Loneliness and Problematic Media Use: A Meta-Analysis of Longitudinal Studies

Jia Yuin Fam, Niko Männikkö

Table of Contents

Loneliness and Problematic Media Use: A Meta-Analysis of Longitudinal Studies

Jia Yuin Fam[1*] PhD; Niko Männikkö[2*] PhD

[1]Sunway University Bandar Sunway MY
[2]Oulu University of Applied Sciences Oulu FI
[*]these authors contributed equally

Corresponding Author:
Jia Yuin Fam PhD
Sunway University
5, Jalan Universiti
Bandar Sunway
MY

Abstract

While past research has established the association between loneliness and problematic media use, the direction of causality remains unclear. This meta-analysis investigates the longitudinal relationships between loneliness and problematic media use. Systematic searches in three online databases identified 26 longitudinal studies involving a total of 24,798 participants. Random-effects models revealed bidirectional relationships between loneliness and problematic media use. However, the effect sizes were weaker than anticipated when using beta coefficients as estimates of the longitudinal relationships. Subgroup analyses demonstrated stable results for beta coefficients across various study designs. This meta-analysis also highlights potential methodological limitations and provides recommendations for future research on longitudinal relationships.

Preprint Settings

1) Would you like to publish your submitted manuscript as preprint?

✓ **Please make my preprint PDF available to anyone at any time (recommended).**
   Please make my preprint PDF available only to logged-in users; I understand that my title and abstract will remain visible to all users.
   Only make the preprint title and abstract visible.
   No, I do not wish to publish my submitted manuscript as a preprint.

2) If accepted for publication in a JMIR journal, would you like the PDF to be visible to the public?

✓ **Yes, please make my accepted manuscript PDF available to anyone at any time (Recommended).**
   Yes, but please make my accepted manuscript PDF available only to logged-in users; I understand that the title and abstract will remain v
   Yes, but only make the title and abstract visible (see Important note, above). I understand that if I later pay to participate in <a href="http

Original Manuscript

Abstract

While past research has established the association between loneliness and problematic media use, the direction of causality remains unclear. This meta-analysis investigates the longitudinal relationships between loneliness and problematic media use. Systematic searches in three online databases identified 26 longitudinal studies involving a total of 24,798 participants. Random-effects models revealed bidirectional relationships between loneliness and problematic media use. However, the effect sizes were weaker than anticipated when using beta coefficients as estimates of the longitudinal relationships. Subgroup analyses demonstrated stable results for beta coefficients across various study designs. This meta-analysis also highlights potential methodological limitations and provides recommendations for future research on longitudinal relationships.

Keywords. Meta-analysis, longitudinal studies, loneliness, problematic media use, bidirectional relationship

Loneliness and Problematic Media Use: A Meta-Analysis of Longitudinal Studies

Introduction

The internet has become an integral part of daily life, fundamentally transforming social interaction compared to its predecessors like the telegraph, telephone, and television (Bargh & McKenna, 2004). The internet offers a vast array of opportunities for communication, entertainment, and social connection. However, this ease of access has also brought about concerns regarding problematic media use. Problematic media use involves behaviours that go beyond typical or normative media consumption and may include internet-related activities such as excessive gaming, online shopping, and social network use (Ruckwongpatr et al., 2022). Consequently, problematic media use is characterised by an individual's continued or escalated media or internet over-engagement despite significant impairment to daily functioning across different areas of life (Fineberg et al., 2018). According to Pan et al. (2020), the pooled average prevalence rate of problematic media use among the general population is around 7%, but it can be significantly higher among youth.

Internet Paradox

The internet paradox (Kraut et al., 1998) suggests that despite the internet's potential to enhance social connection, it may paradoxically lead to decreased social engagement. While the internet offers a wider range of social functionalities compared to traditional media, its use for asocial purposes (e.g., private entertainment) might hinder face-to-face social interaction (Kraut et al., 1998). As a result, problematic media use (e.g., excessive social media scrolling and compulsive gaming) might lead to unintentional social isolation despite the presence of numerous online connections.

Expanding on the internet paradox, numerous cross-sectional studies have yielded empirical evidence of a link between feelings of loneliness and problematic use of various modern media platforms, including gaming (Li et al., 2021), social media (Reer et al., 2021), smartphones (Lapierre, 2020), as well as internet use in general (Dalton & Cassidy, 2021). Collectively, these studies consistently report a significant positive correlation, suggesting that individuals experiencing loneliness tend to engage in higher levels of problematic media use. Further supporting this link, a meta-analysis of 26 studies (mostly cross-sectional) by Saadati et al. (2021) found a positive association between loneliness and problematic media use (pooled r range between .20 and .26). Several reviews have reached similar conclusions about this significant relationship (Cai et al., 2023; Moretta & Buodo, 2020; O'Day & Heimberg, 2021). However, a critical limitation identified in these reviews is the predominant use of cross-sectional designs, making it difficult to establish causal direction in the relationship between loneliness and problematic media use.

Direction of Causality between Loneliness and Problematic Media Use

This prompts inquiry into the directionality of this relationship. Some studies suggest that loneliness may precede problematic media use (Gao et al., 2024; Kim, 2017; Rogier et al., 2021), as individuals experiencing loneliness may seek social connection through online platforms. According to the theory of compensatory internet use (Kardefelt-Winther, 2014), individuals may engage in internet activities to fulfil unmet social needs. The internet offers various avenues for social interaction, ranging from active participation (e.g., joining online gaming communities) to passive consumption (e.g., browsing stories in social media). Lonely individuals may initially utilise the internet to satisfy their social needs. However, while this strategy may provide short-term fulfilment,

it can lead to a cycle of dependence on the internet to meet these social needs. This dependence can make it difficult for individuals to disengage from the virtual world, potentially resulting in problematic media use.

