Technology in Society 68 (2022) 101832



Contents lists available at ScienceDirect

Technology in Society

journal homepage: www.elsevier.com/locate/techsoc





# Combatting digital addiction: Current approaches and future directions

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ARTICLE INFO

*Keywords:*
Digital addiction
Intervention
Prevention
Harm reduction
Behaviour change

ABSTRACT

In recent years, the notion of digital addiction has become popular. Calls for solutions to combat it, especially in adolescents, are on the rise. Whilst there remains debate on the status of this phenomenon as a diagnosable mental health condition; there is a need for prevention and intervention approaches that encourage individuals to have more control over their digital usage. This narrative review examines digital addiction countermeasures proposed in the last ten years. By countermeasures, we mean strategies and techniques for prevention, harm reduction, and intervention towards addictive digital behaviours. We include studies published in peer-reviewed journals between 2010 and 2021 and based on empirical evidence. In total, 87 studies were included in the review. The findings show that the main countermeasures could be grouped under four categories: psycho-social, software mediated, pharmacological, and combined. Overall, it has been shown that the proposed countermeasures were effective in reducing addictive digital use. However, a general statement on the efficacy of proposed countermeasures cannot be made due to inconsistent conceptualisation of digital addiction and methodological weaknesses. Accordingly, this review highlights issues that need to be addressed in future studies.

## 1. Introduction

Over the past few years, digital addiction (DA) has emerged as a significant research area due to its increasing prevalence. The prevalence of DA differs globally, varying between 8.90% in Eastern countries and 4.60% in Western countries [1]. Currently, there is a lack of consensus on defining DA, including what term to use to identify it. Different conceptualisations are utilised to characterise DA. Usage style (e.g., time spent on the device, over-attachment to the device), DSM-V diagnostic criteria for behavioural addiction (e.g., preoccupation, mood modification, withdrawal), and harmful consequences due to the addictive relationship (e.g., relationship harm, occupational harm) are suggested to be characteristic features of DA [2,3]. Studies show that DA is associated with depression and anxiety [4], poor sleep quality [5,6], problems with self-care, performing daily activities [7], and social relationships [8].

While no consensus has been reached on the reality, definition, or diagnostic criteria of DA, health organisations have started to acknowledge that some aspects of digital device use may be indicative of an underlying condition. For example, Internet Gaming Disorder is identified within the Diagnostic and Statistical Manual of Mental Disorders, 5th Edition, (DSM-5) for further research [9], and the World Health Organisation recognised Gaming Disorder in its International Classification of Diseases [10]. Accordingly, as a response to individuals seeking professional help, intervention approaches to treat different types of DA such as Internet Addiction, Gaming Addiction, Social Media Addiction have been proposed [11–13]. In addition, there is an increasing number of self-help software applications available to help individuals manage their digital device use [14]. Such countermeasures aim to moderate problematic digital activities whilst maintaining a balance of internet use in daily life. However, these apps may include features that are either ineffective or which may even be harmful. There is a lack of understanding as to which DA countermeasures are currently in use and what their impact may be.

With the World Health Organisation recognising Gaming Disorder [10], the emergence of health care services to address DA, and the latest congress inquiry about social media's harmful effects on children's mental health [15,16], it is vital to evaluate current research to identify

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https://doi.org/10.1016/j.techsoc.2021.101832
Received 30 July 2021; Received in revised form 19 November 2021; Accepted 3 December 2021
Available online 4 December 2021
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characteristics of DA countermeasure studies. Since DA is an emerging research field where standardised methodologies and metrics are absent, the findings will help inform future research and policy by filtering studies that lack empirical evidence, categorising existing countermeasure approaches, examining DA screening instruments, and discussing limitations and opportunities for future research. The present narrative review examines DA countermeasures proposed in the research literature in the last ten years. Given the emerging nature of the field of DA and the debate on whether to consider it as a formal disorder and what to qualify as a suitable intervention, a narrative review approach is taken to provide a comprehensive overview of the research topic and enable making interpretation and critique on current knowledge [17]. Accordingly, the present review evaluates the range of DA preventions and interventions that have been developed and the quality of the evidence base that supports these countermeasures. This review differs from recent reviews on DA countermeasures [18–20] in a number of ways. Firstly, we include software-mediated countermeasures, which started to receive increased interest recently. Secondly, the present review does not limit DA types to Internet Addiction and Internet Gaming Disorder but adopts a more encompassing view by also exploring DA types such as Smartphone Addiction and Social Media Addiction. This is because the online connection feature is not a prerequisite for DA, as individuals can excessively use digital devices even when those devices are not actively connected to the internet [3]. Lastly, the present review provides detailed information on DA countermeasures by giving reference to the etiological factors these countermeasures address.

Although using digital means to intervene with DA might be perceived to be counterintuitive due to the use of the medium, software-mediated countermeasures may benefit from unique advantages such as digital monitoring, automated real-time intervention, accessibility, and cost-effectiveness compared to traditional interventions [21]. Research suggests that design features which may be responsible for triggering digital overuse may also be altered to reduce DA. The software can be designed to increase literacy about the relationship between design features and excessive online activity and include features to promote healthier and more informed usage styles [22,23].

