Nature connection and wellbeing in children and adolescents: A systematic review and meta-analysis

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Highlights

- This is the first meta-analysis to look at nature connection and wellbeing in children and young people.
- The meta-analysis looked at 12 studies with a total sample of 30,075 children and young people.
- We found a moderate significant effect (r = .31, 95% CI = .22-.41) for the relationship between nature connection and wellbeing in children and adolescents.

Abstract

Nature connection (also referred to as nature connectedness, connectedness to nature connection to nature, or nature relatedness) describes a positive relationship between humans and the natural world, with various benefits for both nature and humans. The latter include a small but robust positive correlation of nature connection with various types of wellbeing and flourishing. However, this correlation has been investigated meta-analytically in adults only; no meta-analysis to-date has investigated the relationship between nature connection and wellbeing in children and adolescents. This is the aim of the present study. We undertook searches through four databases (Google Scholar, ERIC, PsycInfo and Scopus). The criteria were (i) the mean age of participants is below 18, with no restrictions on sex or ethnicity and that they were drawn from the general population; (ii) that there were at least one explicit, non-dichotomised measure for nature connection and one for wellbeing and (iii) that there were adequate data reported so that we could record or compute the correlation coefficient between the main variables. Our systematic review identified twelve studies (k = 12) that fulfilled the criteria and could be included in the meta-analysis. The total sample (n = 30,075) included children and adolescents aged four to 18. An overall moderate significant effect was found (*r* = .31, 95% CI = .22-.41) for the relationship between nature connection and wellbeing in children and adolescents, which is comparable but slightly higher than the effect found in previous meta-analyses focused on adults.

Pre-registered: https://osf.io/msjg4

Keywords: nature connectedness, nature connection, wellbeing, children, young people, meta-analysis

1.1 Human-nature relationships

Human-nature relationships have long been of interest but have seen a relatively recent increase in focus (Chawla, 2020) as the climate crisis and rates of mental ill-health have worsened globally (Whelan et al., 2022). Concurrently, time spent outdoors and in nature has decreased, especially when it comes to children and adolescents (Soga & Gaston, 2016). Louv (2005) even suggested that children are experiencing 'nature deficit disorder.' This fictitious ailment was coined to express the idea that children are spending far less time outside than in previous generations at the expense of physical and emotional wellbeing. While the validity of Louv's conceptualisation of child-nature disconnection is contentious (e.g., because it excludes divergent perspectives; Dickinson, 2013), two assertions do receive empirical support: 1) time in nature and relationships with nature are associated with a range of benefits for humans, including children; and 2) over the last several decades, people seem to have been spending increasingly less time in nature, leading to an extinction of experience and an alienation, or disconnection, from nature (Barrable & Booth, 2022; Beery et al., 2023; Pyle, 1993; Soga & Gaston, 2016).

In addition to engaging critically with concepts related to nature (dis)connection, it is also necessary to acknowledge that definitions of the very concept of 'nature' differ widely depending on the study, time period, individual researcher, and academic discipline. While nature is sometimes used generally to refer to the universe or force of life, the term is also employed as a synonym to such words as wilderness and landscape or used to refer to elements of ecology (Ducarme & Couvet, 2020). Our aim with this metanalysis is not to arrive at a consensus regarding one definition of nature. Indeed, all the studies included here will likely have conceptualised nature differently, and some do not clarify how they define nature for the purposes of their studies at all; a similar challenge was noted by Ives et al. in their 2017 review of research on human-nature connection. Thus, it would be impossible to develop a definition of nature that accurately represents the heterogeneity across studies included in this metanalysis.

Nature connection encompasses the psychological relationship that humans have with non-human nature. This term is also referred to as nature relatedness (Nisbet et al., 2009), connection to nature, and nature connectedness. In describing the various conceptualisations of nature connection, most ecopsychologists draw upon Kellert and Wilson's (1993) influential biophilia hypothesis, which suggests that humans have an innate attraction or affiliation to nature (e.g., Nisbet et al., 2009; Tam, 2013). In line with this idea, connection to nature seems to capture the feeling of belonging to the wider natural world (Mayer & Frantz, 2004). Importantly, it is a subjective and multi-dimensional construct. Amongst its various conceptualisations, connection to nature seems to encapsulate the cognitive (e.g., mental representations of nature within one's perception of self; Schultz, 2002), emotional (e.g., feelings of belonging or closeness with nature; Mayer & Frantz, 2004), and experiential/behavioural (e.g., time spent physically among nature; Nisbet et al., 2009) aspects of human relationships with nature (Tam, 2013). Quite simply, these domains reflect how we think, feel, and act about/in the natural world.

There are many different measures for nature connection, which present slight divergence in relation to conceptualisation, dimensionality and predictive power (Tam, 2013). However, despite their differences, there are strong similarities between them and a common underlying construct that allows us to be able to integrate previous research findings, as in this meta-analysis (Tam, 2013; Tiscareno-Osorno et al., 2023). It should be noted that while more than twenty measures exist for use with adults, the number of measures appropriate for use with children and adolescents is relatively smaller (Tiscareno-Osorno et al., 2023).

Research from the last two decades suggests that nature connection is associated with a range of positive outcomes. For instance, nature connection is significantly associated with domains of wellbeing including vitality, life satisfaction, and positive affect, though the effect size is small (n = 8523, r = .19; Capaldi et al., 2015). Pritchard et al. (2020) undertook a meta-analysis of 20 samples (n = 4758) and found a similar effect size for the relationship of nature connection and eudaimonic well-being (r = .24). Another more recent meta-analysis of 47 papers and 430 effect sizes (n = 28,558) by Barragan-Jason et al. (2022) also found a positive correlation of similar magnitude (r = .22) between connectedness to nature and health and happiness. However, much of this work has been conducted in adults, with no meta-analysis having been undertaken on children.

1.2 Nature connection and childhood

Childhood is a formative period for the development of many relationships, and the relationship with nature is no exception. Children are often influenced by their parents' and guardians' nature connection (Barrable & Booth, 2020a; Passmore et al., 2021) and by spending greater amounts of time in nature in youth (Chawla, 2020). A body of research on 'significant life experiences' explores how experiences in nature during youth inform environmental identity later in life; three influential forces have been identified in this literature: time in nature as a child, role models who demonstrate care for the environment, and opportunities to care for nature (D'Amore & Chawla, 2020). Thus, the relationships that a child forms with nature during childhood can be encouraged through a variety of means and sustained through their entire lives.