Conversely, evidence suggests that problematic media use can also contribute to loneliness (Karsay et al., 2019). Individuals who become excessively reliant on online interactions may neglect face-to-face social connections, potentially leading to feelings of isolation (Kraut et al., 1998). This aligns with media displacement theory (Bryant & Fondren, 2009), which posits that excessive media consumption can displace real-world social activities. The perceived convenience of the internet, particularly its ability to remove geographical and temporal constrains, might incentivise individuals to substitute face-to-face interactions with online social activities. While successful online relationships exist, research suggests that the quality of online relationships might be poorer compared to those in physical settings (Chan & Cheng, 2004). Online communication is argued to be better suited for maintaining weak ties (superficial connections) rather than strong ties (close relationships).

The contrasting perspectives on the direction of causality between loneliness and problematic media use create a bidirectional relationship, suggesting that the two variables may influence each other. However, the strength of the longitudinal relationships appears to vary considerably across studies. While some longitudinal studies support the relationship in both directions, with effect sizes ranging from weak (e.g., Lapierre et al., 2019) to strong (e.g., Reed et al., 2023), other studies report a nonsignificant longitudinal relationship (Zhou et al., 2023).

In light of this consideration, meta-analysis that synthesises past longitudinal findings might provide the best estimate for the longitudinal relationships. Zhang et al. (2023) conducted a meta-analysis examining the longitudinal relationship between loneliness and problematic internet use, revealing significant positive correlations in both directions. While their work is valuable, it is noteworthy that they extracted and synthesised Pearson correlation coefficients from past studies (e.g., the correlation between loneliness at Time 1 and problematic internet use at Time 2). However, pooling the Pearson coefficients might not be entirely accurate because they do not account for the effect of the outcome variable at Time 1 (i.e., problematic internet use at Time 1). For instance, Fang et al. (2023), a study included in Zhang et al.'s (2023) meta-analysis, reported a Pearson correlation of .22 between loneliness at Time 1 and problematic internet use at Time 2. However, their cross-lagged model revealed a nonsignificant standardised beta coefficient of only .05 for the same causal relationship. This suggests that the pooled correlations reported by Zhang et al. (2023) might be overestimated.

The Current Study

The limitations of cross-sectional studies (e.g., inability to establish causality), varying past findings from longitudinal studies, and reliance of Pearson correlation coefficients in previous meta-analysis, underscore the need for a more robust approach to examining the longitudinal relationships between loneliness and problematic media use. To address these limitations, the current meta-analysis aims to: (1) examine the longitudinal relationship between loneliness and problematic media use based on other statistical analyses, and (2) explore potential moderators that might influence the strength of the longitudinal relationships.

Methods

The current meta-analysis was conducted in accordance with the standard specified in the updated Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines (Page et al., 2021). This study protocol was preregistered in the OSF Registry on 17th January 2024 (link: https://doi.org/10.17605/OSF.IO/3P6JR).

Search Strategy

A literature search was performed on 24th January (year?) in three online databases, namely Scopus, APA PsycArticles, and PubMed. The following terms were used as keywords: (loneliness AND (internet OR "social media" OR "social network" OR gam* (gaming?) OR smartphone) AND (addict* OR disorder OR problem* OR excessive OR patholog* (pathology?)) AND (longitudinal OR prospective)). Additionally, the grey literature was searched from the references of included studies. The data screening process is illustrated in Figure 1.

Study Inclusion and Exclusion Criteria

To be included in the current meta-analysis, a study had to: (a) be written in English; (b) be published in a peer-reviewed journal; (c) report estimates of the longitudinal relationship between loneliness and problematic media use (e.g., reported as correlation coefficient, path coefficient, beta coefficient, odds ratio, or Cohen's d; problematic media use include internet gaming disorder, social media disorder, internet addiction, or smartphone addiction); (d) be a longitudinal study.

Studies were ineligible if they: (a) focused on gambling disorder or gambling-related behaviour (e.g., loot boxes); (b) did not include measures of loneliness and problematic media use as the investigated variables; (c) were case studies or qualitative studies; (d) focused exclusively on the therapeutic aspects of problematic media use (i.e., randomised controlled trial of cognitive behavioural therapy); and (e) were pre-prints, dissertations and theses studies, conference proceedings and abstracts, and/or government/industry reports.

Data Extraction

The following information was extracted from the studies: (i) sample size, (ii) study location, (iii) age, (iv) gender ratio, (v) recorded problematic media use, (vi) measures of loneliness, (vii) measures of problematic media use, (viii) number of waves, (ix) time lag, and (x) effect size.