## 2. Method

A literature search was conducted using Web of Science, ScienceDirect, PsychInfo, PubMed, Scopus, and ACM Digital Library to include a variety of multidisciplinary sources. The search was conducted with the following search terms specified for "Title" only: ("digital" OR "Internet" OR "online gam*" OR "social networking sites" OR "social media" OR "smartphone" OR "screen time") AND ("*use" OR "addict*" OR "dependen*" OR "patholog*" OR "excessive" OR "compulsive*" OR "problem*" OR "disorder") AND ("treat*" OR "intervention" OR "prevention" OR "therap*" OR "counselling" OR "app" OR "combat*" OR "limit*"). The search term selection is aligned with similar studies within the field [19,24,25]. As the first step of the search was conducted on "Title" only, backward reference searching was employed to account for possible missouts. The database search was conducted on the July 5, 2021.

We included studies that were (i) published between 2010 and 2021, (ii) based on empirical evidence, (iii) published in peer-reviewed journals and conference proceedings, and (iv) available as full-text articles in English. We excluded studies that (i) did not give adequate information about employed countermeasure, (ii) did not discuss countermeasure efficacy, (iii) were conference abstracts, editorials, doctoral dissertations, reviews, theoretical papers, and case studies, and (iv) focused on gambling. The exclusion of gambling studies was needed due to the use of the term 'gaming' within the gambling research literature. Also, since no consensus exists on whether DA can be classified as a mental disorder and with Gaming Disorder being only recently recognised by World Health Organisation in International Classification of Diseases [10], we chose not to include Gambling Disorder in the search as it has been long recognised, and it is included in DSM-V [9]. Including Gambling Disorder in the search may have distorted our understanding of DA as a condition and our analysis of DA countermeasure efficacy. Identified studies were coded by two of the authors. Extracted data were cross-checked by the other authors, and discrepancies were addressed. The following data was extracted from each study: country in which the study took place, study population (number of participants, age and gender), DA behaviour, DA diagnosis instrument, countermeasure type, study design, outcome measures, and results.

## 3. Results

### 3.1. Overview of results

A total of 2483 studies were identified from the initial database search. After removing duplicates, the remaining 1714 studies were screened on the basis of their title and abstracts, and 70 papers were found to be eligible for review. Five studies were excluded as they were either study protocols or did not report results. 22 additional studies were included in the final set through backward reference searching. As a result, 87 studies were included in this review. Fig. 1 demonstrates the selection process of the final studies.

Much of the research was conducted in Korea (n:26) and China (n:26), followed by the USA (n:6), Iran (n:4), and Germany (n:4). The number of studies for each country is shown in Fig. 2. Out of 87 studies, 62 studies used experimental trial methodology, and 25 studies looked at baseline to follow up in a single group. Within the experimental trial studies, 28 of the studies introduced different countermeasure conditions to groups, while the rest included control groups with no intervention.

In terms of sample age, out of studies that reported age (86 of 87), 35 studies focused on participants aged between 12 and 19, and one study focused on participants less than 12 years old, which is the study conducted by Yoo et al. [26]. The age range for the rest of the studies was broader, including participants aged between 13 and 67. Out of the studies that reported participant gender (80 of 87), 53.7% of the combined sample of all of these studies were male. 22 of the studies included only male participants, with 21 of them examining Internet Gaming Disorder. 26 studies did not screen participants as they were designed to target the general population with preventive measures, while the rest of the studies screened participants with diagnostic inclusion criteria. Young Internet Addiction Scale (YIAS) [27] (n:12) and the DSM-4 and DSM-5 criteria for Internet Gaming Disorder [9] (n:14) were mainly used as the primary screening instruments. Studies that utilised DSM as a screening instrument assessed participants with a clinical interview according to criteria for Gambling Disorder and substance-related disorders [28] or according to section III of DSM-5 [29] instead of developing validated scales. 92.8% of the countermeasure studies that used DSM as a screening instrument were published after 2015, and out of the 14 studies, 13 examined Internet Gaming Disorder. This finding may be due to Internet Gaming Disorder being identified within the Diagnostic and Statistical Manual of Mental Disorders, 5th Edition, (DSM-5) for further research in 2013 [9]. Other scales were utilised to screen participants for Social Media Addiction (n:1), Internet Gaming Disorder (n:5), Smartphone Addiction (n:6), and Internet Addiction (n:12). One scale was used to screen participants for both Internet Addiction and Internet Gaming Disorder [30]. The screening instrument list is shown in Table 1. Of the studies that reported information about the scales, mood modification, tolerance, withdrawal, loss of control, and continued use despite adverse consequences were the most common subscales. All of these subscales were present in the screening instruments used for diagnosing different DA types in reviewed countermeasure studies. 15 of the studies treated the time spent on a device as one of the diagnostic criteria for DA, and 13 of those studies were on Internet Gaming Disorder. Of all the studies, 45 studies excluded participants with co-morbidity such as a psychiatric disorder, including substance abuse.

