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Systematic literature review of nature-based Early Learning and Childcare on children's health, wellbeing and development

CHILDREN, EDUCATION AND SKILLS

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Systematic literature review of nature-based Early Learning and Childcare on children's health, wellbeing and development

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Contents

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Summary

What we already know

Evidence on the impact of the **outdoors** and **nature** on children's physical, cognitive, social and emotional health, wellbeing and development is more established compared to **nature-based Early Learning and Childcare** (ELC). For, example, consistent research tells us that when children are outdoors, they engage in higher levels of physical activity which is important for reducing negative health outcomes, such as obesity, cancer, cardiovascular disease, and depression among other outcomes. Similarly, in older children and adolescents (5-18 years), non-educational nature-based settings has a positive impact across a number of outcomes. Nature appears to be particularly beneficial for physical activity and outcomes related to mental health. Less evidence exists on whether nature can enhance children's cognitive and learning outcomes, but these can be improved through increased levels of physical activity.

What this review adds

To our knowledge, this is the first systematic review to synthesise global evidence on the role of **nature-based ELC** on children's health, wellbeing and development. The evidence thus far, as described above, exists primarily in conceptually similar research fields (outdoors and nature more broadly) and in older children and adolescents (5-18 years). This means that we cannot be certain that the benefits older children and adolescents gain from being in nature will be similar to the benefits of nature-based ELC on younger children.

Overview of methodology

The purpose of this systematic review was to understand the extent to which nature-based ELC influences children's (2-7 years) physical, cognitive, social and emotional, and environmental outcomes.

A search for literature was conducted in 9 databases and websites to find relevant global evidence. Studies were included in this review if a) children were in ELC and had not started primary school, and b) the ELC settings provided children with exposure to nature, and c) included child-level outcomes related to health, wellbeing and development.

To provide a level of scientific trust in our studies and subsequent evidence, we conducted two assessments:

I. Assessment of the **quality of the studies**
II. Assessment of the **certainty of the evidence**

To understand the **quality** of eligible studies, we used the Effective Public Health Practice Project (EPHPP) tool (quantitative) and Dixon-Woods checklist (qualitative). This assessment aids in the interpretation of findings from each study.

For example, if a study was rated weak then we should interpret its findings with caution.

The Grading of Recommendations Assessment, Development and Evaluation (GRADE) framework was used to assess the **certainty** of the evidence for a single outcome which has been reported in more than one study. This assessment provides a rating that enables us to draw conclusions about the findings reported at an outcome level. For example, if the certainty of evidence is low for a specific outcome, we need to be cautious in our interpretation of the findings and subsequently the recommendations.

To present the findings for quantitative evidence, studies with the same exposure and reported on similar outcomes were grouped and summaries provided based on whether evidence favoured nature (i.e. nature-based ELC) or favoured the comparison (traditional ELC). A narrative synthesis was conducted to report on findings grouped by outcome domains with the better-quality evidence prioritised in any conclusions drawn. For qualitative studies, a thematic analysis of reported themes was conducted, grouping them into lower and higher order themes.

Key Findings

Overview of the included studies:

The findings presented in this report are based on 59 unique studies (representing 65 articles). Most of the studies were published in the USA, Australia and Norway. Only 3 studies were published in the UK, of which, one study included data from Scotland. For the quality of the included studies, the majority were rated as weak. Studies were generally given a poor rating because participants were unlikely to be representative (selection bias), it was unclear whether the researchers or outcome assessors were aware of the research questions (blinding) and withdrawals and dropouts were not reported or was high (in before and after studies only). Study designs were also rated weak because most were controlled cross-sectional and cross-sectional studies. Outcomes of cross-sectional studies were assessed at a single timepoint only and so permits drawing conclusions about the causal link between nature exposures in ELC and health and wellbeing outcomes in children. **Given the large number of weak studies, it is important to interpret study findings with caution because it is difficult to know for certain if any possible benefits are as a result of attending nature-based ELC and not any other influencing factor.**

Findings for child-level outcomes:

The **quantitative** element of the review reported generally favourable findings on the role of nature-based ELC on children's physical, cognitive, social, emotional and environmental development compared with traditional ELC. The findings reported are dived into 3 categories:

i) **likely positive association** – positive health outcomes with most studies associated with nature-based ELC;

ii) **likely negative association** – negative health outcome with most studies associated with nature-based ELC; and
iii) **inconsistent findings**– unclear whether these studies favoured nature-based ELC or traditional ELC (i.e. not enough evidence).