To investigate the bidirectional relationship between loneliness and problematic media use, three effect sizes were recorded whenever possible. Firstly, Pearson correlation coefficients between variables at different time points were documented (e.g., the relationship between loneliness at Time 1 and problematic media use at Time 2). In cases where an original study reported an effect size other than Pearson r (e.g., odds ratio), the result was converted into a correlation coefficient using widely accepted formulae (Borenstein et al., 2009). Secondly, standardised beta coefficients from various statistical models were collected (e.g., multiple regression and cross-lagged models). Thirdly, standardised beta coefficients were computed using the following equation (Cohen et al., 2013, p. 68):

$$\beta_{Y1.2} = \frac{r_{Y1} - r_{Y2} r_{12}}{1 - r_{12}^2}$$

To provide further clarity, $\beta_{Y1.2}$ represents the standardised beta coefficient denoting the longitudinal relationship between the independent variable (IV) and dependent variable (DV), while controlling for the effect of DV. For instance, it illustrates the effect of loneliness at Time 1 on problematic media use at Time 2, while controlling for the effect of problematic media use at Time 1. Moreover, r_{Y1} and r_{Y2} denote zero-order correlations between the IVs and DV. For instance, r_{Y1} signifies the correlation between loneliness at Time 1 and problematic media use at Time 2, whereas r_{Y2} indicates the correlation between problematic media use at Time 1 and Time 2. Lastly, r_{12} denotes the relationship between the IV and DV at Time 1. For example, it represents the correlation between loneliness at Time 1 and problematic media use at Time 1.

In cases where there are multiple waves of data, the relationships between the two closest time points were extracted (e.g., between Time 1 and Time 2; between Time 2 and Time 3).

Quality Assessment

A total of 26 original longitudinal studies were assessed for quality based on Joanna Briggs Institute guidelines (Moola et al., 2020). Quality assessment for longitudinal studies incorporated 11 domains. Each domain was assessed as having a high (H), low (L), or unclear (NA) risk of bias. A high risk of bias suggests that the methodology used might significantly affect the measured outcomes. A low risk of bias implies that the methods used met quality requirements. An unclear risk definition was used when there was insufficient information to determine the risk of bias. At the end of the quality appraisal, any discrepancies between the two researchers were discussed until a consensus was reached. Details of the quality assessment can be found in Table 1.

Statistical Analysis

The meta-analysis was conducted using the '*meta*' package within the R software environment (R Core Team, 2013). We utilised a random-effects model to compare effect sizes, assuming heterogeneity between samples. Three meta-analyses were conducted separately for the three types of effect sizes.

To delve deeper into the longitudinal relationships between loneliness and problematic media use, subgroup analyses were conducted to identify potential moderators. We delineated five subgroups: type of problematic media use (categorised as gaming, internet, smartphone, and social media), geographical region (categorised as Asia, Europe, and North America), lag length in months (categorised as $k \leq 3$, $3 < k \leq 6$, and $k > 6$), measure of problematic media use (categorised as validated, DSM criteria-based, and adapted measures), and measure of loneliness (categorised as validated and adapted measures). While we recorded the specific measures of loneliness and problematic media use for each study, it is noteworthy that certain measures were infrequently employed across studies (e.g., Generalized Problematic Internet Use Scale). Consequently, this scarcity hindered our ability to generate meaningful comparisons within these specific measures.

Lastly, contour-enhanced funnel plots were generated to visually inspect for potential publication bias. Additionally, Egger's regression tests were conducted to provide a more robust statistical evaluation of funnel plot asymmetry.

Results

Screening and Selection Process

A total of 2,731 records were retrieved from the three online databases (APA PsycArticles = 2408, PubMed = 128, Scopus = 195). A total of 97 duplicated articles were found and removed. The remaining 2634 records were screened based on the title and abstract, and 2590 articles were further removed. The remaining 44 articles were combined with the key studies identified through manual searches in reference list, and selected for full text review. Finally, a total of 26 seemingly relevant studies were included for the meta-analysis (see Figure 1).

Descriptive Characteristics of the Selected

A summary of the included studies was presented in Table 2. The 26 studies involve a total of 24,798 individuals from diverse backgrounds, ranging from adolescents (Hu & Xiang, 2024) to smartphone users in the general population (Karsay et al., 2019).

Quality of the studies

The quality of appraisal was conducted to evaluate the risk of bias (see Table 1). The maximum quality score among the studies was 9 (range 3-9). The average quality score in the studies were approximately 7 points. In 23 studies, the methodological quality was at least 50% of the total score.

Longitudinal Relationship from Loneliness to Problematic Media Use

Based on the random-effects model, a significant relationship was observed between loneliness at Time 1 and problematic media use at Time 2 (refer to Table 3). Specifically, the strength of this relationship was notably higher when examined using the Pearson correlation coefficient (r = .28, 95% CI = .25 to .31) compared to other research models (r = .11, 95% CI = .07 to .14) and estimated beta coefficients (r = .10, 95% CI = .08 to .12).

Longitudinal Relationship from Problematic Media Use to Loneliness

A significant relationship was observed between problematic media use at Time 1 and loneliness at Time 2 (see Table 4). Similar to the other direction, the relationship is significantly stronger when examined using the Pearson correlation coefficient (r = .29, 95% CI = .26 to .32) compared to other research models (r = .13, 95% CI = .06 to .20) and estimated beta coefficients (r = .09, 95% CI = .06 to .12).

Subgroup Analysis

When examining the relationship using Pearson correlation coefficients, we found that country acted as a significant moderator for the longitudinal relationship in both directions, particularly showing stronger relationships in the Asian region (LN → PMU: Q = 7.05, p = .029; PMU → LN: Q = 10.60, p = .005). On the other hand, the type of problematic media use also acted as a significant moderator in the longitudinal relationship from loneliness to problematic media use, with a stronger relationship in the case of smartphone addiction (Q = 17.44, p < .001).