However, while some people's relationships with nature are steadfast, for many, nature connection typically decreases across childhood, reaching a low point during adolescence (Hughes et al., 2019). Various factors are likely to influence this, including sex, age, location of the child's school, and screen time use (Chawla, 2020; Price et al., 2022).

Understanding the mechanisms which influence nature connection allow for the development of targeted interventions to address those children who are particularly susceptible to experiencing a decrease in nature connection in later childhood and early adolescence. Such interventions could include environmental education programmes, summer camps, and wildlife expeditions. However, existing interventions such as these have variable evidence to support them. Their effectiveness depends on factors like the length of the intervention, the type of activities involved, and the baseline nature connection of participants (Barrable & Booth, 2020b).

Nature connection is most often viewed as a relationship which brings about positive impacts and, therefore, something adults should encourage in children. However, increased knowledge about and feelings of closeness to the natural environment might also be associated with an increased likelihood to feel despair, grief, or fear (amongst other negative emotions) in response to the worsening climate crisis (Chawla, 2020; Pihkala, 2022). A recent paper by Larson et al. (2022) explicitly asked the question of whether we should endeavour to connect children to nature in the Anthropocene. The paper exposed the ethical dilemmas associated with the trade-off between the widely understood health and wellbeing benefits of contact with nature and the potential long-term psychological burdens of experiencing losses in the natural environment (e.g., ecological grief and solastalgia). This debate calls into question whether the relationship between nature connection and improved wellbeing is as straightforward as previously thought.

In the face of a worsening climate crisis, children are often positioned both as victims and as the most promising agents of action (Williams, McEwen & Quinn, 2017); however, encouraging children to undertake the work of repairing harm done to the environment will depend on their feelings towards nature and their desire to act pro-environmentally (Hahn, 2021). Connection to nature is often linked to pro-environmental behaviour in both adults

(Whitburn et al., 2020), and children (Mackay & Scmitt, 2019) Thus, fostering a connection to nature in childhood seems to be a fundamental step in the pursuit of a healthier planet in the future.

1.3 Wellbeing

Wellbeing has been an urgent area of concern in children and adolescents amidst reports of decreased wellbeing amongst this age range globally; this is particularly true following the Covid-19 pandemic and associated lockdowns, global conflicts, and the worsening climate crisis, amongst other widespread stressors (e.g., Bürgin et al., 2022; Kauhanen et al., 2023; UNICEF, 2021). Even very young children, such as those under seven years old, are suffering from mental health difficulties like anxiety and depression (Vasileva et al., 2020), contributing to poor wellbeing.

It has been recognised that wellbeing has been challenging to define (Dodge et al., 2012) and has shifted definitions across history. Not all positive psychological constructs are synonymous with wellbeing, though researchers sometimes conceptualise them as such. Often, wellbeing is considered through two domains: hedonic and eudaimonic. Hedonic wellbeing encompasses constructs related to pleasure and feeling well, and is sometimes referred to in terms of happiness. Eudaimonic wellbeing encapsulates a person's level of functioning, such as their perception that their life has meaning (Ryan & Deci, 2021). For our purposes, while we acknowledge that wellbeing can be conceptualised in different ways, we have opted to take a broad, wide-reaching perspective, using search terms like 'wellbeing' and 'happiness', with an aim towards encompassing as much wellbeing-related literature as possible.

1.4 Nature connection and wellbeing in children and adolescents

Previous literature, including a systematic review of mixed methods research by Arola et al., (2023) suggest that there is positive relationship between nature connection and wellbeing. While it is likely that an effect exists, this paper aims to assess the strength of this relationship by using meta-analytic techniques, and present a single summary estimate of the effect size, as well as assess issues such as publication bias (Buecker, Stricker & Schneider, 2023). Building on previous literature on the relationship between wellbeing and connection to nature in children in the present study, we present a meta-analysis of the relationship between wellbeing and connection to the natural world. Our main question is as follows: What is the relationship between nature connection and wellbeing in children and adolescents? We hypothesise that there will be a positive correlation between nature connection and wellbeing. Our secondary question, is: How are different manifestations of wellbeing (positive affect, life satisfaction, vitality, and subjective wellbeing) correlated with nature connection?

1. Methodology

The methodology for the systematic review and the meta-analysis was pre-registered on the Open Science Framework repository [anonymised PDF submitted]. The search and reporting of this review have followed the guidelines of PRISMA (Page et al., 2020), and the PRISMA 2020 Main Checklist as well as the PRISMA 2020 Abstract Checklist can be found in the supplementary materials.

2.1 Search strategy

The search strategy aimed for completeness. The studies that are included in the meta-analyses were located via the following multi-step process:

(i) Via databases: The electronic databases Google Scholar, Scopus, ERIC, and PsychNet were searched in February 2023. These chosen as they represent key databases in education (ERIC) and psychology (PsychNet), as well as general databases (Scopus and Google Scholar). The latter was also chosen for its access to unpublished and grey literature. The search terms used were the following:

Google Scholar (by default full text): ("nature connect*" OR "nature related*" AND children AND wellbeing OR happiness)

Scopus (by title, keyword, abstract): ("nature connect*" OR "nature related*" AND children AND wellbeing OR happiness)

PsycNet (by title, keyword, abstract): Two searches were conducted: i) (nature connection OR nature connectedness) AND children AND (wellbeing OR happiness) (ii) nature relatedness AND children AND (wellbeing OR happiness)

ERIC (by title, author, source, abstract and descriptor): ("nature connect*" OR "nature related*" AND children AND wellbeing)

(ii) Via other methods: We contacted authors of all studies found to request raw data of published studies that did not report the correlation between the two variables of interest, as well as any relevant studies that were not published. We also looked through the reference lists of recent reviews on nature connection in children (namely Barrable & Booth, 2020; Braus & Milligan-Toffler, 2018; and Chawla, 2020). Finally, we used Litmaps (accessed at https://www.litmaps.com) and Open Knowledge Maps (https://openknowledgemaps.org/), on BASE setting for additional articles. These are literature mapping tools that can help discover relevant papers in literature reviews.

Fourteen requests were sent to corresponding authors requesting any additional studies that have not been published, with nine of those authors responding. Additionally, three requests for raw data were sent out to corresponding authors of studies that did not report the correlation coefficient and had provided no link to raw data in supplementary materials, with two responses returning with data. The data were only usable in one instance. Raw data were additionally accessed through supplementary materials for three studies.