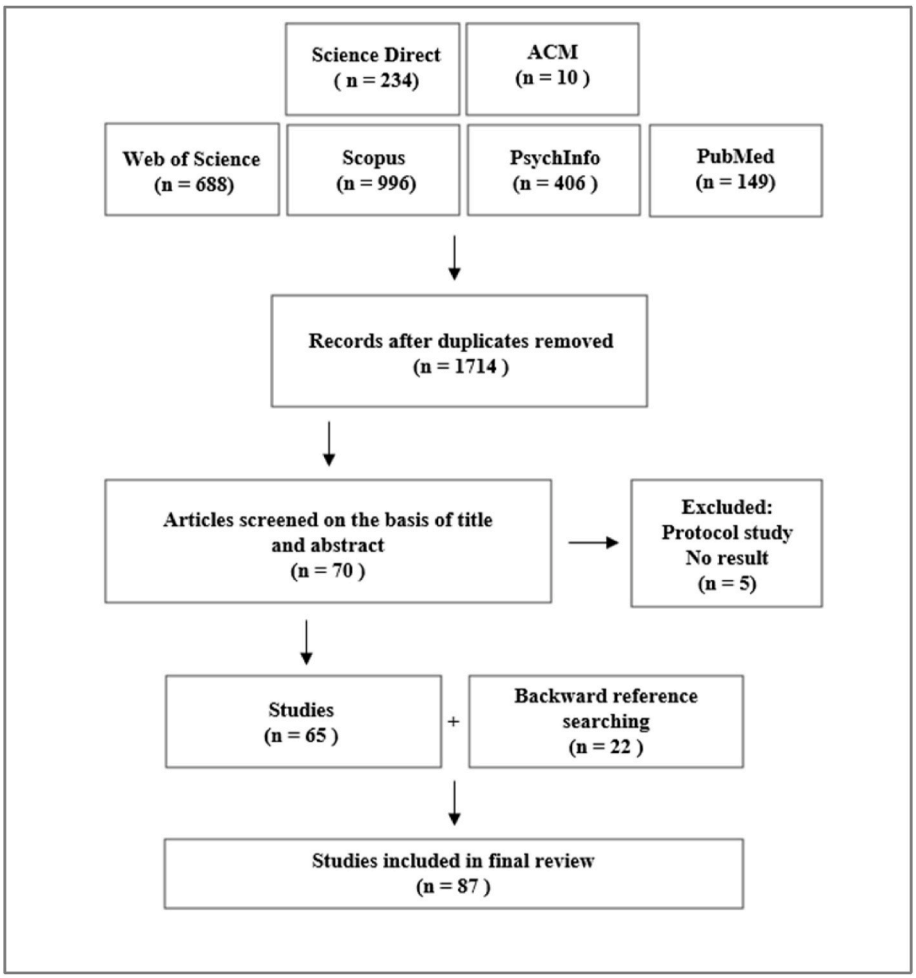



**Fig. 1.** Study selection process.

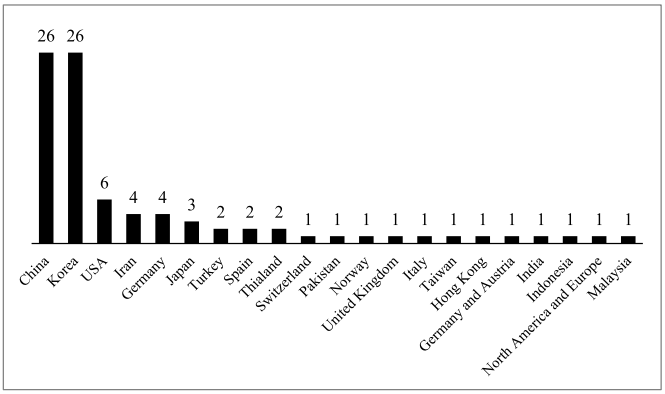



**Fig. 2.** Distribution of studies by country.

The majority of the studies stated to deliver countermeasures for Internet Gaming Disorder (33.3%) and Internet Addiction (31%), followed by Smartphone Addiction (19.3%). The number of studies for the most common DA types are shown in Fig. 3. Internet Gaming Disorder was also referred to as Online Gaming Addiction [56], and Internet Addiction was referred to as Problematic Internet Use [57] or Internet Addiction Disorder [58]. This varying terminology reflects differences in language and conceptualisation within the DA research literature [3]. Four studies out of 87 delivered countermeasures for combined DA conditions, which were Internet Gaming Disorder and Internet Addiction [59,60] and Internet Addiction and Smartphone Addiction [61,62].

Internet Addiction and Internet Gaming Disorder countermeasure studies were published between the time frame of 2010–2021, whereas 94.1% of countermeasure studies on Smartphone Addiction and all countermeasure studies on Social Media Addiction were published after 2015. This finding suggests that as technology advances, new types of DA emerge and attract research attention. The number of studies for each DA type across years is shown in Fig. 4.

While the line separating countermeasure approaches could be blurred, the studies included in the present review could be divided into two categories; studies that focused on reducing digital overuse through interventions and studies that focused on introducing preventive measures to sustain healthy digital use. In this light, nearly all of the studies (73 of 87) aimed to reduce digital overuse with interventions. Five studies only focused on increasing the psychological well-being of people who experience some form of DA [63–67]. Regarding intervention duration, out of 86 studies that reported duration, the most common duration was eight weeks (n:13). The longest intervention period was for two years, which was an educational program given to Chinese rural adolescents [68].

