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Article

Technology-Based Interventions for Promoting Well-Being in Childhood and Adolescence: A Systematic Review and Meta-Analysis

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ABSTRACT

Background: Well-being is crucial for children's and adolescents' mental health. Despite numerous interventions, innovative technological options are still underexplored, particularly for younger populations. This study aims to review, summarize, and discuss experimental studies on the effects of technological interventions on well-being in childhood and adolescence. **Method:** We conducted a systematic review and meta-analysis following PRISMA guidelines, including studies published since 2013. Searches were conducted in PubMed, PsycInfo, Scopus, and Web of Science including randomized and non-randomized controlled trials. The quality of studies was assessed using the Cochrane Risk of Bias (ROB-2) and ROBINS-I tools. Meta-analyses were performed using R studio. **Results:** Of the 2705 articles screened by title and abstract, 55 underwent full-text review. Seventeen articles were included, showing a diversity of technology-based interventions, including apps, web-based intervention, digital intervention, and chatbots. The meta-analysis (n = 5636 participants) showed a small but statistically significant effect in promoting well-being (Hedges's g = 0.18; p < .01). App-based interventions demonstrated a notably larger effect size (Hedges's g = 0.33; p < .001). **Conclusions:** The findings highlight a range of technological interventions for promoting well-being in children and adolescents, with apps showing greater effectiveness. This supports their use as valuable resources for this population..

Intervenciones Basadas en Tecnología para Promover el Bienestar en la Infancia y la Adolescencia: una Revisión Sistemática y Metaanálisis

RESUMEN

Antecedentes: El bienestar es crucial para la salud mental de niños y adolescentes. A pesar de numerosas intervenciones, las tecnologías innovadoras siguen siendo poco exploradas, especialmente en poblaciones jóvenes. Este estudio pretende revisar, sintetizar y discutir estudios experimentales sobre los efectos de intervenciones tecnológicas en el bienestar infantil y adolescencente. **Método:** Se realizó una revisión sistemática y metaanálisis siguiendo las directrices PRISMA, incluyendo estudios desde el 2013. Las búsquedas se realizaron en PubMed, PsycInfo, Scopus y WOS. La calidad de los estudios fue evaluada mediante las herramientas ROB-2 y ROBINS-I. El metanálisis se realizó mediante R Studio. **Resultados:** De los 2705 artículos seleccionados, 55 se revisaron en texto completo. Se incluyeron 17 artículos, mostrando una diversidad de intervenciones, incluyendo apps, intervenciones web, intervención digital y chatbot. El metaanálisis (n = 5636 participantes) mostró un efecto pequeño pero estadísticamente significativo en la promoción del bienestar (Hedges's g = 0.18; p < .01). Las intervenciones basadas en aplicaciones demostraron un tamaño del efecto notablemente mayor (Hedges´s g = 0.33; p < .001). **Conclusiones:** Los hallazgos destacan una diversidad de intervenciones tecnológicas para promover el bienestar, con una mayor efectividad de las aplicaciones. Esto respalda su implementación como recursos valiosos para esta población.

Palabras clave:
Bienestar
Intervenciones basadas en tecnología
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Aplicaciones
Intervenciones basadas en internet

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Wll-being is a core component of mental health and positive development in children and adolescents (Goswami, 2014). In 2011, the United Nations determined that the pursuit of happiness and well-being should be a fundamental goal of human development. This has driven the interest of governments and non-governmental agencies in developing programs along these lines (OECD, 2013).

In general, the literature defines well-being as the state of feeling good, encompassing happiness, effective functioning, engagement, and positive relationships (Huppert, 2009). However, varied descriptions of well-being have also been reported, with two conceptual approaches dominating the discussion: subjective and objective well-being (Ross et al., 2020). Subjective well-being emphasizes personal experiences and includes eudaimonic well-being and hedonic well-being (Ryan & Deci, 2001). The former includes notions such as psychological well-being and the latter includes concepts such as subjective well-being (Ryff et al., 2021). In contrast, objective well-being defines well-being in terms of quality of life with respect to material resources and social attributes.

The promotion of well-being during childhood and adolescence is a crucial aspect for the positive development of this age group, significantly impacting their mental health and socioemotional development (Abraham et al., 2019; Kuosmanen et al., 2019). Furthermore, public policies recognize the promotion of well-being as a priority dimension for fostering positive trajectories in mental health, socioemotional development, and social integration. This approach has positive effects at individual, family, school, and peer relationship levels, reducing risk factors such as emotional stress, depressive symptoms, and lower academic achievement (Gónzalez-Carrasco et al., 2017; Huebner et al., 2014; Rodríguez-Rivas et al., 2022, 2023; Shoshani & Slone, 2013).

Over the last decade, there has been an increasing interest in developing interventions that promote the well-being of children and adolescents, which have shown a significant effect in promoting their mental health and positive development. This growing interest has also contributed to higher-quality studies, allowing for deeper exploration of the subject (Lam & Lam, 2023).

Different systematic reviews have indicated that interventions aiming to promote the subjective well-being of children and adolescents encompass various frameworks highlighting, for example, mindfulness-based interventions, positive psychology interventions with single or multicomponent approaches, character strengths, optimism, gratitude, expressive writing, and cognitive therapy (Chuecas et al., 2022; van Agteren et al., 2021). Overall, interventions that combine multiple components of positive psychology and mindfulness-based interventions have been reported to yield the most positive outcomes (Chuecas et al., 2022; Mendes de Oliveira et al., 2022).

In general, these interventions have been reported to yield small to medium effects on well-being variables, with these impacts observed over time (Mendes de Oliveira et al., 2022; Tejada-Gallardo et al., 2020).

Lou et al. (2024) conducted a meta-analysis of psycho-behavioral interventions aimed at improving the subjective well-being of healthy adolescents, categorizing them into four types: physical activity/health behavior, psychosocial skills to foster positive traits, psychosocial skills to teach coping skills, and a mixed intervention type. The findings indicated that the effect of these interventions on subjective well-being was small, both at post-intervention and at follow-up. In particular, the most effective interventions were those with a longer duration and delivered in group settings, suggesting that intervention design and delivery modality are important factors in their effectiveness.