In contrast, the majority of subgroup analyses based on research models and estimated beta coefficients did not yield significant results, suggesting a high level of stability in the findings across the two methods. While problematic media use emerged as a significant moderator when examining the relationship with beta coefficients from various statistical models, it is important to note that only one study employed DSM criteria to measure problematic media use (i.e., Finserås et al., 2019). Exploratory data analysis with the exclusion of this study revealed a non-significant moderating effect with regard to the measure of problematic media use (finding is not shown in this paper). Overall, the subgroup analyses provide general support for the bidirectional relationship between loneliness and problematic media use.

Publication Bias

Contour-enhanced funnel plots and Egger's regression test were performed separately for the two causal directions to identify potential publication bias. The funnel plot for the direction of loneliness to problematic media use is asymmetrical (see Figure 2), with a bias estimate of -1.55, $t(26)$ = -4.94, p < .001. It is noteworthy that studies with lower standard errors scatter in the middle of the funnel plot, while studies with larger standard errors generally scatter around the left side of the funnel plot.

On the other hand, the funnel plot for the direction of problematic media use to loneliness is symmetrical (see Figure 3), with a bias estimate of 0.32, $t(25)$ = 0.62, p = .540. The results generally suggest a low risk of publication bias.

Discussion

Employing a random-effects model, the current meta-analysis synthesised the longitudinal relationships between loneliness and problematic media use. Given the contrasting perspectives on the direction of causality, two separate analyses were carried out for both directions. Three types of effect sizes were extracted from 26 longitudinal studies: Pearson correlation coefficients, standardised beta coefficients from various statistical models, and estimated beta coefficients based

on Cohen et al.'s (2013, p. 68) formula.

Longitudinal Relationships between Loneliness and Problematic Media Use

Regardless of the type of effect size, the results consistently revealed significant longitudinal relationships between loneliness and problematic media use in both directions. The findings support a bidirectional model where loneliness and problematic media use can influence each other over time. Consistent with the compensatory internet use theory (Kardefelt-Winther, 2014), lonely individuals may initially utilise the internet to fulfil unmet social needs, finding temporary relief through online connection. The individuals might be increasingly dependent on the internet to fulfil their social needs, resulting in problematic media use. Conversely, as highlighted in the internet paradox (Kraut et al., 1998), excessive internet use can displace real-world interactions and weaken social skills. Additionally, the quality of online interactions may not fully satisfy social needs, leading to a sense of loneliness despite being connected online.

Explaining Heterogeneity

This meta-analysis revealed a medium effect size when examining longitudinal relationships with Pearson correlation coefficients ($r_{LPIU} = .28$, $r_{PIUL} = .29$). This finding aligns with a previous meta-analysis by Zhang et al. ($r_{LPIU} = .29$, $r_{PIUL} = .26$; 2023). However, the effect sizes were weaker when the relationships were examined using standardised beta coefficients ($\beta_{LPIU} = .11$, $\beta_{PIUL} = .13$) or estimated beta coefficients ($\beta_{LPIU} = .10$, $\beta_{PIUL} = .09$). This suggests that beta coefficients may provide a more accurate estimate of the longitudinal relationships between loneliness and problematic media use (with narrower confidence intervals), particularly by accounting for the influence of the outcome variable at Time 1. Furthermore, both types of beta coefficient exhibit greater stability across diverse study designs compared to Pearson correlation coefficients (e.g., geographical region, type of measures, and lag length). Based on these findings, it is recommended for future meta-analyses examining longitudinal relationships to prioritise the use of beta coefficients obtained from robust research models such as cross-lagged models. Additionally, individual studies were recommended reporting a complete correlation matrix across all variables and time points. These practices would enhance the accuracy and interpretability of findings on longitudinal relationships.

The current findings suggest that the longitudinal relationships between loneliness and problematic media use may be weaker than expected. This could be partially explained by the evolving nature of the internet. Kraut et al. (2002) revisited the internet paradox and found a more positive long-term impact a few years after their initial study, attributing it to technology advancements that facilitated healthier online social interactions. Nearly two decades after Kraut et al.'s (2002) study, the internet offers a wider array of social functions through social media, smartphones, and online gaming. These advancements may have indeed fostered more positive social interaction experiences within online environments (Scott et al., 2021). For instance, instant messaging allows connection with offline friends, potentially facilitating discussions of more intimate topics (Mittmann et al., 2022). Similarly, online and offline gaming communities can connect individuals with similar interests, promoting a sense of belonging. Therefore, the maturing and diverse functionalities of the internet may contribute to healthy friendship formation and maintenance, potentially weakening the longitudinal relationships between loneliness and problematic media use. Future studies could explore specific aspects of the internet (e.g., social media features) that foster healthier social interactions.

Lastly, it is important to acknowledge that the current meta-analysis focused on problematic media use (i.e., internet gaming disorder, social media disorder, internet addiction, or smartphone addiction). The magnitude of the longitudinal relationships might be stronger if the focus is on

general media use. On one hand, loneliness might lead individuals to engage more in online social interactions, but not to the extent of problematic use (Skues et al., 2017). On the other hand, spending long hours on the internet might result in reduced social interactions and contribute to feeling of loneliness (Kraut et al., 1998; Song et al., 2014). Further complicating the relationship, some studies suggest that internet use can effectively decrease loneliness (Yu et al., 2021). This highlights the importance of considering the different purposes of internet use beyond solely focusing on symptoms of behavioural addiction. For example, one longitudinal study by Szabo et al. (2019) found that the social use of the internet specifically, such as online interactions with friends and family, can decrease loneliness and increase social engagement. In contrast, informational and instrumental uses, such as browsing news or searching for information, were not related to loneliness. These findings suggest that future research should examine the longitudinal relationships between loneliness and general media use or internet use, and explore the potential moderating role of different purposes of internet use.