The evidence suggested that there were no harms associated with attending nature-based ELC.

Based on very low and moderate evidence, playgrounds which included grassed areas, vegetation, natural elements, rocks, hills or shaded areas were **positively associated** with increased **total physical activity**, **moderate-to-vigorous physical activity (MVPA)** and **step counts** and **decreased sedentary time** during ELC.

Based on low and moderate evidence, compared to traditional ELC, nature-based ELC was **positively** associated with:

- **balance**
- **self-regulation** (ability to understand and manage behaviour)
- **nature relatedness** (or biophilia)
- **play interactions**

Based on moderate evidence, compared to traditional ELC, nature-based ELC was **negatively** associated with children's **speed and agility.**

Based on very low, low and moderate evidence, compared to traditional ELC, nature-based ELC had **inconsistent** findings on the following outcomes:

- object control skills
- attention
- social skills
- social and emotional development
- attachment
- initiative
- awareness of nature
- environmentally responsible behaviour
- illnesses
- behavioural problems (such as temper tantrums or hyperactivity)
- play disruption (aggressive and antisocial behaviours in play) and disconnection (withdrawn behaviour and nonparticipation in play)

Similarly, the **qualitative** (e.g. practitioner reported feedback) element of the review reported generally positive findings:

- Nature affords many more opportunities for children to be active, diversify their play, engage in risky play, interact with peers and teachers, increase their creativity and enable child-initiated learning compared to traditional settings.
- Nature-based ELC affords opportunities for children to be physically active, to engage in diverse types of play and interact with peers. This combination is likely to have an impact on a range of physical, cognitive, and social emotional and environmental outcomes
- Children prefer settings which integrate some nature: either a full naturalised playground or a mixed area. A small number of studies indicated that movement and risky play were similar no matter the setting type.

Summary

In summary, evidence suggested that specific natural elements: grass, hills, vegetation, or rocks had a positive association with **MVPA**, **total physical activity** and reduction in **sedentary time** during the ELC day, whereas trees may limit physical activity levels. Findings for motor competence were mixed: generally, **balance** was better in children who attended nature-based ELC, but they performed worse in a test of **speed and agility** compared to children from traditional ELC. Findings for **object control skills** and **illnesses** were inconsistent. For the cognitive domain, children who attended nature ELC also demonstrated better levels of **self-regulation** (ability to understand and manage behaviour) compared to typical ELC settings. However, findings for **attention** were inconsistent. For emotional outcomes, findings were inconsistent for **social skills, social and emotional development, attachment, initiative and behavioural problems.** For environmental outcomes, **nature relatedness** was higher in children who attended nature-based ELC compared to traditional ELC. However, findings were also inconsistent for **awareness of nature** and **environmentally responsible behaviour**. There was also an indication that **play interaction** was higher in children who attended nature ELC compared to traditional ELC. Findings for **play disruption** and **disconnection** were inconsistent.

Findings from the qualitative evidence suggests that compared to traditional settings, the natural environment affords many more opportunities for children to be physically active, play and interact with their peers. Children also prefer settings which integrate some nature either a full naturalised playground or a mixed area.

Suggested Recommendations

The evidence base in the present report makes it difficult to provide strong recommendations. The evidence is predominately weak and outcomes were assessed over a short period of time meaning that we could not fully understand the mechanisms by which any improvements may have occurred. However, based on the available evidence, there are **three** suggested recommendations:

1. Ensure that ELCs have a rich and varied environment that includes a combination of grassed areas, vegetation, natural elements, rocks, hills and/or shaded areas. These appear particularly important for encouraging physical activity, diversifying play types and enabling human interactions which are all important for childhood development.