On the other hand, Fu (2024) conducted a systematic review of positive psychology interventions in educational settings, focusing on programs designed to improve adolescent well-being by promoting resilience and positive emotions. The findings showed that these interventions can generate significant short-term benefits, such as improved subjective happiness, demonstrating the value of psychological interventions in school contexts. However, Fu highlighted the lack of literature in this field, along with the exclusive use of one database in the study search, which resulted in a relatively small number of included studies and may have led to incomplete literature coverage.

Interventions to promote well-being of children and adolescents occur in different contexts, including community centers, family foster care, among others, but they are predominantly observed in schools, where this age group is readily accessible, facilitating implementation (Chuecas et al., 2022; García-Carrión et al., 2019). Despite this predominance, there has been a rapid increase in interventions utilizing digital platforms, tools, and apps, particularly in response to the COVID-19 pandemic (Pavarini et al., 2024; Reupert et al., 2019; Wright et al., 2023).

Worldwide, there have been several initiatives and studies focused on mental health promotion, prevention and treatment, highlighting a growing development in the use of new technologies in this field (Rodriguez-Rivas et al., 2022; Xu et al., 2024). In recent years, several authors have shown that innovative technology-based interventions have a significant impact on mental health, including the reduction of depressive and anxiety symptoms (Piers et al., 2023). Furthermore, with the rapid expansion of technology, mobile app-based interventions, video games, and virtual and immersive reality are increasingly integrated into mental health practices (Cieślik et al., 2020; Dewhirst et al., 2022).

For example, the efficacy of technological interventions in the treatment of phobias, depressive symptoms, and anxiety in child and adolescent populations has been explored and demonstrated (Botella et al., 2017; Schueller et al., 2024). However, despite the progress in this field, the application of these technologies to promote well-being in the adolescent and child population has been less explored compared to the adult population (Xu et al., 2024).

Specifically, among the worldwide technological interventions aimed at promoting adolescent well-being, Manicavasagar et al. (2014) conducted a study with participants aged 12 to 18 years. In their randomized controlled study, it was observed that, through the use of a web-based program focused on promoting the application of fundamental principles of positive psychology, a statistically significant difference was generated in the levels of psychological well-being in the intervention group, which was not the case in the control group. In addition, it was shown that this effect was greater in participants who used the program more than twice a week.

In another quasi-experimental study by Huen et al. (2016), through the implementation of a digital game-based program focused on improving the mental health of young people, the results suggested that a higher degree of participation in the program activities facilitated users' achievement in the learning constructs in most modules and, in turn, improved their psychological well-being after controlling for users' initial psychological well-being.

Despite significant progress in the field, there is a pressing need to continue experimental research on innovative interventions for child and adolescent mental health care (Dekkers et al., 2024). Given the increasing prevalence of mental health problems in these life stages and the potential positive impact of technologies, there is a clear urgency in research to better understand how technological interventions can promote wellbeing and mental health in this group (Lehtimaki et al., 2021).

In addition, it is crucial to continue to advance experimental interventions focused on promoting wellbeing and mental health, especially in the child and adolescent population, that not only address existing mental health problems, but also promote wellbeing from an early age (Lehtimaki et al., 2021).

This study aims to systematically review, synthesize, and critically analyze experimental studies that assess the impact of technological interventions on well-being among children and adolescents. It addresses a significant gap in current literature by focusing on experimental research evaluating technological interventions designed to improve well-being in this age group. Previous systematic reviews have predominantly examined interventions targeting adults and have often neglected to comprehensively assess the effectiveness of these interventions through rigorous experimental designs.

Existing reviews of technology-based interventions for children and adolescents often lack a clear focus on well-being or restrict their scope to specific technologies, such as mobile apps. For example, Chen et al. (2023) conducted a systematic review and meta-analysis on digital technology interventions for promoting mental health in children and adolescents, addressing depression, anxiety, and social-emotional competencies but not well-being exclusively. Similarly, Conley et al. (2022) demonstrated the positive impact of mobile app-based interventions on youth well-being but limited their analysis to a single type of technology.

Other reviews, such as Lou et al. (2024) and Fu (2024), have explored interventions targeting adolescents' well-being in general but have not focused on technology-based approaches. Lou et al. (2024) offered insights into various types of interventions but excluded digital tools, while Fu (2024) concentrated on positive psychology interventions in educational contexts, highlighting resilience and positive emotions but with narrow evidence base derived from a single database.

In contrast, this review focuses exclusively on randomized controlled trials and quasi-experimental studies with control and experimental groups. Through systematic review and synthesis of this evidence, our goal is to provide a comprehensive understanding of how technological interventions can effectively promote well-being in children and adolescents. This approach not only fills a critical gap in the literature but also supports the development of evidence-based practices tailored to the unique developmental needs of younger populations.

Method

Systematic review and meta-analysis based on PRISMA guidelines, including studies in English and Spanish published between 2013 and 2023. This methodological decision is related to the remarkable growth in the use of digital health technologies. This period reflects significant and recent advances in the accessibility and effectiveness of technological interventions, driven by the expansion of access to portable devices (Bond et al., 2023; Giasanti, 2023).

Search Strategy

Searches were conducted in four databases (ie, PubMed, PsycInfo, Scopus, and Web of Science). The following search strategy was used: [Wellbeing OR "Well-being" OR "Life Satisfaction" OR Happiness OR Flourishing OR Eudaimonia OR Hedonic] AND [technology or technologies or simulation or virtual or digital or Internet or web or computer or app or online OR mHealth OR immersive reality OR videogame OR chatbot] AND [Promote OR Intervention OR program OR strategy OR promotion OR prevention] AND [Child* OR Youth OR Adolesc* OR Young OR Teen* NOT Universit* NOT Adult NOT Childbirth].

The protocol of the present review is registered in the PROSPERO platform (ID CRD42023397324).

Inclusion and Exclusion Criteria

Published articles were included if they met the following criteria: (1) quasi-experimental or randomized controlled trials using technologies (such as apps, video games, virtual reality, chatbot); (2) interventions aimed at promoting well-being as a primary outcome, including at least one relevant quantitative measure of well-being (e.g., subjective, psychological, social well-being, flourishing or happiness); (3) interventions focus in child and adolescent population; (4) articles in English and Spanish, published in peer-reviewed journals.