Limitations and Future Directions

This meta-analysis has several limitations. First, although the contour-enhanced funnel plot and Egger's regression test suggest an asymmetrical pattern in studies examining the direction of loneliness to problematic media use, it is notable that the studies seem to be missing in the area of significance ($p < .01$). Hence, the asymmetrical pattern might not be the outcome of publication bias or selective nonreporting of results (Sterne et al., 2011). One possible explanation for this outcome is between-study heterogeneity ($I^2 = 38.6\%$), but more longitudinal studies are needed to confirm this.

Second, a few studies reported non-significant longitudinal relationships without specifying the actual coefficients (e.g., Jia et al., 2018; Shi et al., 2023; Tian et al., 2018). With the nonsignificant findings primarily found in the cross-lagged model, the actual relationships might be even smaller than the current findings.

Third, there are a few studies that met the inclusion criteria, but did not report the estimate of the hypothesised longitudinal relationships (most of these studies focused on other relationships). While attempts were made to contact authors for missing data, most did not respond. Finally, the screening process was limited to studies published exclusively in English, potentially excluding valuable information from other linguistic sources.

Conclusion

In conclusion, the findings support a bidirectional model, suggesting that loneliness and problematic media use can influence each other over time. While significant relationships were found in both directions, the effect sizes were weaker than anticipated. This may be partially explained by the evolving nature of the internet, as evidenced by advancements that facilitate healthier online social interactions. Additionally, subgroup analyses revealed greater stability in the relationships when examined using beta coefficients, which account for prior outcome variables.

Reference

Bargh, J. A., & McKenna, K. Y. (2004). The Internet and social life. *Annual Review of Psychology*, *55*, 573-590. https://doi.org/10.1146/annurev.psych.55.090902.141922

Borenstein, M., Cooper, H., Hedges, L., & Valentine, J. (2009). Effect sizes for continuous data. In M. Borenstein, L. V. Hedges, J. P. T. Higgins, & H. R. Rothstein (Eds.), *The handbook of research synthesis and meta-analysis* (pp. 45–49). Russell Sage Foundation.

Bryant, J., & Fondren, W. (2009). Displacement effects. In N.L. Nabi & M. B. Oliver (Eds.), *Handbook of media processes and effects* (pp. 505-516). Sage.

Cai, Z., Mao, P., Wang, Z., Wang, D., He, J., & Fan, X. (2023). Associations between problematic

internet use and mental health outcomes of students: a meta-analytic review. *Adolescent research review, 8*(1), 45-62. https://doi.org/10.1007/s40894-022-00201-9

Chan, D. K. S., & Cheng, G. H. L. (2004). A comparison of offline and online friendship qualities at different stages of relationship development. *Journal of Social and Personal Relationships, 21*(3), 305-320. https://doi.org/10.1177/0265407504042834

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2013). *Applied multiple regression/correlation analysis for the behavioral sciences* (3rd ed.). Routledge.

Dalton, F., & Cassidy, T. (2021). Problematic Internet usage, personality, loneliness, and psychological well-being in emerging adulthood. *Analyses of Social Issues and Public Policy, 21*(1), 509-519. https://doi.org/10.1111/asap.12224

Fang, X., Tian, M., Wang, R., & Wang, P. (2023). Relationships between depression, loneliness and pathological internet use in adolescents: A cross-lagged analysis. *Current Psychology, 42*(24), 20696-20706. https://doi.org/10.1007/s12144-022-03180-1

Fineberg, N. A., Demetrovics, Z., Stein, D. J., Ioannidis, K., Potenza, M. N., Grünblatt, E., Brand, M., Billieux, J., Carmi, L., & King, D. L. (2018). Manifesto for a European research network into problematic usage of the internet. *European Neuropsychopharmacology, 28*(11), 1232-1246. https://doi.org/10.1016/j.euroneuro.2018.08.004

Finserås, T. R., Pallesen, S., Mentzoni, R. A., Krossbakken, E., King, D. L., & Molde, H. (2019). Evaluating an internet gaming disorder scale using Mokken scaling analysis. *Frontiers in Psychology, 10*. https://doi.org/10.3389/fpsyg.2019.00911

Gao, B., Cai, Y., Zhao, C., Qian, Y., Zheng, R., & Liu, C. (2024). Longitudinal associations between loneliness and online game addiction among undergraduates: A moderated mediation model. *Acta Psychologica, 243*, 104134. https://doi.org/10.1016/j.actpsy.2024.104134

Hu, Z., & Xiang, Y. (2024). Who is the chief culprit, loneliness, or smartphone addiction? Evidence from longitudinal study and weekly diary method. *International Journal of Mental Health and Addiction, 22*(1), 599-614. https://doi.org/10.1007/s11469-022-00892-0

Jia, Z., Wang, Y., Yang, Y., & Yang, L. (2018). Chinese university students' loneliness and generalized pathological internet use: A longitudinal cross-lagged analysis. *Social Behavior and Personality: an international journal, 46*(5), 861-870. https://doi.org/10.2224/sbp.6807

Kardefelt-Winther, D. (2014). A conceptual and methodological critique of internet addiction research: Towards a model of compensatory internet use. *Computers in Human Behavior, 31*, 351-354. https://doi.org/10.1016/j.chb.2013.10.059