Countermeasure outcomes were assessed mainly by self-reports on DA assessment questionnaires and hours spent with digital devices or services. A number of studies further assessed countermeasure success with improvements related to comorbid conditions. This included decreases in symptoms of depression [29,60,69,70], anxiety [71], social anxiety [72,73], psychopathology [74,75] and an increase in self-esteem [13]. 13 studies used brain imaging techniques to observe the

**Table 1**
Digital addiction screening instruments utilised by the countermeasure studies.

| DA screening instrument | Frequency of Use |
|---|---|
| DSM IV and DSM V [9] | 14 |
| YIAS [27] | 12 |
| Chen Internet Addiction Scale [31] | 5 |
| Criteria for Internet Addiction [32] | 2 |
| American Association of Psychology [33] | 2 |
| Beards Diagnostic Questionnaire [34] | 2 |
| Game Addiction Scale for Adolescents [35] | 2 |
| Assessment of Internet and Computer Game Addiction Self-report [30] | 2 |
| Standardized Clinical Interview of Internet Addiction [36] | 2 |
| Mobile Phone Addiction Index [37] | 2 |
| Smartphone Addiction Scale–Short Version [38] | 2 |
| Mobile Phone Internet Addiction Scale [39] | 1 |
| Smartphone Addiction Inventory [40] | 1 |
| Korean Smartphone Addiction Proneness Scale [41] | 1 |
| Chinese Test of Mobile Phone Dependence [42] | 1 |
| Bergen Social Media Addiction Scale [43] | 1 |
| Internet Gaming Disorder Test [44] | 1 |
| Game Addiction Screening Test [45] | 1 |
| Online Game Cognition Addiction Scale [46] | 1 |
| Korean Internet Addiction Self-Report Test [47] | 1 |
| Problem Video Game Playing Scale [48] | 1 |
| Adaptation of YIAS [49] | 1 |
| Compulsive Internet Use Scale [50] | 1 |
| Internet Addiction Proneness Scale [51] | 1 |
| Revised Chinese Internet Addiction Scale [52] | 1 |
| Problematic Internet Use Scale [53] | 1 |
| The Online Cognition Scale [54] | 1 |
| Adolescent Pathological Internet Use Scale [55] | 1 |

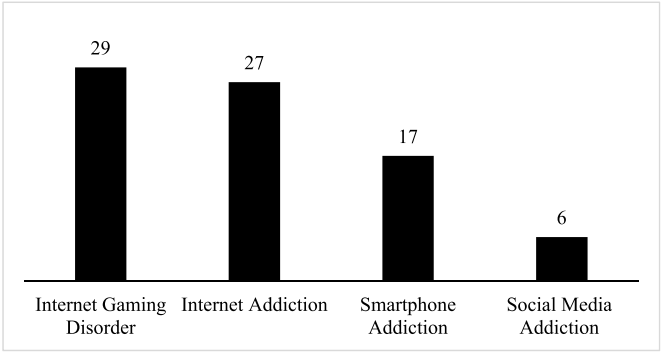



**Fig. 3.** Top four digital addition types that have been examined.

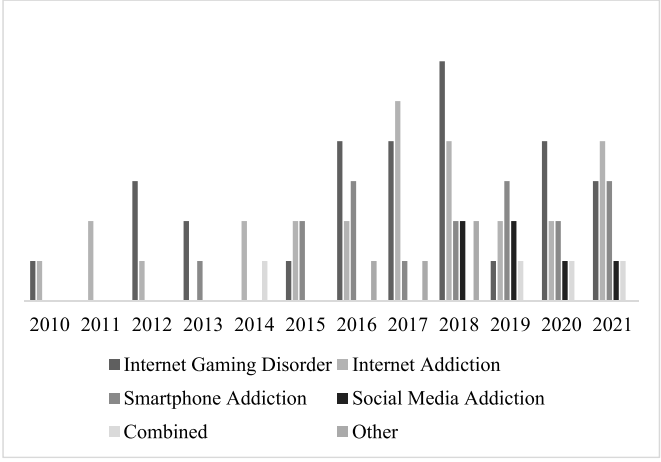



**Fig. 4.** Countermeasure studies on different types of digital addiction across years.

intervention effect on brain activity [29,56,61,76–85]. Most of the studies did not include longitudinal follow-up assessments (56 of 87). Out of the studies that included follow-up intervention assessments, typical assessment times were three months and six months post-intervention.

### 3.2. Countermeasure types

The countermeasure resulting from the 87 studies could be grouped under four categories: psycho-social, software mediated, pharmacological, and combined. The number of studies for each countermeasure category is shown in Fig. 5.

#### 3.2.1. Psycho-social countermeasures

Most of the studies in the review (52 of 87) adopted a psycho-social therapeutic approach in intervening with DA, with Cognitive Behavioural Therapy (CBT) being the most common one (n:17). Subcategories of psycho-social countermeasure studies are shown in Table 2. 11 of the CBT interventions were given in a group setting, while six were given on an individual basis. In general, CBT aims to help individuals understand behavioural and cognitive components of their excessive actions and trains them on coping responses and means to avoid relapse [86]. Within the context of DA, CBT was used to increase self-awareness on addictive usage by highlighting internal and external triggers that challenge their impulse control and by highlighting feelings, psychological needs, and cognitive distortions (e.g., all or nothing thinking, "I am only loved and cared for in online platforms") behind excessive use [72,74]. Such understanding can help individuals recognise the causes of addictive usage patterns and challenge negative emotions and faulty thoughts linked with digital overuse. Eight studies within the psycho-social countermeasure category adopted an educational strategy. Half of the studies introduced preventive measures to combat DA, and the other half introduced reactive measures. The majority of the studies in this group (n:6) focused on participants aged 12–17, and countermeasures were carried out in a school setting. In general, educational countermeasure studies aimed to teach students about DA and coping strategies against such behaviour through the use of group activities, video watching, and role modelling. In terms of coping strategies, one study focused on self-efficacy and self-regulation [87], and another study focused on knowledge of sleep hygiene [88]. One education-based countermeasure study [89] targeted both children and mothers by giving an educational session for mothers too.