2.2 Study selection

Screening was undertaken sequentially, initially by AB and then by SF. Screening was initially conducted by title, then abstract and keywords. The third round of screening included full text manuscript. Any inconsistencies were resolved (i) by taking the records to the next stage of the review in the titles and abstracts screening stages, and (ii) through discussion between [removed for anonymisation] and [removed for anonymisation] at the full-text stage. During the discussion the two reviewers looked at the inclusion/exclusion criteria again and more closely, and considered how the study fit within or outwith them. No differences remained after discussion. During the screening and discussion processes, some of the records were excluded for more than one reason, as is reported in the final PRISMA flow diagram.

2.2.1 Inclusion criteria

The following criteria were set for inclusion of an individual study in the meta-analysis:

1. Participants: The mean age of the sample had to be below 18. No restrictions regarding sex or ethnicity. Participants had to be drawn from a general population sample, thus excluding studies where clinical populations have been used

2. Variables: i) At least one explicit, non-dichotomised (i.e., continuous) measure of nature connection. This measure could include self-report or other-report (e.g., parental report in the case of young children)

ii) At least one explicit, non-dichotomised (i.e., continuous) measure of wellbeing

3. Data reported: i) Studies needed to provide enough information for us to record or calculate a correlation coefficient between the main variables

ii) Studies reporting experimental designs were included only when a baseline correlation between the two main variables was reported or could be calculated

4. Publication type and date: No case studies or qualitative studies were included. Review studies were also excluded, and no date parameters were set

5. Publication language: Reports had to be written in English to be included

2.2.2 Exclusion criteria

We had to exclude studies for which the definition of wellbeing was too broad, or included constructs that may be highly correlated with wellbeing, such as self-esteem or competence, which do not fall within a more precise definition of wellbeing, as discussed in our introduction.

2.3 Data extraction

AB and SF performed the data extraction. These were stored on an ongoing basis in a shared Google Sheets where all collaborators could access. Any inconsistencies arising were resolved through discussion. The following data were extracted for each study, where available:

1) bibliographic details (reference)

2) measures used for nature connection and wellbeing

3) sample size

4) participants' age (ideally mean and range)

5) participants' sex

6) country in which the study was conducted

7) estimation of associations (ideally Pearson's r) and p-value, if reported. When not reported, raw data were requested or found in the supplementary data so that it could be calculated.

Missing values were not replaced.

2.4 Deviation from pre-registration protocol

Pre-registration was conducted to ensure unbiased data analysis. While the meta-analysis was pre-registered on 17th December 2022 on the Open Science Framework before the authors started to identify eligible studies for inclusion, the following deviations are reported:

1) The reasons for exclusion had to include definitions of wellbeing that were too broad; for example, self-esteem or hope, which describe psychological resources associated but not synonymous with wellbeing
2) We extracted both Pearson's *r and* the *p*-value (rather than 'or' as was written in the pre-registration by error).
3) An issue that was not considered during the pre-registration protocol, and which we encountered after the systematic review regarding the choice of instruments, were instances when more than two instruments for the same or similar construct were included in the original study. This occurred in several studies and was dealt with in two ways: for nature connection, the validity and reliability measures were examined, and the instrument with better psychometric properties was chosen, as for example in the case of Barrable et al., (2021) where both the one-item INS (Schultz, 2004), as well as the NCI (Richardson et al., 2019), were used, and where the NCI was chosen for inclusion in the meta-analysis due to higher reliability measures. For wellbeing, we used the instrument that had been used more often in other studies, in order to achieve a closest match of constructs and therefore homogeneity. For example, in the two cases of Pirchio et al. (2021) and Whitburn (2020), the instrument measuring Life Satisfaction (Huebner et al., 2012) was preferred, as it was used in another four studies included in the meta-analysis.
4) We used R to undertake the analysis instead of Jamovi.
5) We did not use the AI powered tool Rayaan for study selection.

6) In terms of data analysis, this followed the pre-registered protocol accurately, but more details (e.g., the type of adjustment used for calculating the overall effect size) and some extra analyses (namely the use of drapery plots and influential cases identification) are reported in the manuscript.

2.5 Statistical analysis

We used R (v. 4.2.1 for macOS) and RStudio (2022.07.1 Build 554; R Core Team 2022) for the statistical analysis, employing the “meta” (v. 5.5-0; Balduzzi et al., 2019), “metafor” (v. 3.4-0; Viechtbauer, 2010), “dmetar” (v.0.0.9000; Harrer et al., 2019), and “tidyverse” (v. 1.3.2; Wickham et al., 2019)), and "robvis" (v 0.3.0; McGuiness, 2019) packages.

MPP performed the analysis and AB assessed its reliability. The effect size was the correlation (Pearson’s *r*) between NC and wellbeing as extracted from the included studies. For the two studies where we had to calculate the *r*, [removed for anonymisation] undertook the analysis. For Barrable et al. (2021), using the pre-test data, KPT computed the sum of the 6 items of Nature Connection Index and the sum of the 5 positive affect items in PANAS (items #1, 3, 5, 7, and 9 in the original study). For Jackson et al. (2021), nature connectedness was measured with 6 items from the Nature Relatedness Scale, and wellbeing with the 4 items adapted from the WHO index. Participants in the study responded to these items twice, first with reference to the time before the COVID-19 pandemic and then the time during the pandemic. Pearson’s *r* correlation was calculated using the first set of responses.

The single-data-set effect sizes were then combined using a random effects model to provide a pooled effect size and a test (*t*) for the overall effect (with its corresponding *p*-value). Of note, *r* was transformed to Fisher’s *z* for this analysis (and then transformed back to *r*), because correlations have a restricted range which can introduce bias in the estimation of the standard error for studies with a small sample size (Alexander et al., 1989). A random-effects model rather than a fixed effects model was put forward given the variability in NC and wellbeing measures used. The Hartung-Knapp adjustment (Knapp & Hartung, 2003) was applied to calculate the confidence interval around the pooled effect, as it has been suggested to reduce the chance of false positives, especially when the number of studies is small, as is the case here (IntHout et al., 2014; Langan et al., 2019). The inverse variance method was used to calculate the weights of studies.