Karsay, K., Schmuck, D., Matthes, J., & Stevic, A. (2019). Longitudinal effects of excessive smartphone use on stress and loneliness: The moderating role of self-disclosure. *Cyberpsychology, Behavior, and Social Networking, 22*(11), 706-713. https://doi.org/10.1089/cyber.2019.0255

Kim, J. H. (2017). Longitudinal associations among psychological issues and problematic use of smartphones. *Journal of Media Psychology, 31*(3). https://doi.org/10.1027/1864-1105/a000234

Kraut, R., Patterson, M., Lundmark, V., Kiesler, S., Mukophadhyay, T., & Scherlis, W. (1998). Internet paradox: A social technology that reduces social involvement and psychological well-being? *American Psychologist, 53*(9), 1017. https://doi.org/10.1037/0003-066X.53.9.1017

Lapierre, M. A. (2020). Smartphones and loneliness in love: Testing links between smartphone engagement, loneliness, and relational health. *Psychology of Popular Media, 9*(2), 125-134. https://doi.org/10.1037/ppm0000230

Lapierre, M. A., Zhao, P., & Custer, B. E. (2019). Short-term longitudinal relationships between smartphone use/dependency and psychological well-being among late adolescents. *Journal of Adolescent Health, 65*(5), 607-612. https://doi.org/10.1016/j.jadohealth.2019.06.001

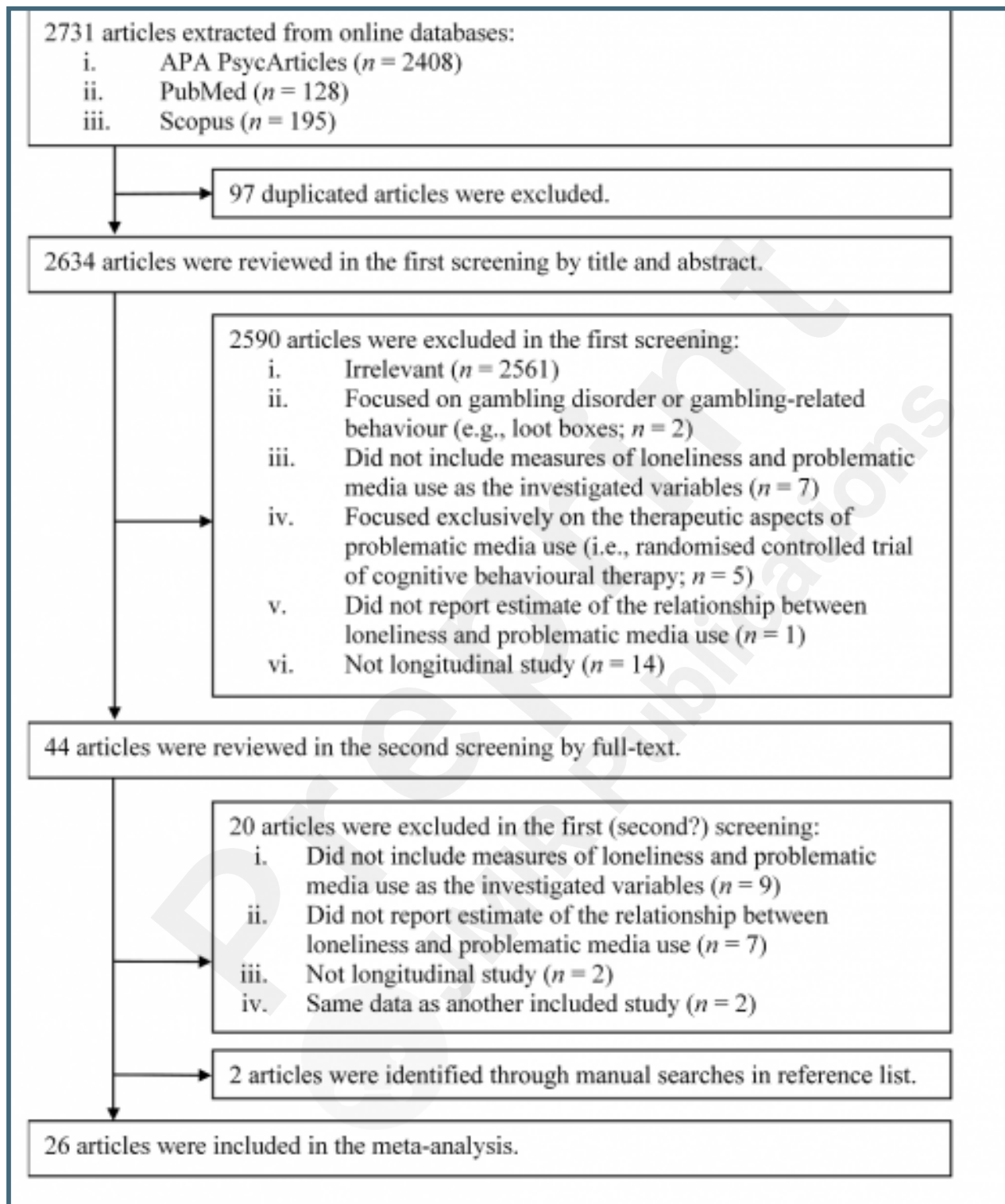Li, L., Niu, Z., Griffiths, M. D., Wang, W., Chang, C., & Mei, S. (2021). A network perspective on

the relationship between gaming disorder, depression, alexithymia, boredom, and loneliness among a sample of Chinese university students. *Technology in Society, 67*. https://doi.org/10.1016/j.techsoc.2021.101740

Mittmann, G., Woodcock, K., Dörfler, S., Krammer, I., Pollak, I., & Schrank, B. (2022). "TikTok is my life and Snapchat is my ventricle": A mixed-methods study on the role of online communication tools for friendships in early adolescents. *The Journal of Early Adolescence, 42*(2), 172-203. https://doi.org/10.1177/02724316211020368

Moola, S., Munn, Z., Tufanaru, C., Aromataris, E., Sears, K., Sfetcu, R., Currie, M., Qureshi, R., Mattis, P., Lisy, K., & Mu, P. F. (2020). Chapter 7: Systematic reviews of etiology and risk. In Aromataris E & M. Z (Eds.), *JBI Manual for Evidence Synthesis*. JBI.

