross-sectional questionnaire study | 2 | 1 | 1 | 4(high quality) |
| Bousono Serrano, M. (2017) | Spain | Cross-sectional questionnaire study | 2 | 1 | 1 | 4(high quality) |
| Pearcy, B.T. (2017) | Australia | Cross-sectional questionnaire study | 2 | 2 | 1 | 5(high quality) |
| Alpaslan, A.H. (2016) | Turkey | Cross-sectional questionnaire study | 2 | 0 | 1 | 3(low quality) |
| Kim, B.S. (2016) | Korea | Cross-sectional questionnaire study | 2 | 2 | 1 | 5(high quality) |
| Lee, S.Y. (2016) | Korea | Cross-sectional questionnaire study | 2 | 2 | 1 | 5(high quality) |
| Liu, H.C. (2016) | Taiwan | Cross-sectional questionnaire study | 2 | 2 | 1 | 5(high quality) |

| | | | | | | |
|---|---|---|---|---|---|---|
| Strittmatter, E. (2016) | Germany | Cohort study | 2 | 2 | 2 | 6(high quality) |
| Wu, C.Y. (2015) | Taiwan | Cross-sectional questionnaire study | 2 | 0 | 1 | 3(low quality) |
| Strittmatter, E. (2015) | Europe | Cross-sectional questionnaire study | 2 | 2 | 1 | 5(high quality) |
| Senormanci, O. (2014) | Turkey | Cross-sectional questionnaire study | 2 | 2 | 1 | 5(high quality) |
| Kaess, M. (2014) | Multiple country | Cross-sectional questionnaire study | 2 | 2 | 1 | 5(high quality) |
| Estevez Gutierrez, A. (2014) | Spain | Cross-sectional questionnaire study | 1 | 0 | 1 | 2(low quality) |
| Lin, I.H. (2014) | Taiwan | Cross-sectional questionnaire study | 2 | 2 | 1 | 5(high quality) |
| Park, S. (2013) | Korea | Cross-sectional questionnaire study | 2 | 2 | 1 | 5(high quality) |
| King, D.L. (2013) | Australia | Cross-sectional questionnaire study | 2 | 1 | 1 | 4(high quality) |
| Fischer, G. (2012) | Germany | Cross-sectional questionnaire study | 2 | 1 | 1 | 4(high quality) |
| Tsouvelas, G. (2011) | Greece | Cross-sectional questionnaire study | 2 | 0 | 1 | 3(high quality) |