Other countermeasure studies in the psycho-social countermeasure category are as follows. Five studies focused on craving intervention: recognising irrational beliefs and negative emotions regarding cravings and learning to cope with them [69,78,79,84,85]. Three studies focused on the role of family dynamics: satisfying unmet psychological needs that lead to digital overuse by strengthening family communication and relationship [56,90,91]. Other studies were mind subtraction mediation [26,92], mindfulness intervention [93–95], short term abstinence intervention [63,67,96], positive psychology intervention [65,97], motivational

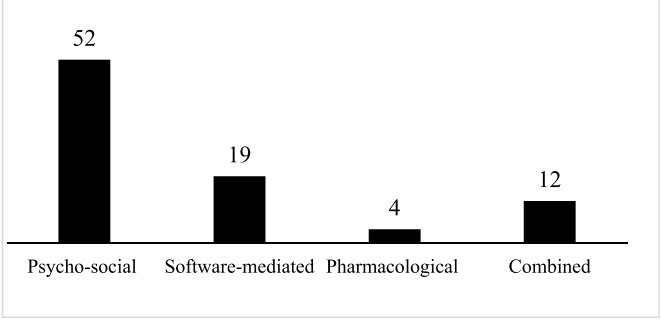



**Fig. 5.** Number of studies by countermeasure types.

**Table 2**
Subcategories of psycho-social countermeasure studies.

| Psycho-social Countermeasures (n:52) |
|---|
| 1. Cognitive Behavioural Therapy (n:17) [13,28,42,60,61,72–75,84,86,104–109] |
| 2. Educational Countermeasure (n:8) [11,59,68,87–89,110,111] |
| 3. Other Countermeasures (n:27) |
| *Craving Intervention* [69,78,79,84,85] |
| *Family-Focused Countermeasure* [56,90,91] |
| *Mindfulness Intervention* [93–95] |
| *Short term Abstinence Intervention* [63,67,96] |
| *Mind Subtraction Mediation* [26,92] |
| *Positive Psychology Intervention* [65,97] |
| *Motivational Enhancement Therapy* [64,70] |
| *Manualized Therapy* [99] |
| *Specialized Psychotherapy for Adolescents (PIPATIC)* [100] |
| *Reality Therapy* [98] |
| *Solution-focused Brief Therapy* [52] |
| *Electro-acupuncture* [101] |
| *Mind-body Exercise* [102] |
| *Group-based Basketball Exercise* [103] |

enhancement therapy [64,70], reality therapy [98], manualized therapy [99], specialized psychotherapy for adolescents (PIPATIC) [100], solution-focused brief therapy [52]. Three studies focused more on the mind-body association through electro-acupuncture [101], mind-body exercise [102] group-based basketball exercise [103] countermeasures.

Overall, most of the studies on psycho-social countermeasures were shown to be effective, whether in reducing DA level or in reducing hours spent with digital devices or services. Out of 52 studies within the psycho-social countermeasure category, 46 studies reported significant results. In addition, some studies reported a post-intervention decrease in comorbid disorder symptoms.

### 3.2.2. *Software-mediated countermeasures*

19 studies within the review adopted a software-mediated approach. The software-mediated countermeasures were mainly divided into two groups: software mediation to raise awareness on DA and software mediation to introduce direct interventions to behaviour. Subcategories of software-mediated countermeasure studies are shown in Table 3.

**Table 3**
Subcategories of software mediated countermeasure studies.

| Software-mediated Countermeasures (n:19) |
|---|
| 1. Awareness Raising (n:5) [12,112–115] |
| 2. Direct Intervention (n:12) |
| *Limit Setting* [117–124,129] |
| *Cognitive Task* [125,126] |
| *Message Framing* [127] |
| 3. Other Countermeasures (n:2) |
| *Use of Virtual Reality* [66,77] |

Five studies which used software-mediated countermeasures focused on raising DA awareness. Two of these studies used a website as their main platform for intervention [112,113]. Students visited the website to gain general knowledge about Internet Addiction, receive personalised feedback about their digital usage and learn about coping mechanisms. Another study adopted a gamification approach and made use of online training modules [12]. Students were informed about hasty online behaviour, negative consequences related to Internet Gaming Disorder, and ways of preventing such problems with educational presentations, games, tournaments, and video discussions. Two other studies within the raising DA awareness group used mindfulness apps which consisted of tasks to increase mindful attention awareness to cravings [114,115]. The findings demonstrated a negative correlation between mindful attention awareness and DA.