Moretta, T., & Buodo, G. (2020). Problematic Internet use and loneliness: How complex is the relationship? A short literature review. *Current Addiction Reports, 7*, 125-136. https://doi.org/10.1007/s40429-020-00305-z

O'Day, E. B., & Heimberg, R. G. (2021). Social media use, social anxiety, and loneliness: A systematic review. *Computers in Human Behavior Reports, 3*. https://doi.org/10.1016/j.chbr.2021.100070

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., & Brennan, S. E. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ, 372*. https://doi.org/10.1136/bmj.n71

Pan, Y. C., Chiu, Y. C., & Lin, Y. H. (2020). Systematic review and meta-analysis of epidemiology of internet addiction. *Neuroscience & Biobehavioral Reviews, 118*, 612-622. https://doi.org/10.1016/j.neubiorev.2020.08.013

R Core Team. (2013). R: A language and environment for statistical computing. http://www.R-project.org/

Reed, P., Davies, A., Evans, K., & Osborne, L. A. (2023). Longitudinal relationship between problematic internet use with loneliness during and after COVID-19 social restrictions. *Psychiatry Research, 323*. https://doi.org/10.1016/j.psychres.2023.115148

Reer, F., Festl, R., & Quandt, T. (2021). Investigating problematic social media and game use in a nationally representative sample of adolescents and younger adults. *Behaviour & Information Technology, 40*(8), 776-789. https://doi.org/10.1080/0144929X.2020.1724333

Rogier, G., Beomonte Zobel, S., & Velotti, P. (2021). COVID-19, loneliness and technological addiction: Longitudinal data. *Journal of Gambling Issues, 47*. https://doi.org/10.4309/jgi.2021.47.4

Ruckwongpatr, K., Chirawat, P., Ghavifekr, S., Gan, W. Y., Tung, S. E., Nurmala, I., Nadhiroh, S. R., Pramukti, I., & Lin, C.-Y. (2022). Problematic internet use (PIU) in youth: a brief literature review of selected topics. *Current Opinion in Behavioral Sciences, 46*, 101150. https://doi.org/10.1016/j.cobeha.2022.101150

Saadati, H. M., Mirzaei, H., Okhovat, B., & Khodamoradi, F. (2021). Association between internet addiction and loneliness across the world: A meta-analysis and systematic review. *SSM - Population Health, 16*. https://doi.org/10.1016/j.ssmph.2021.100948

Scott, R. A., Stuart, J., & Barber, B. L. (2021). Contemporary friendships and social vulnerability among youth: Understanding the role of online and offline contexts of interaction in friendship quality. *Journal of Social and Personal Relationships, 38*(12), 3451-3471. https://doi.org/10.1177/02654075211029384

Shi, X., Wang, A., & Zhu, Y. (2023). Longitudinal associations among smartphone addiction, loneliness, and depressive symptoms in college students: Disentangling between– and within–person associations. *Addictive behaviors, 142*. https://doi.org/10.1016/j.addbeh.2023.107676

Skues, J., Williams, B. J., & Wise, L. (2017). Personality traits, boredom, and loneliness as predictors

of Facebook use in on-campus and Online University students. *International Journal of Cyber Behavior, Psychology and Learning (IJCBPL), 7*(2), 36-48. https://doi.org/10.4018/IJCBPL.2017040104

Song, H., Zmyslinski-Seelig, A., Kim, J., Drent, A., Victor, A., Omori, K., & Allen, M. (2014). Does Facebook make you lonely?: A meta analysis. *Computers in Human Behavior, 36*, 446-452. https://doi.org/10.1016/j.chb.2014.04.011

Sterne, J. A., Sutton, A. J., Ioannidis, J. P., Terrin, N., Jones, D. R., Lau, J., Carpenter, J., Rücker, G., Harbord, R. M., & Schmid, C. H. (2011). Recommendations for examining and interpreting funnel plot asymmetry in meta-analyses of randomised controlled trials. *BMJ, 343*. https://doi.org/10.1136/bmj.d4002

Szabo, A., Allen, J., Stephens, C., & Alpass, F. (2019). Longitudinal analysis of the relationship between purposes of internet use and well-being among older adults. *The gerontologist, 59*(1), 58-68. https://doi.org/10.1093/geront/gny036

Tian, Y., Guo, Z. X., Shi, J. R., Bian, Y. L., Han, P. G., Wang, P., & Gao, F. Q. (2018). Bidirectional mediating role of loneliness in the association between shyness and generalized pathological internet use in Chinese university students: A longitudinal cross-lagged analysis. *The Journal of psychology, 152*(8), 529-547. https://doi.org/10.1080/00223980.2018.1468309