Moreover, we explored the presence of heterogeneity using the I^2 index (with 95% confidence intervals), the Q statistic, and the τ^2 statistic. The I^2 index is interpreted as the percentage of total variation across studies that is due to heterogeneity rather than chance. Higgins et al. (2003) suggest that levels of 25%, 50%, and 75% can be considered as low, moderate, and high, respectively. The Q statistic is used to ascertain whether the primary level effect sizes estimate a common population effect size. The τ^2 statistic is an estimate of the between-study variance as it represents the variance of the distribution of the true effect sizes. Tau-squared was estimated using the restricted maximum likelihood estimator (Viechtbauer, 2005). We also report prediction intervals, which represent the range into which we can expect the effects of future studies to fall based on present evidence.

As preregistered, because heterogeneity was found to be present, we conducted moderating variables analysis for the following pre-registered variables: mean age (meta-regression; only the eight studies that reported mean age were included in this analysis, while the four studies reporting only age-range were not included) and measure of wellbeing (comparing the Life Satisfaction scale with all other instruments, because to perform any moderating variables analysis on categorical moderators at least five data points per level of the moderator were needed, as pre-registered). We could not run moderating analyses on the other pre-registered variables (namely sex of the participants and measure of wellbeing), as not enough data points were available.

We also performed influential cases identification, by producing a Baujat plot, an overall influence diagnostic plot, and two leave-one-out meta-analysis plots (one sorted by effect size and the other by I^2) for each meta-analysis (see Harrer et al., (2021) for more details). The overall effect was recalculated using the Paule-Mandel method as the tau-squared estimator before the influential cases identification analysis was performed. We also tested for the presence of small study bias using Egger's *t* test, the Funnel plot, and the Trim-and-Fill method (Duval & Tweedie, 2000).

Forest plots as well as drapery plots are provided for visualisation of findings (Rücker & Schwarzer, 2021). Forest plots display confidence intervals using a fixed significance threshold ($p < 0.05$ in our case). Drapery plots, on the other hand, are based on *p*-value functions. In this case, what is plotted is a continuous curve, which depicts the confidence interval for varying values of *p*.

Although the PRISMA guidelines (Page et al., 2020) ask for a risk-of-bias-analysis, this analysis does not fit the context of this meta-analysis. Risk-of-bias analysis procedures have been developed to be used in meta-analyses of studies assessing an intervention (thus including elements like the blinding of participants and randomization) or an experimental manipulation (thus including elements like blinding of the experimenters), which is not our case. We did perform a quality assessment of studies, though. For this purpose, the following information was extracted by [removed for anonymisation]: (i) whether studies reported a power analysis to determine sample size, (ii) whether they provided information about the validity and reliability of their measures, (iii) whether they were preregistered, and (iv) whether they provided raw data in open access repositories.

3. Results

3.1 Systematic review

Figure 1 is a flow diagram of the search and selection process.

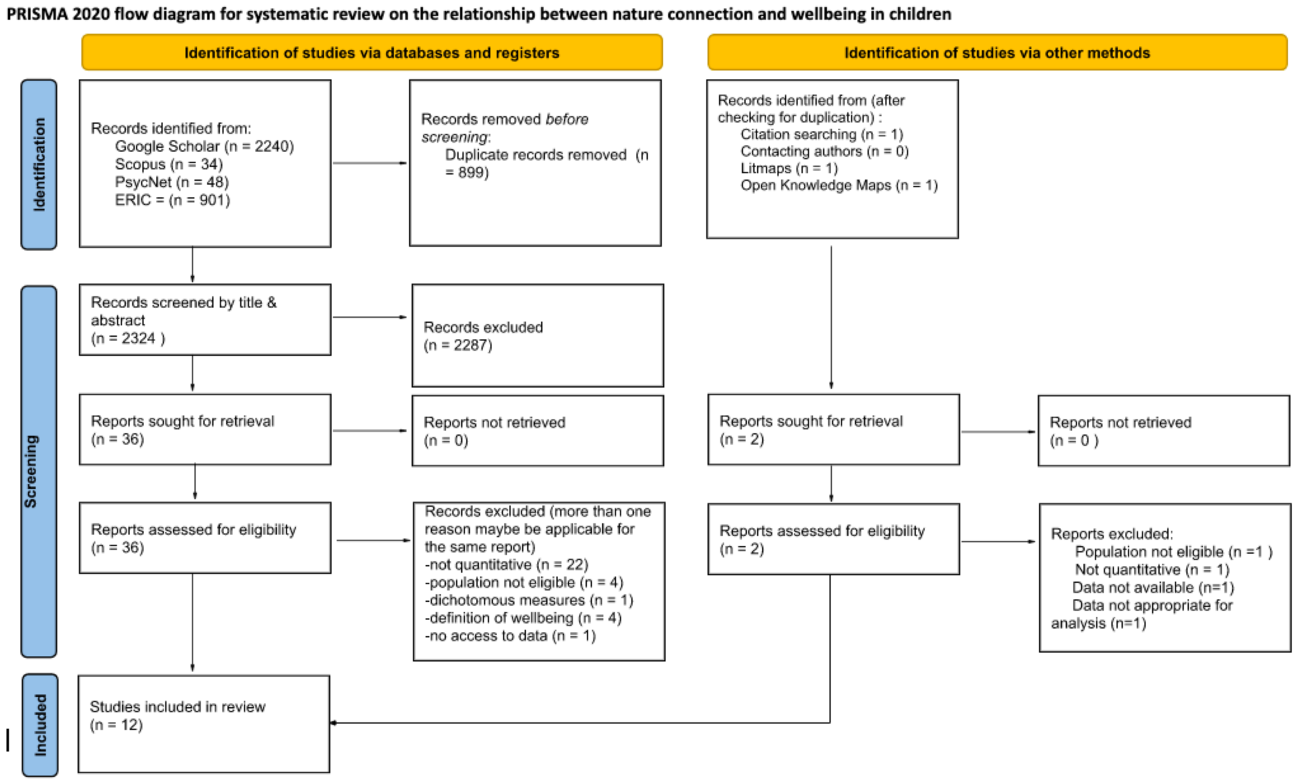

Figure 1: Flow diagram of the search and selection process, adapted from the PRISMA flow diagram (Page et al., 2021; editable file downloaded from http://prisma-statement.org/PRISMAStatement/FlowDiagram). Note: Some records were excluded for more than one reason

As of August 25, 2023, twelve studies that fulfilled the inclusion criteria, and which either reported a correlation or provided data with which we could compute it, were identified. One paper was authored by a member of our team (AB). General characteristics of the study can be seen in Table 1.