12 studies that used software-mediated countermeasures introduced direct intervention to behaviour. Nine of these 12 studies focused on limit setting as a DA countermeasure, with four studies being group-based and five studies being individual-based. In the group-based studies, self-regulation was suggested as an underlying mechanism related to addictive behaviour as individuals need to exercise self-control to overcome their impulses and regulate their behaviours [116]. Accordingly, studies that used group-based intervention [117–119] aimed to increase self-regulation by utilising social support in which people would lessen their use together. This was accomplished through a mobile service or app which supported the sub-functions of self-regulation (i) self-monitoring, (ii) goal setting and usage limiting, and (iii) social learning. The results of the studies showed that the countermeasure was successful in improving self-regulation and that peers in the group encouraged each other in reducing the time spent on smartphones. Individual-based limit setting intervention studies focused on creating usage restriction rules [120], limiting by setting time for non-use [121,122] or limiting by setting time for use [123]. Instead of limiting by blocking usage, which is the general trend, Hiniker et al. [123] developed an app where participants set how much time they want to spend with certain apps in their phones and were presented with a timer, a timeout message, and a self-defined aspiration message when one reaches the use goal. Overall, participants decreased their daily device usage by 33 min post-intervention. Another study within the individual limit setting group investigated the use of nudge [124], in which participants were informed with a phone vibration when they reached their daily time limit. While real-time feedback was successful in decreasing time spent on social media, it was observed that participants returned to their old usage patterns once the intervention was removed. Two of these 12 studies [125,126] focused on impulse behaviours that arise from intuitive decision making in explaining addictive behaviour. Accordingly, they introduced a lockout task that aimed to dissociate gratification seeking thoughts from action outcomes. In terms of delivering intervention messages through software, one study investigated framing and observed the effect of positive and negative framing on personal productivity in a collaborative work setting [127]. The findings showed that productivity was improved when the intervention message emphasised time spent with distracting activities (i.e., negative framing) compared to time spent with productive activities (i.e., positive framing). It was suggested that delivery of software mediated interventions can be improved with context-dependent interventions, for example, through the use of location-based reminders, which can be activated in class or work settings [118,119]. Monitoring the use across multiple platforms were also suggested to improve software mediated interventions as this will limit addictive behaviour in a more comprehensive style [121].

Two studies within the software-mediated countermeasure category employed virtual reality to intervene with DA [66,77]. While Shin et al. [66] investigated the use of virtual reality in improving interpersonal conflict management between parents and young adults, Park et al. [77] used virtual reality for conditioning. According to learning theories, addictive behaviours develop into a habit as a result of the continuous

pairing of addictive action with positive outcomes [128]. Accordingly, virtual reality was used to pair previously enjoyed gaming scenes with irritating noise to reduce excessive gameplay. The result showed a similar effect as CBT in decreasing DA level. Out of 19 studies within the software-mediated countermeasure category, 13 studies reported significant results with respect to countermeasure success.

#### 3.2.3. Pharmacological countermeasures

In the present review, four studies employed a pharmacological countermeasure approach [80,82,130,131]. All studies examined the efficacy of antidepressants, either bupropion or escitalopram, on reducing Internet Gaming Disorder. One study examined such effects on participants who also show symptoms of major depressive disorder [80]. Previous studies showed that antidepressants effectively reduce dependence on cocaine, nicotine, and gambling [132–134]. Such effect could be explained by antidepressants inhibiting dopamine signalling, which is responsible for increased sensitivity to pleasure-seeking [135], or antidepressants reducing comorbid depressive symptoms, which may share underlying mechanisms with addiction [136]. All studies within this group reported significant results in reducing Internet Gaming Disorder symptoms, with two studies also showing intervention effects on brain activity [80,82].

#### 3.2.4. Combined countermeasures

Combined countermeasures are when two or more countermeasure techniques are employed together to intervene with the behaviour. 12 studies combined different countermeasure strategies. These studies utilised CBT with pharmaceutical drug prescription [137,138], CBT with motivational interviewing [57], CBT with music therapy [62] CBT with mindfulness training [139], psychological intervention with electro-acupuncture [76]; Li et al., 2017a), psychological intervention with physical exercise [29,58] and reality therapy and mindfulness mediation [71]. As an alternative approach, two studies employed therapeutic residential camp countermeasures [140,141]. Sakuma et al. [140] employed a Self-Discovery Camp which included CBT sessions, medical lectures, personal counselling, and a workshop to train participants on the importance of a balanced life, face to face communication, and collaboration with others. During the nine-day camp, participants were prohibited from using their digital devices and were directed to outdoor activities and hobbies. Overall, eight of the studies in this group reported significant results with respect to countermeasure success.

## 4. Discussion

The present review summarised studies that proposed DA countermeasures and were conducted within the last ten years. Different from recent reviews on DA countermeasures, the present review adopted a more encompassing view on defining DA, examined countermeasure regarding underlying mechanisms related to digital overuse, and highlighted software mediated countermeasure, which is new to the field. The findings of this review help inform future research and policy initiatives by filtering studies that lack empirical evidence, categorising existing countermeasure approaches, examining DA screening tools, and discussing limitations and opportunities for future research.

Our review showed that the countermeasure used in the literature could be grouped under four categories: psycho-social, software mediated, and combined. Overall, our study showed that the countermeasure reported in the papers reviewed were demonstrated either useful or accepted in the attempt to reduce DA level and hours spent with digital devices or services. Our review did not include studies that reported negative results, raising the question of whether studies of that kind were ever reported and published. However, the inconsistent conceptualisation of DA and methodological weaknesses regarding sampling strategy, experiment conditions, outcome measures, and follow-up measures threaten the reliability and validity of the findings and evidence reported in our reported studies.