Yu, K., Wu, S., & Chi, I. (2021). Internet use and loneliness of older adults over time: The mediating effect of social contact. *The Journals of Gerontology: Series B, 76*(3), 541-550. https://doi.org/10.1093/geronb/gbaa004

Zhang, Y., Li, J., Zhang, M., Bote, A., & Jia, F. (2023). Bidirectional associations between loneliness and problematic internet use: A meta-analytic review of longitudinal studies. *Addictive behaviors*. https://doi.org/10.1016/j.addbeh.2023.107916

Zhou, W., Yang, Z., & Hussain, Z. (2023). Problematic social media use and mental health risks among first-year Chinese undergraduates: A three-wave longitudinal study. *Frontiers in Psychiatry, 14*. https://doi.org/10.3389/fpsyt.2023.1237924
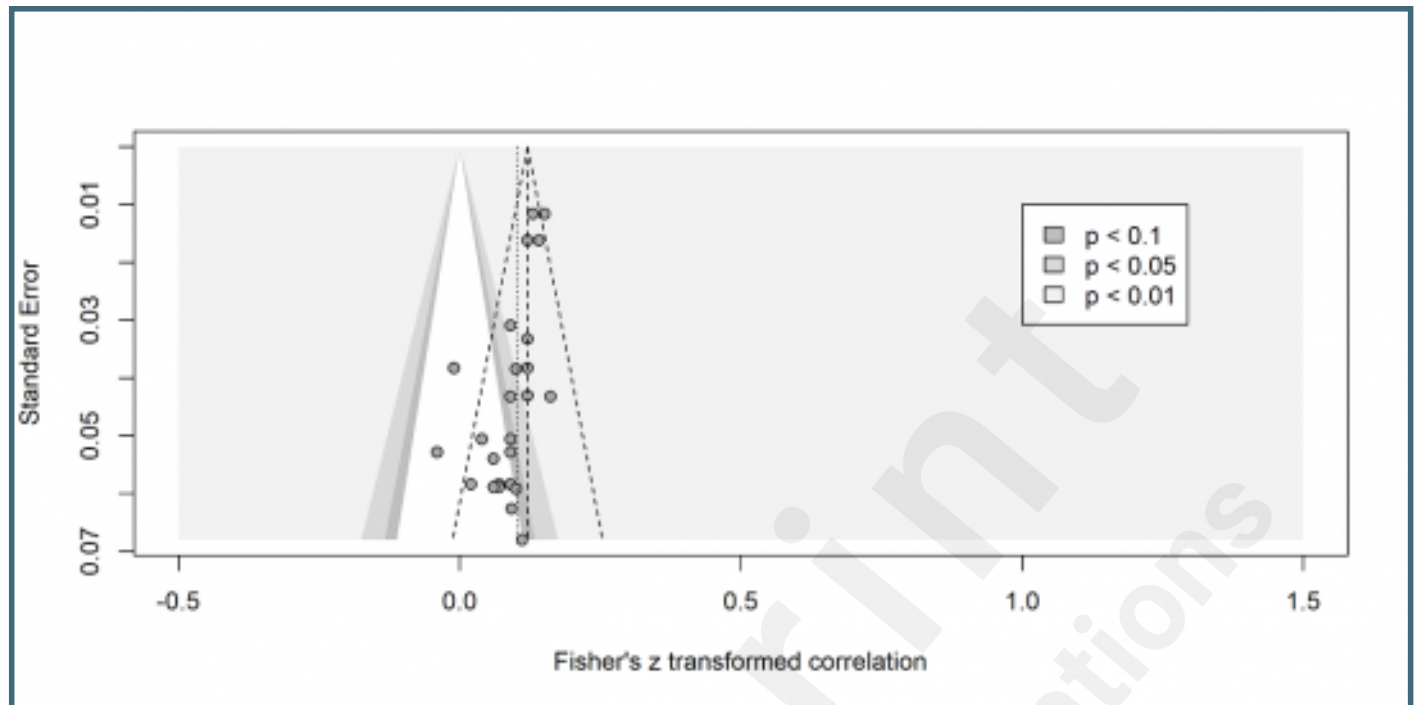
Supplementary Files

Figures

Untitled.

2731 articles extracted from online databases:
  i.   APA PsycArticles ($n = 2408$)
  ii.   PubMed ($n = 128$)
  iii. Scopus ($n = 195$)

→ 97 duplicated articles were excluded.

2634 articles were reviewed in the first screening by title and abstract.

→ 2590 articles were excluded in the first screening:
  i.   Irrelevant ($n = 2561$)
  ii.   Focused on gambling disorder or gambling-related behaviour (e.g., loot boxes; $n = 2$)
  iii. Did not include measures of loneliness and problematic media use as the investigated variables ($n = 7$)
  iv.   Focused exclusively on the therapeutic aspects of problematic media use (i.e., randomised controlled trial of cognitive behavioural therapy; $n = 5$)
  v.   Did not report estimate of the relationship between loneliness and problematic media use ($n = 1$)
  vi.   Not longitudinal study ($n = 14$)

44 articles were reviewed in the second screening by full-text.

→ 20 articles were excluded in the first (second?) screening:
  i.   Did not include measures of loneliness and problematic media use as the investigated variables ($n = 9$)
  ii.   Did not report estimate of the relationship between loneliness and problematic media use ($n = 7$)
  iii. Not longitudinal study ($n = 2$)
  iv.   Same data as another included study ($n = 2$)

→ 2 articles were identified through manual searches in reference list.

26 articles were included in the meta-analysis.

Untitled.

Untitled.