Exclusion criteria were (1) interventions not focused on promoting well-being; (2) research protocols; (3) interventions focused on mental health treatment; (4) interventions focused on adult population; (5) interventions not using technology; (6) articles focused on measuring well-being; (7) studies that did not include a control group; and (8) articles that did not include pre- and post intervention measurement.

Study Selection and Data Extraction

Two independent reviewers assessed eligibility, extracted data, and evaluated methodological quality. Duplicate records were removed with Endnote®, and articles were screened for inclusion using the Rayyan tool (Valizadeh et al., 2022). Two reviewers (MER-R and PV) independently screened articles, with a third reviewer (JA) resolving discrepancies and confirming final selections. Eligibility was assessed in two stages: first by title and abstract, then by full text, with reasons for exclusion documented.

Data extraction was performed by MER-R and PV using a standardized table, reviewed by JA. Extracted information included study design, sample size, technology type, intervention details, theoretical model of well-being, instruments, and outcomes. When effect size data were incomplete, principal investigators were contacted for additional details.

To ensure consistency, inter-rater reliability was calculated using Cohen's κ. Agreement was medium to high, with $\kappa = 0.78$ ($SE = 0.17$) for selection and coding, $\kappa = 0.75$ ($SE = 0.23$) for data extraction, and $\kappa = 0.74$ ($SE = 0.11$) for risk of bias assessment.

Quality and Risk-of-Bias Assessment

Two investigators (MER-R and PV) independently evaluated the risk of bias (ROB) for each study. For randomized controlled trials, the Cochrane ROB-2 tool was used to assess five quality criteria: randomization, deviations from intended interventions, missing outcome data, outcome measurement, and selective reporting, classifying each as high, some concerns, or low risk (Higgins et al., 2011). Non-randomized studies were assessed using the ROBINS-I tool, evaluating seven domains: confounding, selection bias, information bias, deviations from intended interventions, missing data, measurement bias, and selective reporting, with classifications of low, moderate, serious, or critical risk.

Discrepancies were resolved by discussion and consensus among the authors. ROB results for randomized trials are summarized in Figure 2 and Figure 3, both visualized using the robvis tool (McGuinness & Higgins, 2020).

Statistical Analysis

The meta-analysis was conducted using the *dmetar* and *meta* packages in R Studio (Harrer et al., 2021), employing a random-effects model with inverse-variance weighting. This method accounts for both within-study sampling error and between-study heterogeneity, providing a generalized effect size applicable across diverse populations. Prediction intervals were calculated to estimate the range of likely effects in future studies, offering a practical interpretation of variability across interventions (Al Amer & Lin, 2021). A wider prediction interval compared to the confidence interval indicates greater heterogeneity.

For studies with multiple well-being measures, a combined effect size was calculated following Pigott and Polanin's (2020) approach for complex data structures. This synthetic effect size was included in the meta-analysis. Outliers were identified based on data distribution (Lipsey & Wilson, 2001), with Iyer et al. (2021) exceeding two standard deviations from the pooled effect size. Windsorization was applied to mitigate this outlier's influence by replacing its value with the next highest non-outlying value (Belham, 2022), preserving data integrity and reducing bias (Badr & Krebs, 2013).

Subgroup analyses explored differences in effect sizes by type of technological intervention. Sensitivity analyses were performed by including and excluding the identified outlier and the quasi-experimental study to assess robustness.

Publication Bias Analysis

Finally, statistical procedures were applied to quantify the effect of publication bias, including the use of a funnel plot as a visual diagnostic tool to assess symmetry in the distribution of effect sizes (Godavitarne et al., 2018), the Duval and Tweedie's trim-and-fill analysis, and the Egger´s regression test (Shi et al., 2019; van Enst et al., 2014).

Duval and Tweedie's Trim and Fill

Statistical analyses were conducted to assess publication bias, using Duval & Tweedie's trim-and-fill technique to identify possible discrepancies in effect sizes attributable to bias (Shi et al., 2019). This technique adjusts the effect sizes to approximate normality in the error distribution, thereby providing a more precise estimate of the unbiased effect (Pigott & Polanin, 2020).

Egger's Regression Test

This test evaluates the asymmetry in the funnel plot by regressing the standardized effect size against the standard error of each study (Egger et al., 1997). In this analysis, the intercept (B0) of the regression is used as an indicator of publication bias; an intercept significantly different from zero suggests the presence of publication bias (Lin & Chu, 2018). We calculated 95% confidence intervals and unilateral and bilateral *p*-values to assess the statistical significance of the intercept.

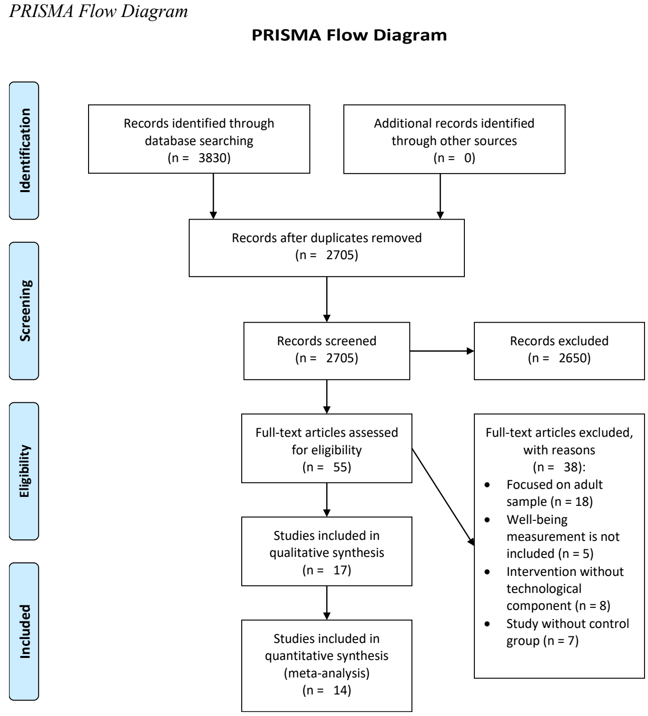
Results

Output of Searches

As shown in Figure 1, a total of 3830 articles were identified in the various databases, and after removing duplicates (n = 1125), 2705 were screened by title and abstract. Below, 55 articles were analyzed in full text, with 17 articles included in the qualitative synthesis and 14 in the quantitative synthesis.