Table 1

Descriptive information for included studies

Number	Citation	N	Mean age (years)	Location
1	Barrable et al., 2021	74	9-10 years (mean age = 9.51 years)	Wales, UK
2	Barrera-Hernández et al., 2020	296	9-12 years (mean age = 10.42 years; SD = 1 year)	Mexico

3	Cui & Yang, 2022	458	9-10 years (mean age = 9.36 years; SD = .98 years)	China
4	Diržytė & Perminas, 2020	722	Mean age = 16.61 years (SD = 1.24 years)	Lithuania
5	Harvey et al., 2022	138	9-11 (mean age = 10 years, 7 months)	England, UK
6	Jackson et al., 2021	624	10-18 years (mean age = 13.85 years; SD = 2.54)	USA
7	Lycos, 2021	349	4-12 years	Australia
8	Pirchio et al., 2021	407	9-11 years	Italy
9	Richardson et al., 2015	775	10-11 years	England, UK
10	Uhlmann et al., 2022	46	11-17 years	Australia
11	Whitburn, 2020	324	7-13 years (mean age = 10.6 years; SD 1.42 years)	New Zealand
12	Whitten et al., 2018	26893	11 years	Australia

The total sample size over the twelve studies was n = 30,075, and not all studies provided sex disaggregated data. The range of ages in the study was 4-17 years of age and again not all studies presented mean age and corresponding standard deviation for their sample. The years of the studies ranged from 2018 to 2022. Studies were coded as published if they had been accessed from a peer-reviewed journal or book chapter, with nine studies being published and three unpublished (one was an undergraduate dissertation, Lycos, 2021; one a doctoral dissertation, Whitburn, 2020; and the third a report for the Royal Society for the Protection of Birds, Richardson et al., 2015). Five of the studies reported interventions (studies 1, 4, 7, 8 and 11), in which case we looked at the initial correlation reported, prior to the intervention, while the other seven studies reported cross-sectional data.

A variety of measures for nature connection were used across the studies, with one study (Barrable et al., 2021) using two separate measures. Similarly, ten different wellbeing measures were used. The measures that each study used can be seen in tables 2 and 3.

Table 2

Nature connectedness measures used in studies

Measure	Citation	Study number
Connectedness to nature scale (CNS)	Mayer & Frantz, 2004	8
Connection to nature index (CNI)	Cheng & Monroe, 2012	2, 4, 9
Inclusion of nature in self (INS)	Schultz, 2002	1, 5
Modified connection to nature index	Cheng & Monroe, 2012	3, 12
Modified nature relatedness scale - 6 item	Nisbet & Zelenski, 2013	6
Nature connection index (NCI)	Richardson et al., 2019	1
Nature relatedness scale – 6 item (NR-6)	Nisbet & Zelenski, 2013	10
Own (combination of elements from other measures)	Lycos, 2021	7
Own	Diržytė & Perminas, 2020	4
Own	Whitten et al., 2018	12
See Table 1 for studies associated with each study number		

Table 3

Wellbeing measures used in studies

Measure	Citation	Study number
Faces Scale	Andrews & Withey, 1976	3
Personal Wellbeing Index-School Children	Cummings & Lau, 2005	10
Positive affect, negative affect scale for children (PANAS-C)	Laurent et al., 1999	1
Student Life Satisfaction Scale (S-LSS)	Huebner, 1991	5, 9, 11
Subjective Happiness Scale (SHS)	Lyubomirsky and Lepper, 1999	2
The Flourishing Scale	Diener et al., 2009	4
Modified Student Life Satisfaction Scale (S-LSS)	Huebner, 1991	12
Modified World Health Organisation Five Wellbeing Index (WHO-5)	WHO, 1998	6
Own (combination of elements from other measures)	Lycos, 2021	7
World Health Organisation Five Wellbeing Index (WHO-5)	WHO, 1998	8
See Table 1 for studies associated with each study number		

In terms of the qualitative assessment, none of the studies reported a power analysis or were pre-registered, while seven of the 12 provided information about the validity and reliability of the measures used. Three of the studies had raw data available in open access repositories. For one of the studies (Whitten et al., 2018) the above were not applicable, as it was a secondary data analysis of an existing data set. Table 4 depicts all these elements.

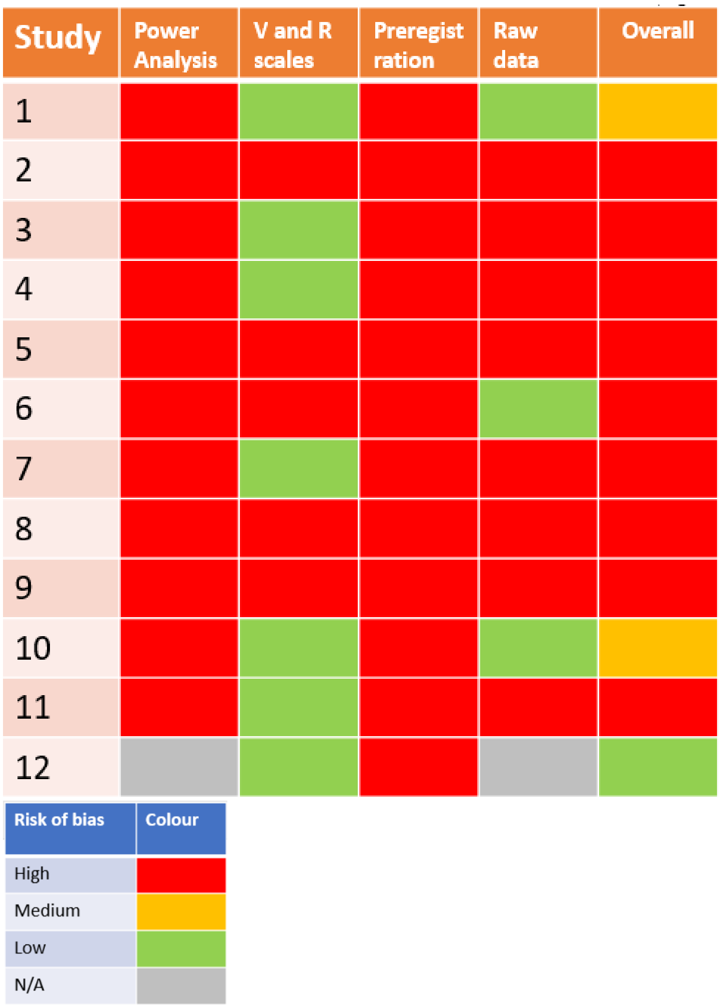

Table 4
Traffic light plot of the quality assessment of the studies as per the above criteria

3.2 Meta-analysis

Overall analysis. The pooled effect (k = 12, n = 30,075) was found to be small but significant, r = .31, 95% CI (.21, .40), t = 6.66, p =.001 (see forest plot, Fig. 3, and drapery plot, Fig. 4). This suggests that there is indeed a correlation between nature connection and wellbeing. Heterogeneity was present among the datasets, $Q(11) = 190.78$, $p < 0.001$, with high inconsistency between studies, $I^2 = 94.20\%$ [95 % CI: 91.60%; 96.00%]. The between-study heterogeneity variance was $\tau^2 = 0.02$ [95 % CI: 0.01; 0.07], suggesting a 95% prediction interval from -0.05 to 0.59. As the prediction interval of the between-study heterogeneity variance includes a correlation of zero, the findings must be treated with caution.