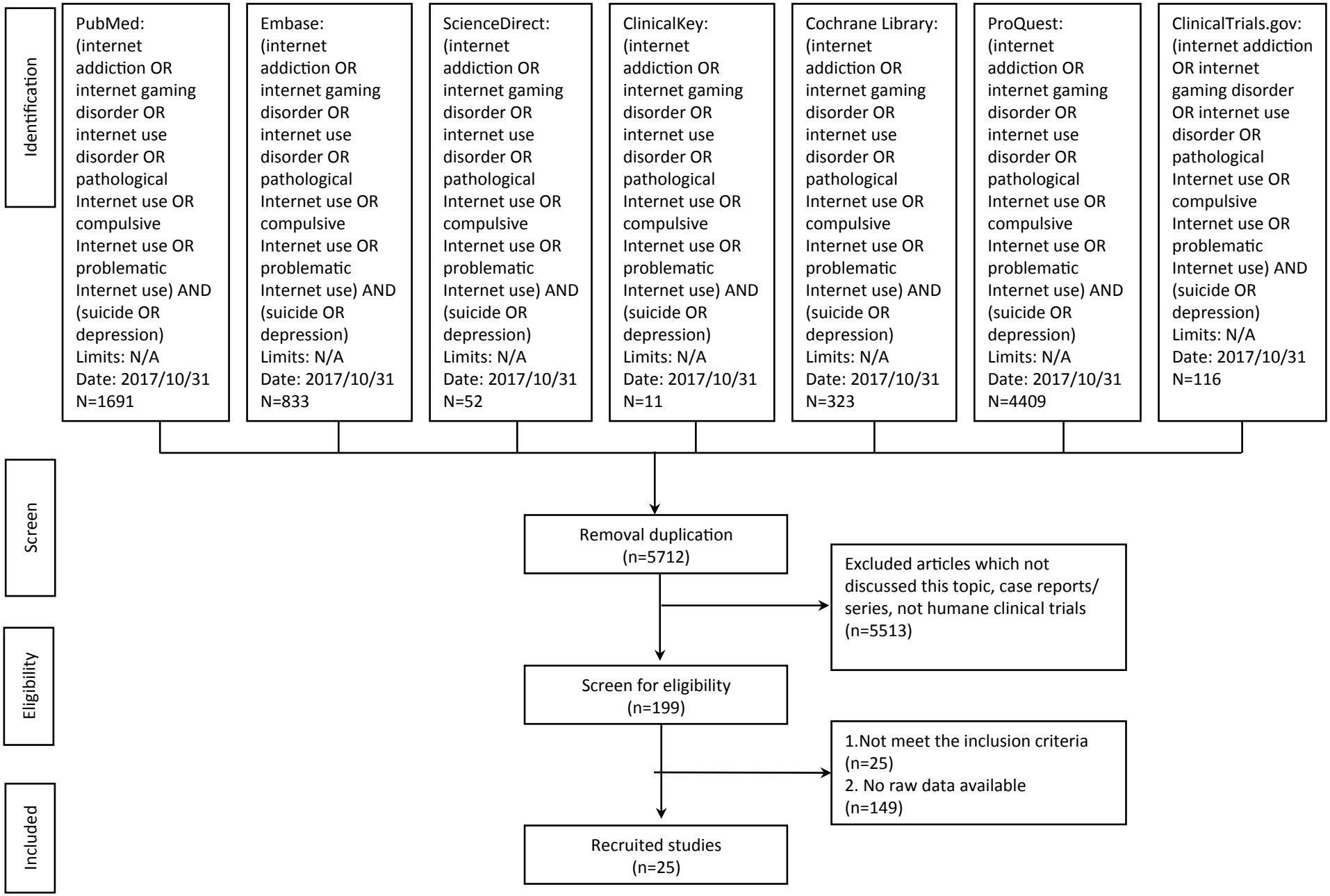
| | | | | | | |
|---|---|---|---|---|---|---|
| Fu, K.W. (2010) | Hong-Kong | Panel household survey, cohort | 3 | 2 | 2 | 7(High quality) |
| Yang, L.S. (2010) | China | Cross-sectional questionnaire study | 2 | 2 | 1 | 5(high quality) |
| Bakken, I.J. (2009) | Norway | Cross-sectional questionnaire study | 2 | 2 | 1 | 5(high quality) |
| Kim, K. (2006) | Korea | Cross-sectional questionnaire study | 2 | 0 | 1 | 3(low quality) |
| Ryu, E.J. (2004) | Korea | Cross-sectional questionnaire study | 2 | 0 | 1 | 3(low quality) |

**Supplement table 4:** full results of statistical analysis for sensitivity test, meta-regression and subgroup analysis

| Outcome | Sensitivity test | Meta-regression | Subgroup |
|---|---|---|---|
| Suicidal ideation | No change in result | 1. Mean age (p = 0.104)<br>2. Female proportion (p = 0.725)<br>3. Percentage of internet gaming activity (p = 0.625) | 1. Age groups:<br>Children (≦18 years): k = 9, OR = 3.771, 95% CI = 2.802 to 5.075, p < 0.001<br>Adult (≧18 years): k = 5, OR = 1.955, 95% CI = 1.312 to 2.915, p = 0.001<br>Interaction test (p = 0.010)<br>2. Types of addiction:<br>Internet gaming: k = 4, OR = 3.033, 95% CI = 2.515 to 3.657, p < 0.001<br>Internet addiction: k = 15, OR = 2.952, 95% CI = 2.361 to 3.691, p < 0.001<br>Interaction test (p = 0.857)<br>3. Different Surveillance periods:<br>Current: k = 4, OR = 2.478, 95% CI = 1.511 to 4.064, p < 0.001<br>Non-lifetime: k = 11, OR = 3.577, 95% CI = 2.879 to 4.444, p < 0.001<br>Interaction test (p = 0.183) |
| Suicide Severity | No change in result | 1. Mean age (p = 0.796)<br>2. Female proportion (p = 0.175) | 1. Age groups:<br>Children (≦18 years): k = 6, Hedges' g = 0.480, 95% CI = 0.178 to 0.781,p = 0.002<br>2. Different Surveillance periods:<br>Current: k = 3, Hedges' g = 0.508, 95% CI = 0.262 to 0.755, p < 0.001<br>Non-lifetime: k = 8, Hedges' g = 0.810, 95% CI = 0.392 to 1.229, p < 0.001<br>Interaction test (p = 0.223) |