Figure 1

PRISMA Flow Diagram



Study Characteristics

The characteristics of the included studies are presented as Appendix A. A total of 16 randomized control trials and one quasi-experimental study (Bono et al., 2020) were included, showcasing a diversity of technology-based interventions. This included the use of apps (n = 7), Web-based intervention (n = 7), digital intervention

($n = 1$), and chatbot ($n = 1$), where one study used a multicomponent intervention (web-based intervention and app).

The duration and length of the interventions varied considerably, ranging from single sessions of one-hour total duration (O'Dea et al., 2020; Osborn et al., 2020) to programs of six weeks or more (Burckhardt et al., 2015; Lester & Vranceanu, 2021; Manicavasagar et al., 2014), with some extending up to a maximum of 22 weeks (Haug et al., 2021).

Most of the studies were conducted in Europe ($n = 5$), Australia ($n = 4$), and North America ($n = 4$). The remaining studies were conducted in Turkey ($n = 1$), Brazil ($n = 1$), China ($n = 1$), and Kenya ($n = 1$).

The majority of the participants were female, with proportions ranging from 41% to 86.5%. The mean age of the participants ranged from 12.6 to 19.9 years. Well-being in the studies was measured by different scales, the most commonly used being the Student Life Satisfaction Scale (SLSS) and The Short Warwick-Edinburgh Mental Well-Being Scale (SWEMWBS).

The majority of studies was focused on the theoretical models on the promotion of subjective well-being ($n = 9$), psychological well-being ($n = 6$), wellness ($n = 2$), social well-being ($n = 1$). Three studies did not specify their theoretical approach. Of the total number of studies, four included the measurement of more than one type of theoretical model of well-being (Burckhardt et al., 2015; Hides et al., 2019; Osborn et al., 2020; Sun et al., 2022).

Most of the articles focused solely on the personal dimension ($n = 13$). Only two studies (Hämäläinen et al., 2023; Hides et al., 2019) focused on more than one dimension (e.g., personal well-being plus social or school well-being). One study (Belhan Çelik et al., 2022) did not specify the dimensions of well-being addressed.

Risk of Bias of the Included Randomized Control Trials Studies

As illustrated in Figure 1 and Figure 2, the majority of studies included in this review were assessed as having either a low overall risk of bias (ROB) or some concerns regarding their methodological quality. However, three studies exhibited an overall high ROB (Kenny et al., 2020; Lester & Vranceanu, 2021; Sun et al., 2022).

Specifically, upon examination of various bias assessment domains, one study (Lester & Vranceanu, 2021) demonstrated a high ROB pertaining to the randomization process and also in relation to missing outcome data. Additionally, three studies (Kenny et al., 2020; Lester & Vranceanu, 2021; Sun et al., 2022) exhibited a high ROB in the selection of the reported outcome.

Risk of Bias of the Included Quasi-Experimental Study

The risk of bias assessment for the quasi-experimental study by Bono et al. (2020), using the ROBINS-I tool, indicated a low risk of bias in the classification of interventions, deviations from intended interventions, and selective reporting domains. In contrast, a moderate risk of bias was identified in the confounding, selection of participants, missing data, and measurement of outcomes domains. Consequently, the study received an overall rating of moderate risk of bias.

Figure 2

Risk of Bias Graph for Each Bias Item Across Included Randomized Controlled Trials

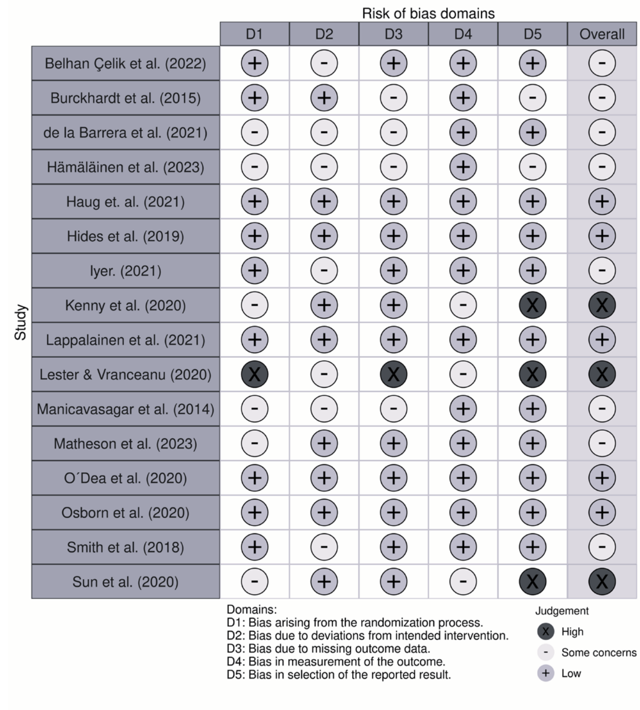
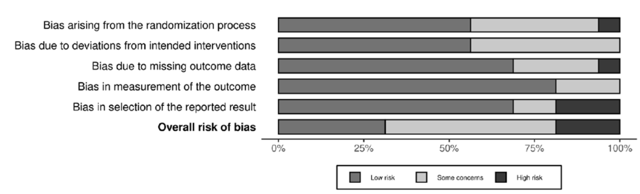


Figure 3

Risk of Bias Graph for Each Risk-of-Bias Item as Percentages Across Randomized Controlled Trials