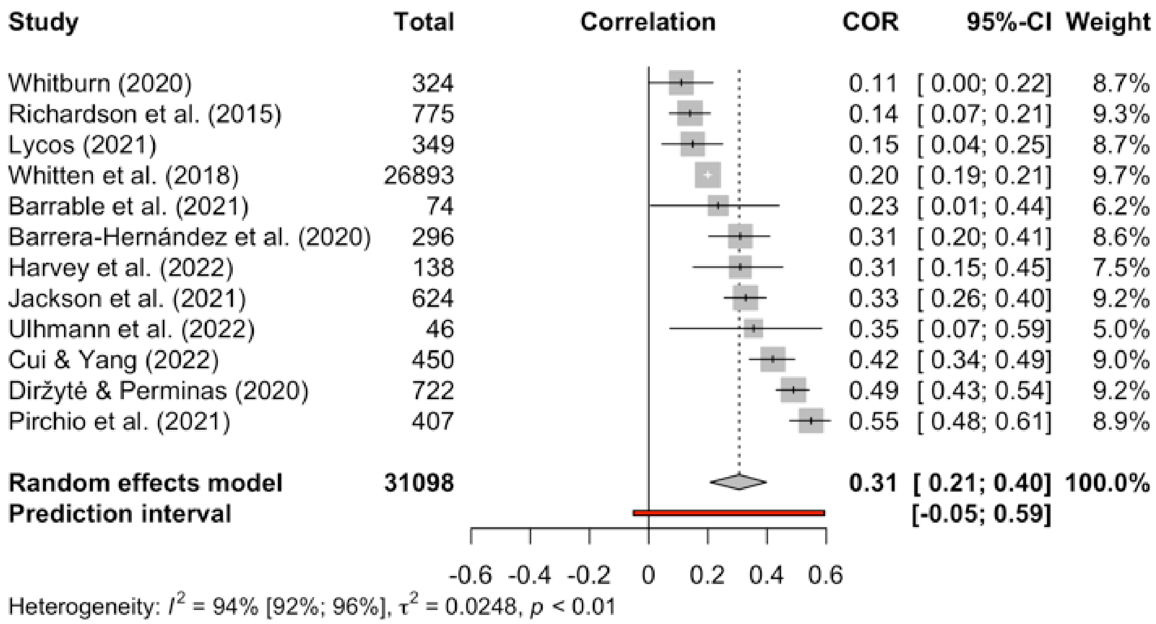

Figure 2.

Forest plot of random effect meta-analysis. In the plot the 95% confidence interval for each study is represented by a horizontal line and the point estimate is represented by a square. The confidence intervals for totals are represented by a diamond shape at the bottom of the plot

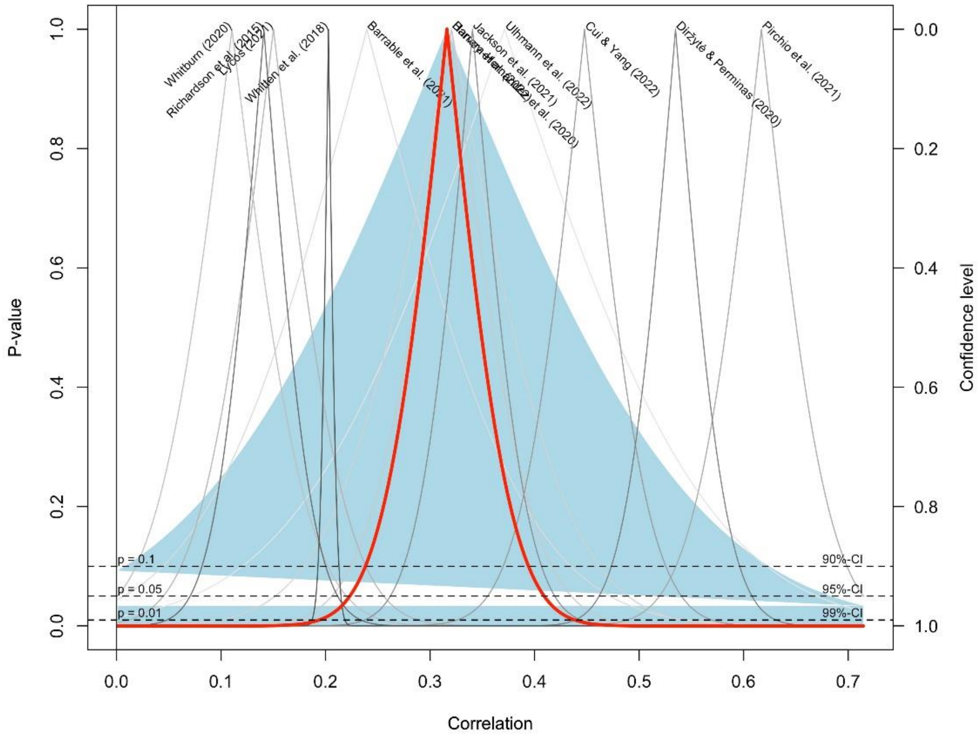

Figure 3

Drapery plot of random effect meta-analysis.

Small study bias. Neither the inspection of the funnel plot (Fig. 5) nor Egger's test (intercept = 2.55 [95% CI: -0.10; 5.20], t = 1.89, p = 0.09) suggested a small study bias. Five studies were added using the Trim-and-Fill method to make the funnel plot symmetrical, but again, the overall effect size remained significant (r = 0.20 [95 % CI: 0.09; 0.31], t = 3.65, p = 0.002).