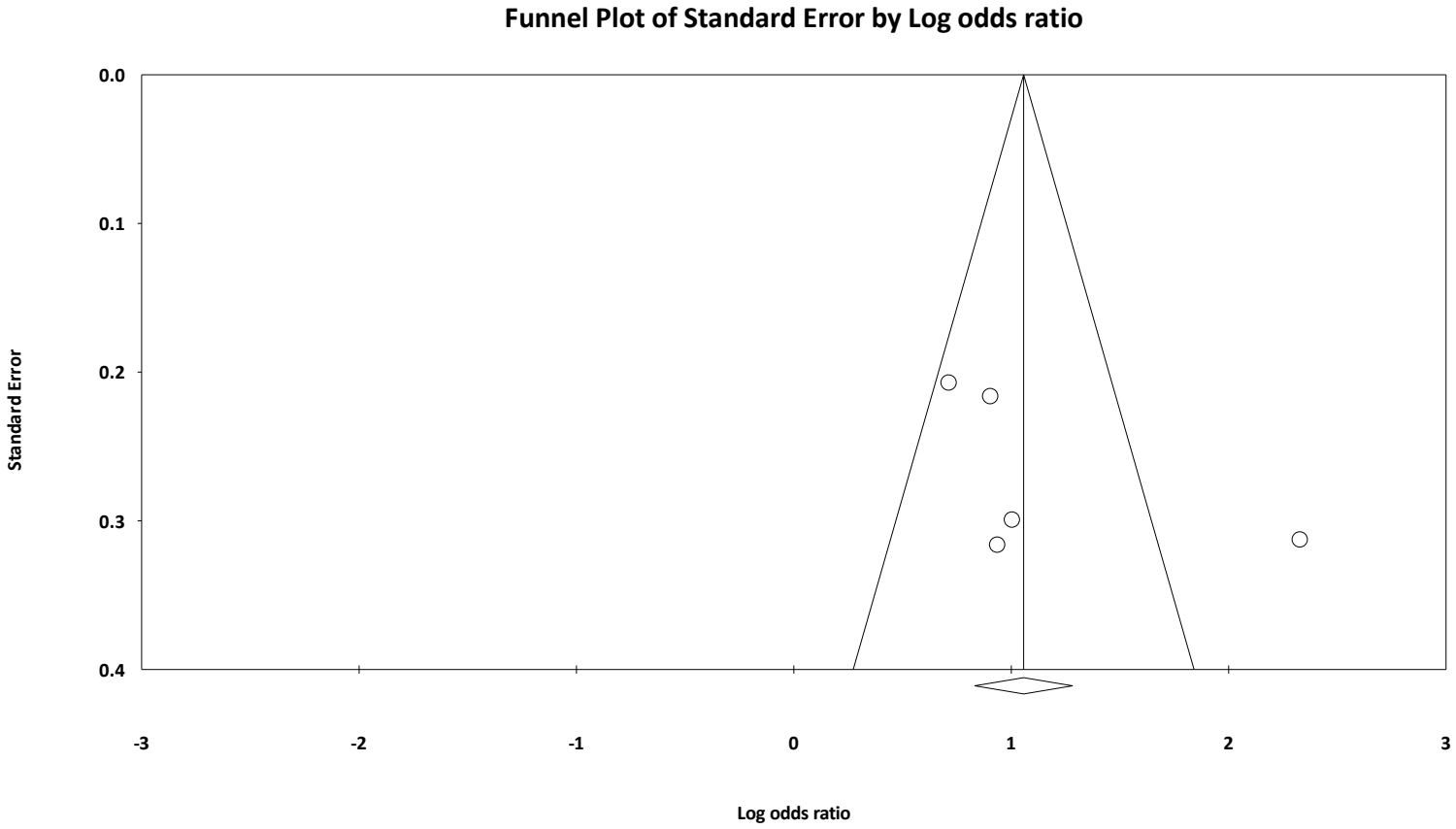
| | | | |
|---|---|---|---|
| Suicidal planning | No change in result | Not performed | Not performed |
| Suicidal attempts | No change in result | 1. Mean age (p = 0.880)<br>2. Female proportion (p = 0.221) | 1. Age groups:<br>Children (≦18 years): k = 3, OR = 3.547, 95% CI = 1.204 to 10.450, p = 0.022<br>Adult (≧18 years): k = 3, OR = 3.251, 95% CI = 1.436 to 7.357, p = 0.005<br>Interaction test (p = 0.899)<br>2. Different Surveillance periods:<br>Lifetime: k = 3, OR = 2.697, 95% CI = 1.374 to 5.297, p = 0.004<br>Non-lifetime: k = 4, OR = 2.742, 95% CI = 2.099 to 3.582, p < 0.001<br>Interaction test (p = 0.899). |
| Adjusted OR | No change in result | Not performed | Not performed |