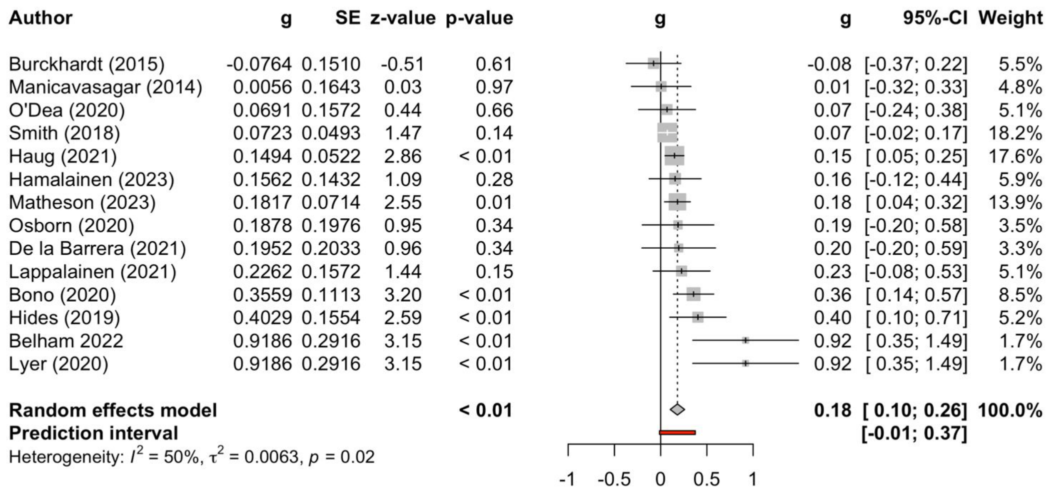


Study and Quantitative Synthesis Outcomes: Meta-Analysis

Although 17 studies were initially included in the qualitative synthesis, three of them (Kenny et al., 2020; Lester & Vranceanu, 2021; Sun et al., 2022) did not provide the necessary data for inclusion in the meta-analysis, despite attempts to contact the authors. As a result, a total of 14 studies were included in the meta-analysis, with a total sample of 5636 participants. As shown in Figure 4, the technology-based interventions demonstrated a pooled effect size of Hedges's $g = 0.18$, with a 95% confidence interval (CI) ranging from 0.10 to 0.26 ($p < .01$), indicating a small but statistically significant positive effect. The prediction interval for this analysis, spanning from -0.01 to 0.37, suggests that future studies may yield a range of effects, including the possibility of null or small positive effects. This indicates that while some studies might observe positive effects, the variability implies that others might see minimal or even no effect, highlighting the mixed effectiveness of these interventions across different settings and populations.

Figure 4

Forest Plot Comparison of the Effect on Well-Being



Specifically, a significant and positive effect of technological interventions in promoting well-being was observed in six out of the 14 included studies (Belhan et al., 2022, Haug et al., 2021, Bono et al., 2020; Hides et al., 2019, Iyer et al., 2021, Matheson et al., 2023). The study with the largest effect size was conducted by Iyer et al. (2021), which specifically used the Relaxation App (HeartBot), focused on reducing stress and promoting emotional well-being.

Furthermore, although eight out of the 14 studies included in the analysis showed a positive effect in the experimental group, these did not have statistical significance ($p > .05$).

Subgroup Analysis

Subgroup analysis revealed differential effects according to the type of technological intervention, divided into three categories: app-based interventions, web-based interventions and "Other interventions" (i.e. multicomponent and chatbot interventions).

As shown in the Figure 5, for app-based interventions, the pooled effect size was Hedges's $g = 0.33$, with a 95% confidence interval (CI) ranging from 0.15 to 0.51 ($z = 3.21$, $p = .001$), indicating a statistically significant positive effect. The prediction interval for this subgroup, spanning from 0.26 to 0.32, suggests that future studies are likely to yield positive effects within this range.

In contrast, the "Other interventions" subgroup yielded a pooled effect size of Hedges's $g = 0.50$, with a 95% CI from -0.12 to 1.21 ($z = 1.37$, $p = .171$), which was not statistically significant. The prediction interval for the "Other interventions" subgroup, -0.21 to 0.37, reflects a broad range of potential outcomes, indicating variability in expected effects.

For web-based interventions, the pooled effect size was Hedges's $g = 0.11$, with a 95% CI of 0.04 to 0.17 ($z = 3.30$, $p = .001$), signifying a statistically significant positive effect. However, the prediction interval for this subgroup was wider, from -0.12 to 0.37, suggesting that while the overall effect is positive, future studies may show considerable variability.

The overall analysis, combining all subgroups, yielded an effect size of Hedges's $g = 0.18$, with a 95% CI of -0.01 to 0.37, indicating a broad prediction interval and underscoring substantial heterogeneity across intervention types.

In summary, significant positive effects were observed for both app-based and web-based interventions, with the strongest effect observed in the app-based subgroup. However, the "Other interventions" subgroup did not reach statistical significance, and the wide prediction intervals across subgroups suggest that future study outcomes may vary considerably.

Sensitive Analysis

Due to the detection of an outlier (Iyer et al., 2021) contributing to statistical heterogeneity, a sensitivity analysis was performed including this study. As shown in Figure 6, the meta-analysis without the outlier study continued to show a positive and statistically significant effect in promoting well-being (Hedges's $g = 0.16$; 95% CI [0.09, 0.23]; $p < .01$) compared to the control group, although the effect size was slightly reduced compared to the initial analysis. Additionally, the prediction interval, spanning from 0.02 to 0.31, suggests that future studies are likely to yield positive effects within this range.

Finally, since the study by Bono et al. (2020) is a quasi-experimental study, a sensitivity analysis was performed excluding this study. As shown in Figure 7, the meta-analysis without the outlier study continued to show a positive and statistically significant effect in promoting well-being (Hedges's $g = 0.15$; 95% CI [0.09, 0.22]; $p < .001$) compared to the control group. The prediction interval, ranging from 0.03 to 0.27, suggests that future studies are likely to yield positive effects within this range.