Although most of our reviewed papers showed positive results, we have reservations on whether the studies can be replicated and whether the results are generalisable. First, the absence of a standardised instrument to assess DA made it difficult to evaluate DA countermeasure efficacy. While a majority of the studies employed DSM-5 criteria for Internet Gaming Disorder [9] or versions of Young Internet Addiction Scale (YIAS) [27], other assessment tools such as Adolescent Pathological Internet Use Scale (APIUS) [55], The Online Cognition Scale (OCS) [54], Beards Diagnostic Questionnaire for Internet Addiction [34] were also employed. A further examination revealed that scales used to diagnose different types of DA share similar subscales, such that Internet Gaming Disorder and Social Media Addiction are measured using similar symptoms. Such similarity may be due to DA screening tools resting on DSM criteria of behavioural addiction [142]. This observation raises two discussion points. First, given that different types of DA share similar symptoms, can different types of DA be referred to as different conditions, or should research refer to them as different manifestations of a shared mental condition? Second, given that individuals interact with devices and digital platforms differently, how can user interaction be accounted for in diagnosing different types of DA if comparable screening tools are used for diagnosis? For example, the current study showed that most studies that treated time spent on the platform as a diagnostic criterion were on Internet Gaming Disorder (13 of 15 studies). This finding suggests that immersion may be a more prominent feature related to Internet Gaming Disorder compared to other DA types. Even though different platforms such as Facebook and Twitter are listed under the umbrella term “social media”, distinctions in their structural and functional features influence how and why individuals use these platforms [143].

The lack of a common framework to define DA in the field is further complicated by the status of the different behaviours included under the label of DA. Gaming Disorder is included as a diagnosable clinical disorder under the American Psychiatric Association and World Health Organisation criteria. Other forms of DA, such as the internet or social media use, are not currently diagnosable conditions under either of these diagnostic systems. This, in turn, creates questions over which language to use when discussing changes to this behaviour. Many of the studies reviewed refer to ‘treatment’ of DA, although some of the behaviours covered within those studies are not diagnosable clinical disorders. Nevertheless, as discussed within this paper, there is an increasing tendency towards approaching all forms of DA as a behaviour associated with harm and one that individuals may wish to change.

While the nature of the digital medium has seen many changes in the last decade, reviewed studies showed that screening instruments since Young [27] have focused on psychological impact and related harmful consequences rather than the digital medium itself. Recently, new items have been added to screening instruments, such as directivity to the virtual world [106], difficulties in distinguishing reality [87], cyberspace-oriented relationship [108]. This finding suggests that as the relationship with digital medium evolves and takes new forms, new criteria specific to DA types can be added to the screening scales making it even harder to develop a standardised instrument to assess DA.

In addition to diagnostic and assessment tools, nearly all of the studies assessed countermeasure success via the reduction of time spent on digital devices and services post-intervention. While such an assessment is important in describing countermeasure outcomes, linking countermeasure efficacy to hours spent with digital devices oversimplifies the multifaceted nature of DA. This is because time spent alone does not indicate problematic usage as the person might be using the device consciously and for purposes deemed to be important for them. Also, the reduction in hours spent with a device only highlights the improvement in one of the DA symptoms. It can be the case that individuals might suffer from DA even though they do not show excessive usage patterns.

The sampling strategy of the reviewed studies causes concern for the generalisability of findings. 22 studies only included male participants.

Half of the studies were conducted in East Asia. In terms of the diversity of the population recruited in the studies, only two studies conducted cross-country analysis. This poses a question about cross-cultural differences in countermeasure success. Moreover, in more than a quarter of the studies, participants were not screened for comorbid conditions such as depression and social anxiety were not excluded from the sample, making it difficult to draw conclusions about countermeasure efficacy to DA on its own. Such an approach to sampling blurs the lines between defining DA as a disorder [27,144–146] or an indication of other psychiatric conditions [147].

In terms of experiment conditions, 25 studies did not include control groups increasing the possibility of cofounding variables in countermeasure outcomes. Within studies that included control groups (n:62), 23 studies did not employ randomisation, and participants were assigned to experimental conditions based on their willingness to be in the intervention group or based on when they were signed up for the study. Willingness to change may be a significant confounding variable affecting countermeasure efficacy as it was shown that not all individuals diagnosed with DA are willing to participate in an intervention program [148]. Also, sampling bias might have occurred at educational countermeasure studies that delivered educational programs to classrooms due to not accounting for different participant characteristics and participants feeling inclined to report that the intervention was successful.

Another methodological limitation of the reviewed studies is their high reliance on self-report in assessing DA diagnosis and countermeasure outcomes. This is because the use of self-report possesses several weaknesses that risk the reliability and validity of the findings. The self-reported data could be distorted due to social desirability bias and/or memory recall bias. For example, in their study, Araujo et al. [149] showed that a great difference exists between self-reported internet use and tracking data and that users with high levels of actual internet use showed higher levels of under-reporting. The intention behaviour gap [150] could also pose threat to self-report validity in which participants report positive intentions to reduce digital overuse but fail to translate intention to actual behaviour.