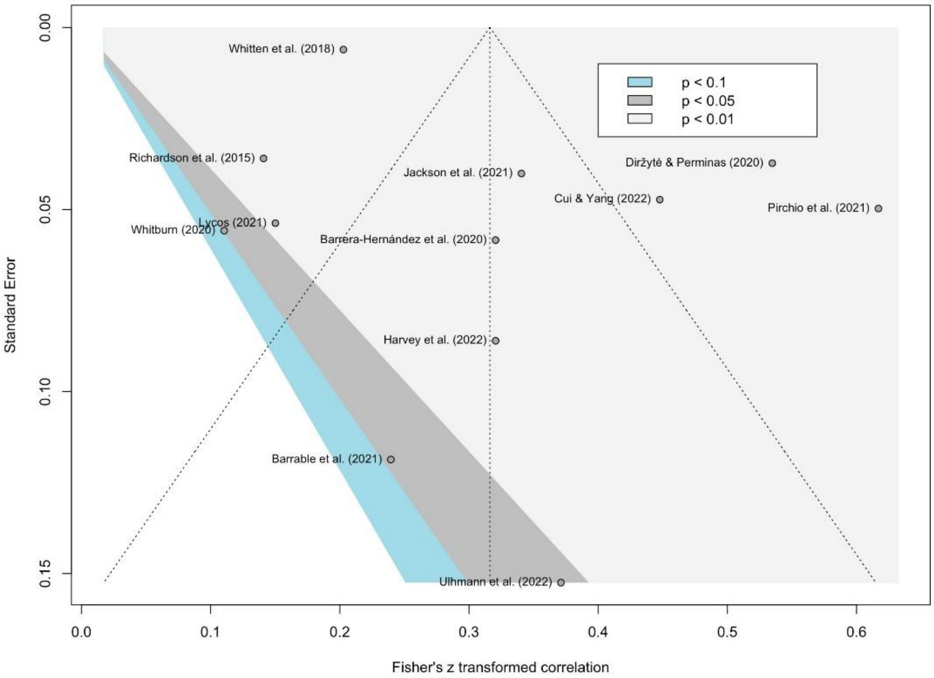

Figure 4

Funnel plot of standard error on Fisher's z transformed correlation

Sensitivity analysis. No influential studies appear influential in the Baujat plot (Suppl. Fig. 1), the two leave-one-out meta-analysis plots (Suppl. Fig. 2 & 3), as well as in the influence diagnostics plot (Suppl. Fig. 4).

Moderating variables analysis. No evidence of an effect of type of wellbeing measure, $Q(1) = 0.50$, $p = 0.48$, or mean age, $F(1,6) = 58.82$, $p = 0.16$, was found. There were not at least two levels with at least $k = 5$ studies for the nature connection measure, nor had enough studies broken down their data by sex, therefore these analyses were not conducted. No moderators were identified.

4. Discussion

Previous research has presented nature connection in children as a worthwhile goal for education and highlight the role of nature connection in supporting pro-environmental attitudes and behaviours (Barrable, 2019; Otto & Pensini, 2017). At the same time, there is an ongoing debate as to whether nature connection is warranted as a factor conducive to well-being or a trigger for despair and other psychological burdens (Chawla, 2020; Larson et al., 2021). A key to resolving this debate would be to examine the relationship between nature connection and wellbeing more closely and quantify it. While previous meta-analytic research has reported a positive association of nature connection and wellbeing in adults, this has not been the case for children.

Our analysis showed that the pooled effect in the 12 identified studies was small but significant ($r = .31$, $p = 0.001$). However, it is noteworthy that there was significant heterogeneity of the effect sizes between the reviewed studies, as indicated by the significant Cochran's Q and Higgins and Thompson's I^2 statistics ($p < 0.001$), as well as the inclusion of the value of 0 in the prediction interval based on the heterogeneity variance τ^2 test. Overall, we have obtained confirmatory evidence for the expected positive correlation between nature connection and wellbeing among children. This observation is in line with those observed in previous meta-analyses looking at nature connection and wellbeing among adults. However, this finding should be taken with caution as there was pronounced variability between studies.

Our moderator analysis did not reveal any evidence of the effect of wellbeing measurement instrument used or of participant age. However, it must be stressed that the number of studies included in the moderator variables analysis was very small therefore the power of this analysis to detect any relationship was very low. In other words, our analysis was not sensitive enough to detect potential moderating effects. Other variables with a possible moderating effect (e.g., nature connection measure type and country of origin of participants) could not be examined within the meta-analysis due to variable data from different studies (we had preregistered that to perform any moderating variables analysis on categorical moderators at least five data points per level of the moderator were needed) or due to insufficiently reported data (e.g., in the case of sex).

4.1 Knowledge gaps and directions for future research

A noticeable pattern in the existing pool of studies on the relationship between nature connection and well-being concerns the heterogeneity of measurement of nature connection across studies. We identified in total ten distinct measures of nature connectedness in the 12 studies reviewed. Therefore, this could be a possible cause for the heterogeneity found between studies. However, we could not test the effect of measurement of nature connection within our meta-analysis, precisely because the measures were so variable, as explained above. That said, there is a strong convergence of the various nature connection measures (Tam, 2013). A related issue is that the findings were not reported separately for the cognitive, affective, or behavioural dimensions of nature connection. These dimensions might have different associations with wellbeing outcomes, therefore exploring their unique relationship with wellbeing constitutes a valuable direction for future studies on both adults and children.

A similar issue can be identified for the measurement of wellbeing. Although an (underpowered) moderating analysis was possible within this meta-analysis, the studies did not report separate findings on the different types of wellbeing. Previous research, such as the meta-analysis by Pritchard et al. (2020) in adults, has shown that the nature connection-wellbeing relationship is likely to be dependent on the subdimensions of wellbeing. Future studies should consider directly testing this notion by including separate measures for the different types of wellbeing and comparing their associations with nature connection in children.

Another gap in the pool of reviewed studies is their heavy reliance on participants from WEIRD (Western, Educated, Industrialized, Rich, and Democratic) countries. As Table 1 shows, except for Barrera-Hernández et al. (2020) and Cui and Yang (2022), all studies assessed participants from Western countries. The English-speaking countries were particularly predominant, associated with eight of the studies. This trend is not surprising, as it has always been a characteristic of psychological and behavioural research (Henrich et al., 2010; Thalmayer et al., 2021). Notably, this issue was also observed in the previous meta-analyses regarding nature connection and wellbeing in adults. For example, in Pritchard et al. (2020), among the 34 samples from the 25 studies reviewed, only three were based on non-Western samples. Barragan-Jason et al. (2022) also concluded that most of studies included in their meta-analysis were strongly biased towards samples from industrialized countries. Without a wide geographical representation, it was not possible for us to test if the nature connection-wellbeing relationship presents differently in different cultural contexts.