Figure 5

Forest Plot Comparison of the Effect on Well-Being, According to the Type of Technological Intervention

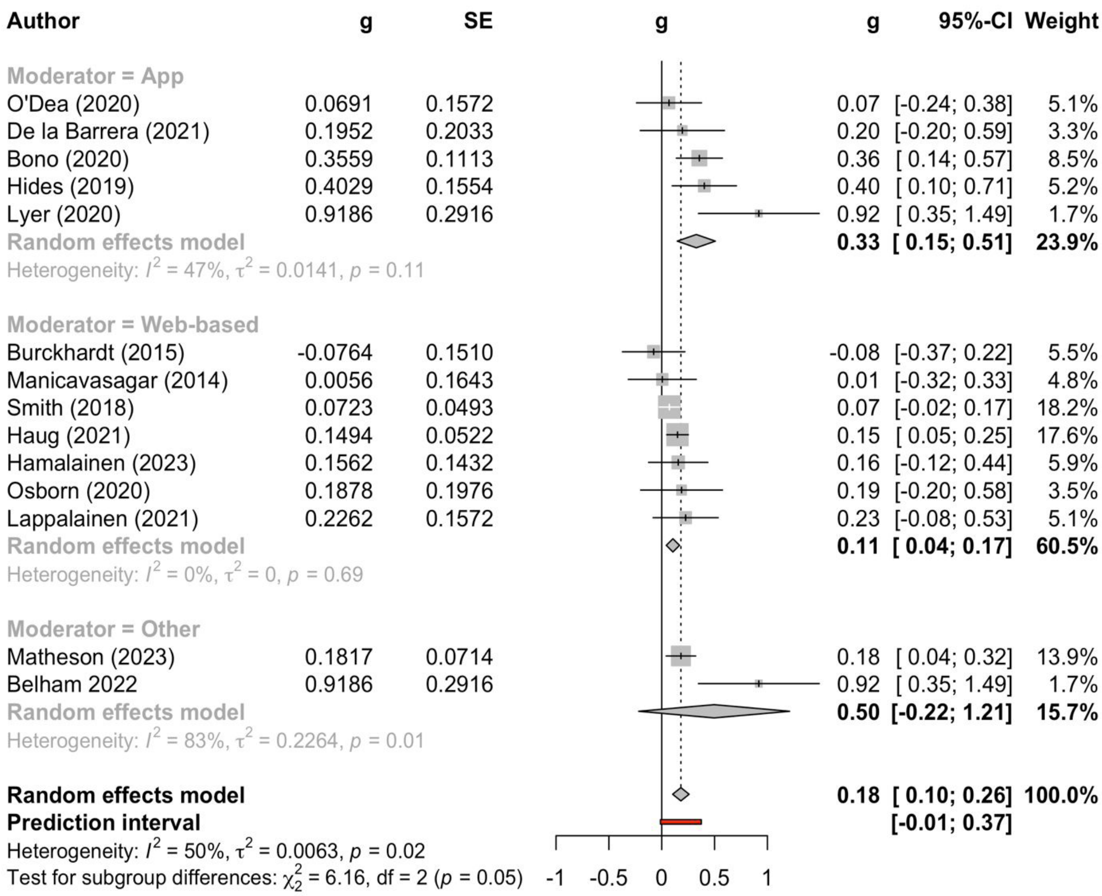


Figure 6

Forest Plot Comparison of the Effect on Well-Being, Excluding the Outlier Study (Iyer et al., 2021)

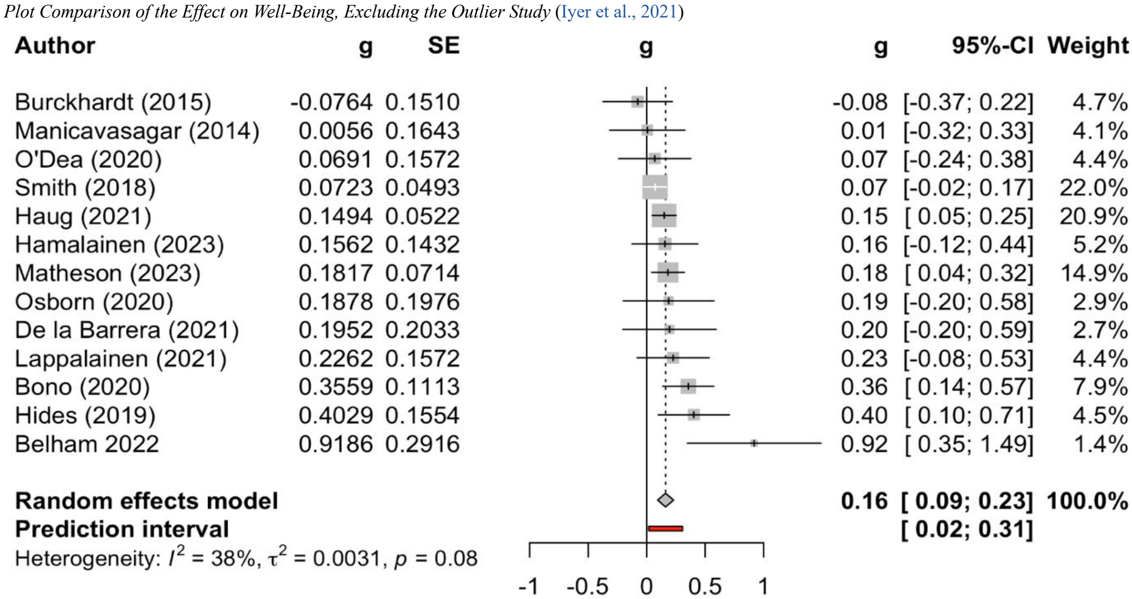
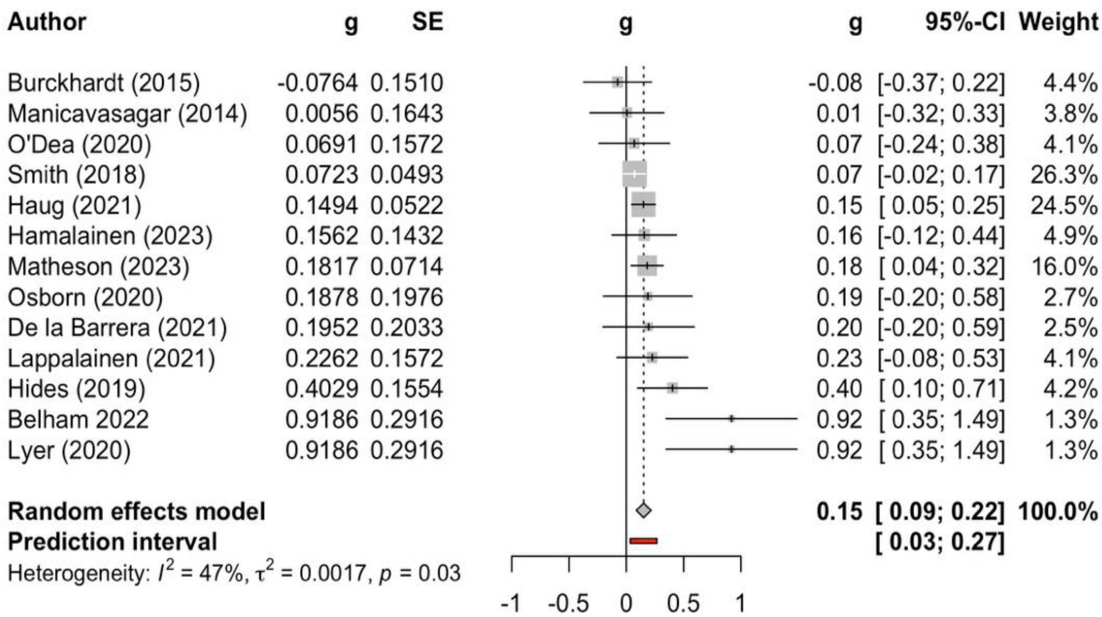