2. Ensure that all children can access nature across all setting types: outdoor; indoor/outdoor; satellite. In studies where there was a likely association, evidence from this review suggested that both indoor/outdoor and satellite approaches provided children with high exposure to nature. Therefore, it is

important to understand **how much and how regularly** (daily, weekly, etc) children are exposed to/engage with nature across each setting.

3. To aide future policy development in Scotland, it is important that researchers work collaboratively with practitioners and policy makers to establish **what** child and ELC level outcomes should be measured and **how** we can best collect data on these. By embedding robust evaluation practices, we can generate stronger evidence on the impact of nature-based ELC in Scotland.

Structure of Report

The introduction will provide an overview of the impact of nature on children's health, wellbeing and development before introducing the research questions. The methodology used will then be described and results will be presented. The results will provide an overview of the eligible studies and findings will be broken down into three outcome domains: (i) **physical**, (ii) **cognitive**, and (iii) **social, emotional and environmental** development. Outcomes will be presented for different types of nature exposures within ELC settings. The present report will conclude with a discussion of the findings, key recommendations for policy, practice and research followed by references and appendices.

Introduction

Emerging evidence suggests that childhood physical, cognitive, and social and emotional health and wellbeing is worsening across low and high-income counties (1, 2). Globally, an estimated 41 million infants and young children (0-5 years) are living with overweight or obesity (1) and 10-20% of children and adolescents experience mental disorders (2). In Scotland, a similar pattern is evident with 22.4% of children living with overweight or obesity when starting primary school (3). As children mature into adolescence and adulthood, these negative health outcomes continue and exacerbate related conditions, including type 2 diabetes, cardiovascular disease, cancer and chronic depression (1, 2). Excess weight and poor mental health are also likely to affect behaviour in childhood and key cognitive outcomes important for educational attainment (4, 5). These negative health outcomes are influenced by complex and interrelated political, environmental, social and individual factors. These have caused children to live increasingly sedentary lifestyles dominated by screen use and low levels of physical activity which begin to decline around the age children start primary school (6, 7).

Providing young children with opportunities outdoors, particularly in nature, could potentially offer an effective strategy for enhancing children's physical, cognitive, and social and emotional wellbeing (8, 9). When children are outdoors, they engage in higher levels of physical activity (10-12); important for improving overweight and obesity, bone and skeletal health, motor skills, and cognitive development (13, 14). Experiences in nature, which can include trees, vegetation, grass, hills, water, sand and other elements may provide additional affordances beyond the benefits of the outdoors alone (15, 16). These natural elements allow children to diversify their play, develop their motor skills and engage in physical activity through climbing and navigating varied surfaces (17, 18). Two separate systematic reviews have suggested that exposure to nature improves emotional wellbeing, overall mental health, resilience, self-esteem and reduced stress in children and adolescents aged 0-18 years (8, 9). There is less evidence on the effect of nature on learning and cognitive outcomes (8).

Key evidence missing that this review addresses:

Evidence primarily exists in older children and adolescents and looks beyond just educational settings. This means that it is not known what specific benefits nature-based early learning and childcare (ELC) provide children and the mechanisms by which potential benefits may occur. To our knowledge, no high-quality evidence synthesis exists that looks at the effect of nature-based ELC on young children's (2-7 years) health, wellbeing and development.

The early years are an important time to intervene as children are rapidly developing across a range of physical, cognitive, and social and emotional outcomes (19). Furthermore, the majority of children aged 3-5 years attend ELC (98%; n= 96,375) in Scotland in 2019 highlighting that educational settings offer a potentially cost-effective and sustainable solution to ensuring that children are provided with opportunities to improve health outcomes (14).

Currently, the Scottish Government is committed to increasing free ELC entitlement for all 3- and 4-year olds (and eligible 2-year-olds) from 600 hours to 1140 hours (20). To achieve this progressive policy, the ELC Directorate has made a substantial investment in the workforce, infrastructure and new, innovative models of delivery. Scotland has looked to Norway, Denmark and Finland to explore increasing full day outdoor nature-based ELC, indoor/outdoor[1] and satellite settings[2]. These models aim to promote high-quality, accessible, and affordable nature-based experiences for young children attending ELC and enhance their health, wellbeing and development (21). This has seen Scotland become the UK and a global leader in promoting nature-based experiences in early years education.