Recent studies have revealed substantial variations across societies and cultures regarding how people perceive and respond to environmental issues (Tam & Chan, 2017; Tam & Milfont, 2020). Several recent studies have also revealed significant variations across countries in terms of levels of connection to nature (e.g., Kleespies & Dierkes, 2023; Richardson et al., 2022). We argue that there is an urgent need to expand the geographical representation of samples in research on nature connection and wellbeing, regardless of whether the target population is adult or child. Replications using non-Western populations, along with direct comparisons of samples from multiple countries, would allow researchers to acknowledge and understand contexts as one potential source of variation in the relationship between nature connection and wellbeing. With this perspective, researchers can build theories and develop new hypotheses for explaining some of the variation observed. These theories will advance from existing ones, understanding the nature connection-wellbeing relationship as a psychological process that is subject to not only intrapersonal mechanisms but also the influence of socio-cultural contexts (Tam & Milfont, 2020).

Addressing the aforementioned issue also requires a sensitivity to the pathways through which nature connection contributes to enhanced or improved wellbeing. One perspective in this regard is that nature connection motivates individuals to engage in behaviours that potentially generate pleasure or remove displeasure (thereby contributing to hedonic wellbeing) or promote satisfaction of psychological needs (thereby contributing to eudaimonic wellbeing; Capaldi et al., 2015; Pritchard et al., 2020). For example, nature connectedness may motivate individuals to spend more time in natural environments, which in itself is a stress-reducing and psychologically restorative experience (Moll et al., 2022) and, in turn, promotes hedonic wellbeing. Nature connection may also drive an individual to learn more about the natural world and ecosystems. The enhanced knowledge and skills, in turn, can promote self-motivated actions, such as protecting wildlife and caring for plants, thereby fulfilling the need for competence. The extent to which nature connection can promote well-being is unlikely to be universal, as it may vary depending on different socio-cultural contexts. For instance, access to natural environments may differ between urban and rural areas, and opportunities for engagement with wildlife are influenced by the levels of biodiversity in each country. Therefore, it should be anticipated that these behaviours may be more or less feasible depending on the specific context. Consequently, the relationship between connection and well-being is anticipated to be stronger in certain contexts compared to others.

4.2 Limitations

While we attempted to exhaustively include all existing datasets related to nature connection and wellbeing among children in our meta-analysis, we encountered multiple obstacles in the process. A broader conceptualisation of wellbeing, as well as a broader search strategy in relation to terminology associated with wellbeing could have yielded more results for inclusion in the meta-analysis. Moreover, we were not able to secure a response from all the corresponding authors of previous studies we contacted. Also, for the three specific requests for raw data we sent out (to corresponding authors of previous studies that either did not readily report the effect size of our interest or did not provide raw data in the paper), we received a response for two of them only; among these two responses only one of the datasets was eventually usable in our meta-analysis. Another limitation pertains to the quality of the studies, as reported above. Given the metrics that we used to assess quality, including open science practices like pre-registration and sharing of raw data, and good practice, like conducting a power-analysis to establish the sample size, none of the studies reached the threshold for high quality. The majority, though not all, of the studies did report the validity and reliability of the psychometric scales used. As the findings of the meta-analysis are influenced by the quality of the primary studies, this should be noted when interpreting the results. We urge researchers to adopt open-science practices, such as uploading raw data in open access repositories. Moreover, we urge them to include in these datasets sufficient data describing participants (namely sex, age, country of origin) to facilitate meta-analyses. Finally, and relating to interventions around nature connection in particular, it is important to report the context in which the research was carried out (rural vs. urban) and the type of nature (green vs blue spaces etc.) participants came into contact with.

5. Conclusion

Our meta-analysis set out to examine the relationship between nature connection, which describes a positive relationship with the natural world, and wellbeing in children and adolescents. We found a small but significant effect, comparable to that of similar meta-analyses in adults, although some caution is necessary as heterogeneity was high. We hope that this meta-analysis can spur on changes in education and policy around providing funding to enable more frequent experiences in nature for children. In particular, it would also be encouraging to see nature connection being explicitly seen as a goal of education and included in national curricula. There are also implications for urban space and school design, to ensure all children have access to natural spaces and the chance to not only come into contact but also build meaningful connections with the rest of the natural world.

The findings of this meta-analysis have practical implications, particularly for practitioners and parents/carers of children. First, children should be encouraged to spend time connecting to nature at school, where they spend much of their time. Not all children are able to access nature in their home environments for a variety of reasons (e.g., lack of access nearby home, safety, constraints on time, lack of availability of parents/carers); therefore, schools can provide opportunities to address these inequities. Connecting to nature at school can be achieved in different ways, including time physically playing and learning in nature through formal environmental education or unstructured, child-led practices like forest school. Elements of nature can also be brought into the classroom, through the integration of plants, nature-based auditory stimuli, and pictures and videos of nature into classroom materials and the broader school environment. As evidenced by the findings from this meta-analysis, encouraging a stronger relationship with nature in children could have the associated benefit of addressing concerns about wellbeing, and this is particularly important amidst a time of rising mental health difficulties and school attendance challenges. Additionally, where possible, parents/carers should seek to support their child’s relationship with nature at home; this might involve noticing local nature together, visiting natural spaces, viewing nature-based media, or a range of other options.

Declarations

Ethical Approval

Ethical approval is not applicable for the present study, which is a meta-analysis of already published studies.

Financial support: There was no external funding for this project.

Competing interests: The first author of this article had a study included in the meta-analysis. There are no other competing interests to declare.

Availability of data: Data and analytic code can be accessed at https://osf.io/qh9e4/

CRediT taxonomy: AB: Conceptualization; Protocol; Searches; Data extraction and curation; Investigation; Methodology; Project administration; Writing

SF: Data extraction; Writing

KPT: Data analysis; Writing

MPP: Protocol; Methodology; Software; Analysis; Visualisation; Writing

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Supplementary Figures Legends

Suppl. Figure 1. Baujat plot

Suppl. Figure 2. Leave-one-out forest plot sorted by correlation

Suppl. Figure 3. Leave-one-out forest plot sorted by I^2

Suppl. Figure 4. Influence diagnostic plots

Supplementary PRISMA checklists