Abbreviation: CI: confidence interval; k: number of studies; OR: odds ratio

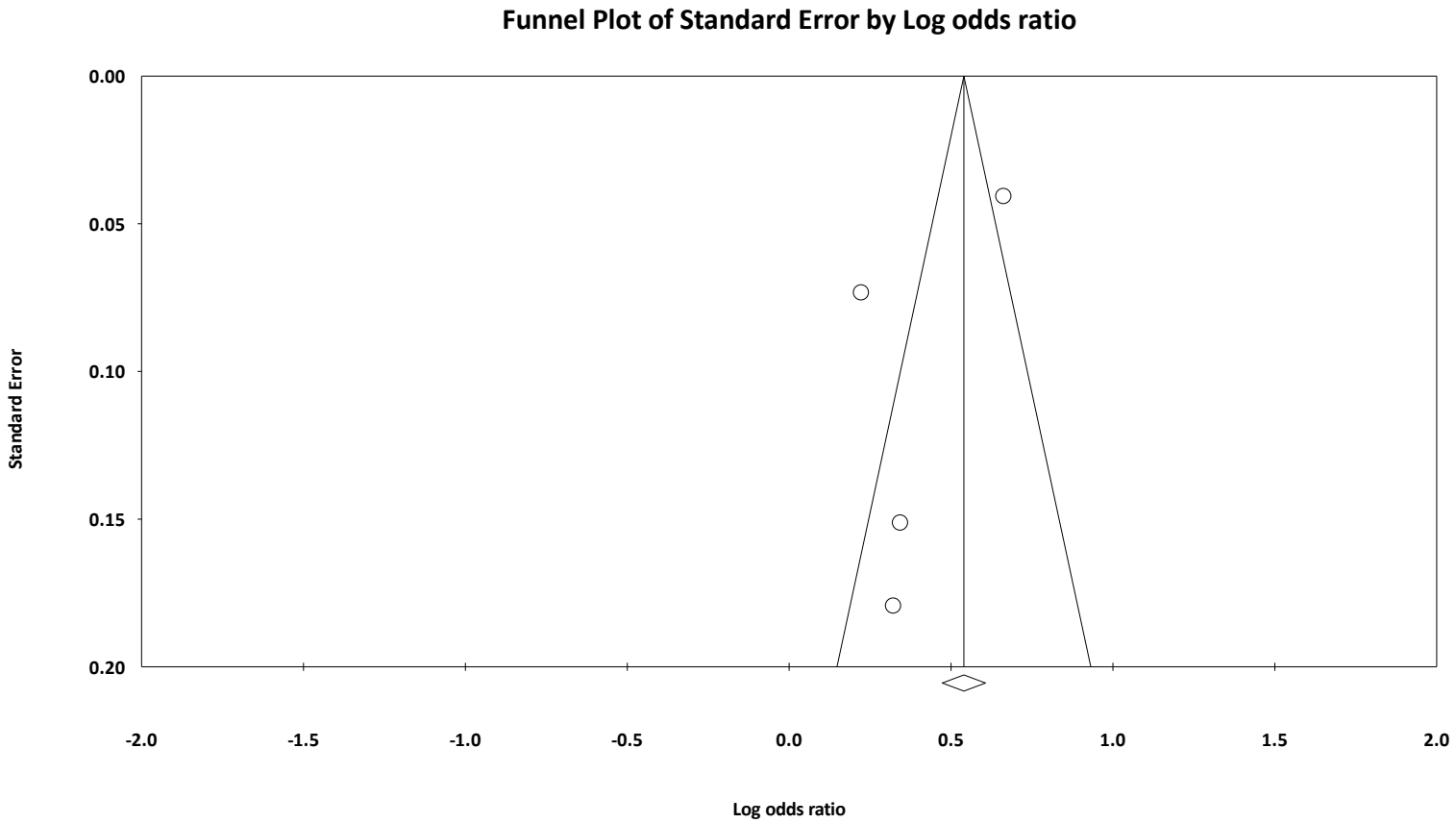




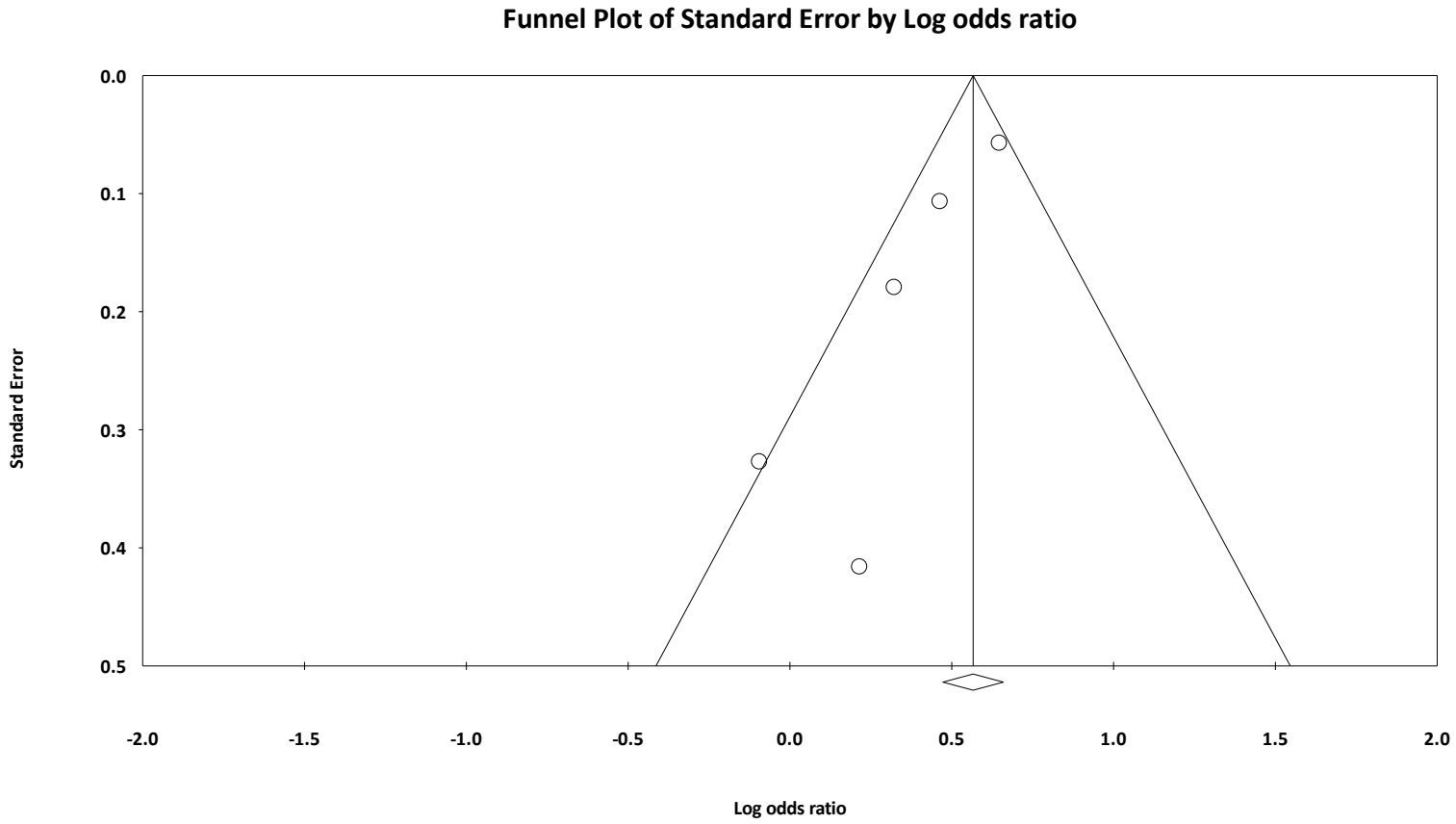

Supplementary Figure 1 Whole flowchart of current meta-analysis




Supplementary Figure 2A Funnel plot of meta-analysis of prevalence rate of suicidal plan




Supplementary Figure 2B Funnel plot of meta-analysis of adjusted odds ratio of suicidal ideation




Supplementary Figure 2C Funnel plot of meta-analysis of adjusted odds ratio of suicidal attempt