With increased nature-based provision in ELC, it is important to understand what the possible benefits and harms are to children's health, wellbeing and development and the process by which they occur. Therefore, the ELC Directorate has commissioned researchers at the MRC/CSO Social and Public Health Sciences, University of Glasgow to conduct a novel and timely systematic review to look at the existing global evidence on nature-based ELC on children's physical, cognitive, social, emotional and environmental development. This will inform future policy, planning, and practice recommendations for their ELC as outdoor, nature-based provision increases. The relevance and timeliness of this report have also increased with the emerging interest of outdoor education on limiting the spread of COVID-19.

Review aim and research questions

The aim of this systematic review is to synthesise existing global literature to answer the following research questions:

1. To what extent does attending nature-based ELC influence children's physical, cognitive, social, emotional and environmental outcomes?
2. What are children's, parent's and/ or practitioner's perceptions of nature-based ELC on children's physical, cognitive, social, emotional and environmental outcomes?
3. What are the potential mechanisms by which nature-based ELC improve children's physical, cognitive, social, emotional and environmental outcomes?

Methods

Step 1: Searching the literature

To ensure transparency and scientific rigour, the methodology of the present review was registered to the International Prospective Register of Systematic Reviews (CRD42019152582) on 2nd October 2019 prior to the commencement of the

[1] Indoor/outdoor settings allow children to move safely and freely from their classroom via a door to the playground

[2] Satellite settings provide children with nature-experiences by taking them to another setting (such as a park or woodland area) for one or two days per week.

literature search. The planned methodology has also been peer-reviewed and published in a scientific journal (22).

This comprehensive systematic review aimed to gather global evidence on the effect of nature-based ELC on children's health, wellbeing and development from both scientific and non-scientific sources:

Scientific sources: nine relevant electronic databases were searched:
1) Education Research Information Centre (ERIC) – (EBSCOhost),
2) Australian Education Index – (Proquest),
3) British Education Index – (EBSCOhost),
4) Child Development and Adolescent Studies – (EBSCOhost),
5) Applied Social Sciences Index and Abstracts – (Proquest),
6) PsycINFO – (EBSCOhost),
7) MEDLINE – (EBSCOhost),
8) SportDiscus – (EBSCOhost) and
9) Scopus (Elsevier).

Search strategies used for the nine electronic databases were constructed by the review team (VW, AM and AJ) and an example search strategy for the ERIC database can be found in Appendix A which was adapted for the other eight databases. To capture as much relevant evidence as possible, the searches were not restricted by year of publication or publication language.

To capture non-peer reviewed evidence, such as dissertations and reports, Open Grey (www.opengrey.eu), Dissertation and Theses Database (ProQuest) and Directory of Open Access Journals (www.doaj.org) were searched. Researchers in the field of children, nature and play were contacted directly to highlight articles. Finally, the first 10 pages of Google Scholar were checked. Literature citing of studies published from 2019 onwards were screened to identify recently published evidence that may have been missed in the initial searches.

Non-scientific sources: Relevant organisations and practitioners in the field were contacted via Twitter and email to obtain additional evidence. Websites of relevant organisations, professional bodies and other groups involved in outdoor education and outdoor play were also searched.

Step 2: Defining the inclusion and exclusion criteria

We followed the PI(E)COS framework for defining the eligibility criteria. PI(E)COS stands for Population, Intervention or Exposure, Comparison, Outcomes and Study design. This provides a systematic approach to capturing evidence relating to the research question.

Population: Children attending ELC settings (i.e. nurseries, preschool) who have not started primary school education were included. The age children start primary (or elementary school as it is known in other countries) varies globally and as this is a review of international evidence, children in eligible studies had to be between 2-7 years. **Studies which included children younger than 2 years or older than 7**

years were excluded because this age group would not typically attend ELC settings. Studies which included solely a child population with disease conditions (for example, autism, physical disability, attention deficit hyperactivity disorder) were excluded.