The absence of longitudinal studies is another prevalent issue as more than half of the reviewed studies (56 of 87) only assessed the immediate effects of the countermeasure and did not employ follow-up measurements. It is possible that countermeasure success may be due to flight to health [151], in which participants instantly feel treated as a defence against the anxiety felt in the face of DA diagnosis. Moreover, within studies that employed software mediated countermeasure, novelty effect [152] could be a factor in immediate countermeasure success. Participants may have engaged with self-regulation apps due to being introduced to a novel phenomenon yet may lose interest once the phenomenon becomes familiar. Given that the DSM requires the addictive behaviour to be present for the last 12 months to identify it as a condition [9], declaring countermeasure success by assessing the immediate effect may be a questionable approach. Moreover, considering the reality of relapse in addictive disorders [153,154], longitudinal studies are required to assess countermeasure efficacy.

Another discussion point could be the ethical dimension of applying certain DA countermeasures. Concerns may be raised over the use of medicine or physical countermeasures, such as antidepressants and electro-acupuncture, to intervene with DA, especially for DA types that are not clinically recognised. DA countermeasure itself may also produce adverse effects. Alrobai et al. [14]; for example, demonstrate the risks of interactive persuasive solutions to combat DA, such as reduced self-esteem, confusion of healthy use, and the development of new addictive behaviours.

### 4.1. Limitations of the review

The exclusion of countermeasure studies that were not accessible in English could have caused overlooking key findings considering most of the research in this field is conducted in South Asia. Secondly, the review only included published studies, and this could have led to publication bias since studies that report intervention success are more likely to be published.

## 5. Future research

Investigating countermeasure options for a condition without a clear definition is a challenge. However, the presence of individuals who seek professional help underlines the necessity of improving DA countermeasure. Accordingly, it is important that DA holds conceptual clarity within the field with respect to definition, diagnosis criteria, and countermeasure outcome measures. Internet Gaming Disorder being stressed within the DSM-5 for further research [9] and being recognised by The World Health Organisation [10] may be seen as the first steps in reaching conceptual clarity.

Linked with DA conceptualisation, another issue that needs to be addressed in future studies is the comorbid psychiatric disorders such as attention deficit hyperactivity disorder, depressive disorder, mood disorder, impulse control disorder, and social avoidance disorder [155–158] that coexist with DA. While it is difficult to suggest a causal relationship between DA and comorbid psychiatric disorders, comorbid conditions can be treated as risk factors to be assessed in relation to DA. This argument is supported through the study conducted by Deshpande and Bisen [159]; which states that co-morbidities are more of a norm than an anomaly in cases of DA.

More studies that adopt a preventive approach need to be conducted compared to intervention studies targeting individuals who already experience DA. Establishing DA literacy through educational initiatives began to gain prominence as DA literacy is seen as a critical component in preventing, detecting, and treating DA [160,161]. Such a proactive approach can help individuals understand their digital consumption and help them manage it before it develops into problematic usage that requires intervention.

In terms of evaluating countermeasure success, it might be an effective approach to examine countermeasure efficacy beyond improvements seen in DA symptoms such as reported time with digital devices and services. For example, studies show a significant correlation between DA and low life satisfaction and negative emotional states [162,163]. By identifying the etiological reasons that cause addictive symptoms in the first place, such as family functioning or psychological well-being, one can discuss countermeasure success in targeting the underlying mechanisms responsible for addictive behaviour.

Our review revealed that a majority of the current intervention and prevention methods involve face to face interaction, whether those targeting individuals separately or within groups. Such approaches may pose challenges in terms of the number of trained therapists and the service distribution [112]. Considering these challenges, software mediated countermeasures could potentially deliver DA intervention to a large scale of people in need. Benefitting from accessibility, digital monitoring, and automated real-time intervention, software-mediated countermeasures can help decrease digital overuse by enabling self-monitoring, goal setting, and social learning [117,123]. Similar software-mediated countermeasure approaches have been taken in other domains, such as designing a smart tray to encourage healthy eating habits [164]. Zhang and Ho [165] suggest that it is possible to have a low-cost development strategy for advanced software-mediated countermeasures to increase user reach and adoption, such as the smartphone-based virtual reality intervention to Internet Addiction and Internet Gaming Disorder. Taking a software-mediated countermeasure approach also widens the discussion on who holds responsibility for DA. While current approaches put the burden of responsibility mainly on the individual in explaining digital overuse, the design of digital devices and services also holds responsibility due to their interactive, intelligent, and personalised nature, which attracts attention and reinforces excessive use [166,167]. Recent studies on digital addiction labels [2] and studies

on combatting procrastination [22] and Fear of Missing Out (FoMO) [23] show that empowering users with explanations and tools to manage digital usage within the design of digital services can help minimise addictive use. These findings suggest that software developers can play a role in preventing or intervening early with DA by developing DA-aware architecture and design. When developing DA-aware platforms, special attention should be given to the type of DA the platforms can trigger, and their etiological underpinnings as design implications would differ accordingly.

## Author statement

Deniz Cemiloglu: Conceptualisation, Methodology, Data curation, Writing – original draft. Mohamed Basel Almourad: Data curation, Writing- Reviewing and Editing. John McAlaney: Conceptualisation, Methodology, Writing- Reviewing and Editing. Raian Ali: Conceptualisation, Methodology, Writing- Reviewing and Editing, Supervision.

## Funding

This work is part of SSCoDA project that was approved and funded by Zayed University, UAE, under grant number R18053.

## Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

## Declaration of competing interest

The authors report no conflict of interest.

## Acknowledgements

Open Access funding has been provided by the Qatar National Library.

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