Figure 7
Forest Plot Comparison of the Effect on Well-Being, Excluding the Quasi-Experimental Study (Bono et al., 2020)



Publication Bias Analysis

Duval and Tweedie's Trim and Fill

The results indicate no significant differences in effect sizes due to bias. Using Trim and Fill, the point estimate of the pooled studies did not vary substantially between the original and adjusted estimate, according to the random-effects model (in both cases, Hedges´s g = 0.17; 95% CI [0.08, 0.27]).

Egger´s Regression Test

In the present meta-analysis, the intercept (B0) is 1.31, 95% confidence interval (-0.09, 2.73), with $t = 2.03$, $df = 12$. The 1-tailed p-value (recommended) is 0.032, and the 2-tailed p-value is 0.065.

Since the intercept is significantly different from zero (particularly with the 1-tailed p-value), Egger's test suggests that there may be publication bias in the study. This implies that studies with smaller or non-significant effects might be underrepresented, potentially inflating the overall effect size in the meta-analysis.

Funnel Plot

The funnel plot (Figure 8) reveals some asymmetry to the right, suggesting potential publication bias due to the possible absence of studies with negative or nonsignificant effects. This interpretation aligns with Egger's regression test results (p = .033). However, the use of the trim-and-fill method of Duval and Tweedie did not indicate a substantial difference in the estimated effect, suggesting that, although there is evidence of bias, its impact on the overall effect is limited.

Discussion

The findings of this systematic review and meta-analysis suggest that technological interventions have significant potential to positively influence the development and mental health of the child and adolescent population. The rigorous experimental studies reviewed provide strong evidence in this regard, supporting that technological interventions may be effective tools for promoting well-being in this population.

Regarding the meta-analysis, positive and significant results were observed for the technological interventions, although with a small effect size. These findings are consistent with other systematic reviews and meta-analyses on interventions for the promotion of well-being of children and adolescents (Lam & Lam, 2023) and in adults (Lim et al., 2023), although they did not focus specifically on the use of technology.

The results of the meta-analysis reveal important differences in effectiveness depending on the type of technological intervention. Specifically, app-based interventions showed a significantly greater positive effect (Hedges' g = 0.33) compared to other types of technology, such as web-based interventions. This finding suggests that apps, due to their accessibility and ease of use, may be particularly beneficial in promoting well-being among children and adolescents (de la Barrera et al., 2021). This result aligns with the findings of Conley et al. (2022), who demonstrated significant benefits of mobile applications for youth (g = 0.27), but across a variety of psychosocial outcomes, including distress, symptoms of psychological disorders, psychosocial strategies and skills, and health-related symptoms and behaviors of youth.

The meta-analysis also demonstrated a notable range in prediction intervals depending on the type of technological intervention. Specifically, mobile app-based interventions yielded a prediction interval from 0.26 to 0.32, indicating a high likelihood of positive effects in future studies within this range. In contrast, web-based interventions presented a wider prediction interval, from -0.12 to 0.37, and for the overall effect across intervention types, the prediction interval spanned -0.01 to 0.37. This wide range suggests a strong influence of contextual factors, such as intervention design and participant characteristics, on efficacy. It also emphasizes the need for additional research to identify the conditions under which these interventions are most effective.

Our findings highlight the feasibility to develop effective technological interventions for the promotion of well-being of children and adolescents. These interventions are not only effective, but also complement previous interventions in the area (Chuecas et al., 2022). The ability to generate change in the promotion of well-being with technological tools adds to developments in the study of well-being (Cunsolo, 2017; Kuosmanen et al., 2019) and its determinants, as well as in the promotion of well-being (Chuecas et al., 2022).

The reviewed technological interventions encompass a broad spectrum, including apps, chatbots, digital interventions, and web-based programs. However, the absence of experimental studies employing immersive intervention, such as virtual and extended reality, is notable, despite extensive research in adult populations (Xu et al., 2024). This gap is also reflected in the lack of experimental articles using serious games for wellbeing promotion, despite recent non-experimental studies in this field (De Jaegere et al., 2024). The identification of this gap in the literature points to an area of nascent experimental development in the child and adolescent population, which, while possessing significant potential for improving the effectiveness and accessibility of technological interventions in wellbeing promotion, poses limitations and implications related to the cost and time required for its development (Khan et al., 2024).

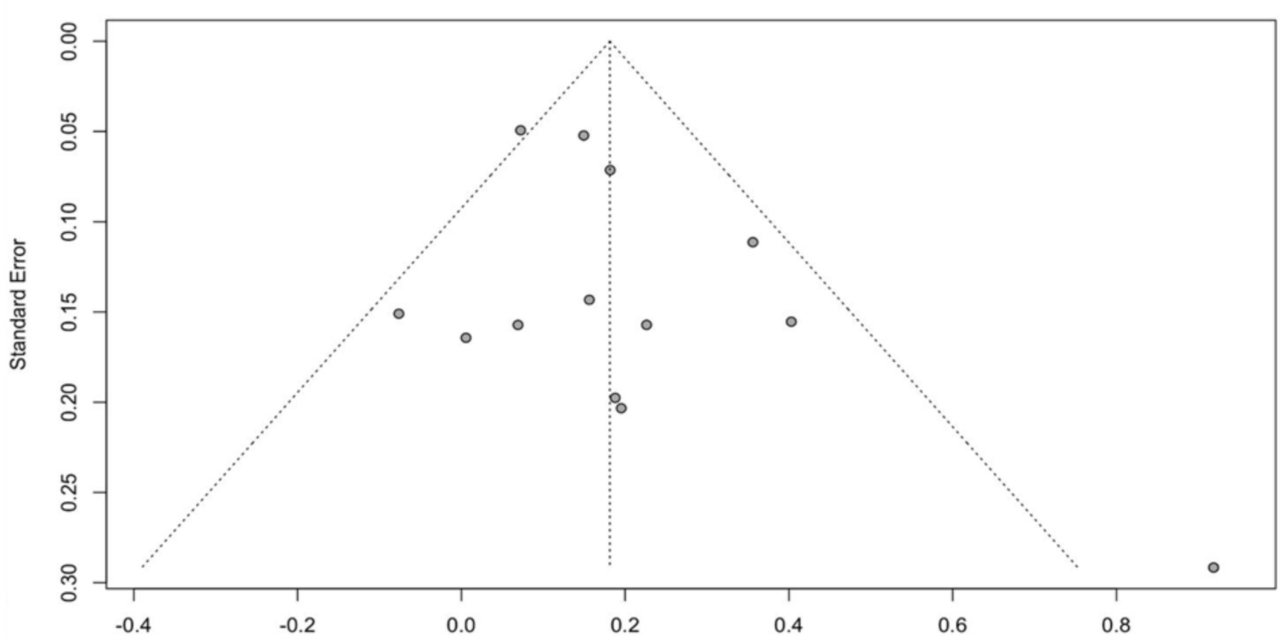
Technological developments hold immense value as integrated components in multidimensional interventions, generating resources that enhance these programs (Lappalainen et al., 2021; Smith et al., 2018). They are also valuable for the development of technological implementations that address various dimensions, levels or components, acting in a summative manner. In addition, they provide evidence that it is possible to develop technological resources capable of generating changes in relevant psychosocial dimensions, addressing social problems such as stigma, bullying, and school violence (Bevan Jones et al., 2020; Boydell et al., 2014; Chen et al., 2023). This line of work has many advantages, such as better cost-effectiveness indicators and the possibility of implementation in diverse countries and populations, including vulnerable contexts.

The ability of technological interventions to influence well-being, reported in this study, must be considered in the context of the general difficulty of generating significant effects on well-being, regardless of the medium used. This is consistently reflected in other systematic reviews and meta-analyses on interventions for promoting well-being of children and adolescents and adults (Lim et al., 2023) that do not use technology. In addition, this difficulty may be influenced by variables such as duration of interventions, age, gender, poverty levels, and psychosocial characteristics of children and adolescents, such as self-esteem, group and family relationships (Ruggeri et al., 2020). These variables are not only relevant as determinants of well-being, but also in its promotion, therefore, it is interesting to observe whether they also affect the effects of technological interventions (Räsänen et al., 2020).

In the same sense, in relation to the effect size of technological interventions, it is possible to discuss aspects of the characteristic of the well-being variable itself, related to its complexity and multidimensionality and its behavior of children and adolescents

Figure 8

Funnel Plot of Included Studies



that condition the possibility of change in well-being (z'Brien et al., 2016). The distribution of well-being is not normal and is often positively skewed due to life optimism, which may influence the evaluation of interventions (Cummins, 2010). Homeostasis theories of well-being propose that individuals tend to maintain a stable level of well-being, and any intervention may result in small, temporary changes within that homeostatic range.

On the other hand, given that most of the studies included in this review focused on promoting a single dimension of well-being, and due to the complexity and multidimensionality of well-being, it is of great relevance to develop and study implementations that address not only personal dimensions focused on the promotion of well-being but also include relational dimensions, such as parent-child bonds, peer relationships, school or community relationships, incorporating an ecological perspective that considers differentiated levels that act summatively in the promotion of well-being (Green et al., 2023).

This study has some limitations. First, we did not include gray literature, which can increase the risk of publication bias. In addition, we did not search for references of included studies or previous systematic reviews and meta-analyses on the subject, which could have expanded the number of studies analyzed. However, our statistical analysis, which includes the use of Duval and Tweedie's trim-and-fill method and Egger's regression test, suggests that although some publication bias may be present, it is highly unlikely that the absence of studies with non-significant effects would substantially impact our results. Future research should explore the gray literature and references of included studies to obtain a larger number of studies in the screening process.

Second, while we conducted a subgroup moderating analysis based on the type of intervention, the lack of detailed information in the reviewed studies hindered our ability to analyze others moderating and mediating variables, such as age, gender, digital literacy, and socioeconomic level. Future research should incorporate more complex measurements to account for these differential effects. As the number of publications in this emerging field increases, it will be possible to conduct subgroup analyses for each type of intervention.

Third, most of the included studies did not conduct follow-up assessments, which prevented the analysis of long-term well-being levels. Future studies should include follow-up assessments to evaluate the sustained impacts of interventions over time.

In conclusion, this systematic review and meta-analysis have demonstrated the significant potential of technological interventions to positively influence the well-being of children and adolescents. The rigorous experimental studies reviewed provide robust evidence supporting the effectiveness of these interventions in promoting well-being within this population.

Author Contributions

Matías E. Rodríguez-Rivas: Conceptualization, Methodology, Data curation, Formal analysis, Investigation, Validation, Writing – Original draft. **Sara Valdebenito:** Methodology, Data curation, Formal analysis, Software, Visualization, Writing – Original draft. **Mariavictoria Benavente:** Conceptualization, Methodology, Validation, Writing – Review and Editing. **Jaime Alfaro:** Conceptualization, Methodology, Validation, Writing – Review and Editing. **Paula Villacura:** Methodology. Data curation, Investigation, Validation. **Josefina Chuecas:** Validation, Writing – Original draft. **Loreto Ditzel:** Validation, Writing – Original draft. **Alejandra Galdames:** Validation, Writing – Original draft.

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Declaration of Interests

The authors declare that there is no conflict of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon request.

Supplementary Material

The appendix for this article is available online. Appendix A: Characteristics of selected studies (n = 17): https://osf.io/kwexh/?view_only=3961ddc05d47445fbfbab796d5764825

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