Exposure/Intervention: The exposure of interest was nature-based ELC which is an umbrella term that encompasses different types of international early years education types, including nature-based preschool, kindergarten and daycare (23). These can vary depending on country context, approach used, level of nature, and duration (half day, full day), but are related through their integration of nature in their curriculum and/or environment. This means to be eligible for inclusion in this review, studies had to include nature-based ELC; that is interventions that provided children with nature-based experiences or explored specific natural elements (e.g. hills, trees, water, snow etc.). ELC settings where they did not integrate nature into their curriculum and/or environment were excluded. For example, studies where settings utilised a more traditional indoor approach or where the playground was predominately concrete and features manmade structures (swings, slide, climbing frame etc.) were excluded.

Comparison: Attendance of traditional, indoor ELC (preschool, daycare) where children's outdoor opportunities were less and in an environment which was predominately concrete and consisted of manmade elements such as swings, slide, and climbing frames.

Outcomes: To capture the possible wide-ranging outcomes of nature-based ELC, any child-level outcome related to health, wellbeing and development were included. Specifically, this included outcomes related to children's physical (e.g. physical activity, motor development), cognitive (e.g. executive functions, attention), social (e.g. prosocial behaviour), emotional (e.g. stress reduction) and environmental (connectedness to nature) health, wellbeing and development. Studies were excluded if they included outcomes which were not child-level. Studies which assessed outcomes using unvalidated questionnaires were also excluded (for both quantitative and qualitative designs).

Study designs: Both quantitative and qualitative designs were eligible. Qualitative studies that explored perceptions (from parent, practitioner or child) at a time when the child was attending nature-based ELC were included. All quantitative study designs, including: cross-sectional and case-control studies measured when the child was attending nature-based ELC; longitudinal, quasi-experimental and experimental studies with at least two time points, and; retrospective studies if outcomes were assessed at a time when the child attended nature-based ELC were included. Studies were excluded where the timepoint of outcome measurement could not be readily associated with the exposure; for example, if studies measured effect once the child had left the nature-based ELC or case studies reviewing only one child. Qualitative studies were also excluded if they did not have a comparator (exposure, control group or pre/post).

Step 3: Selecting the studies

Only studies that met the above criteria were included. References from the nine electronic databases and other searches were imported to the referencing software, Endnote, and one reviewer (AJ) removed duplicates. Titles and abstracts were screened once (AJ, PM, RC, IF, SI, FL, BJ, VW) and 10% were screened in duplicate independently (AM). Two researchers independently screened full text articles in duplicate. A third reviewer was brought in to discuss and resolve any disagreement. Multiple publications for the same study were combined and reported as a single study.

Step 4: Extracting the data

Quantitative Data: Data from eligible studies was extracted by one reviewer (AJ) with another reviewer cross-checking all extracted data (AM, PM). The following information was extracted:

- Study ID (authors, year of publication)
- Country
- Study design (cross-sectional, controlled cross-sectional, controlled before and after etc.)
- Participants (age, gender, socioeconomic status, sample size etc.)
- Intervention/ exposure type and duration (nature-based ELC, naturalised playgrounds etc.). Details on what any possible comparator groups received were also detailed (for example, characteristics of traditional preschool).
- Outcome measures (type, assessment tool, unit and time point of assessment etc.)
- Outcomes and results (effect estimates, standard deviation, confidence intervals etc.)

Qualitative Data: One reviewer read through each eligible qualitative study (AJ) and provided a summary of the main themes as reported by the study author and any other relevant information. A second reviewer read the study and summary provided by reviewer one and added any additional information (HT, PM). The following information was extracted:

- Study ID (authors, year of publication)
- Country
- Participants (i.e. gender, socioeconomic status, sample size etc.)
- Intervention/ exposure type
- Intervention/exposure duration
- Research aims
- Outcome measures (interviews, focus groups etc.)
- Outcomes and results (summary of key themes).

Step 5: Assessing the quality of the studies

The quality of all included studies was assessed by two reviewers independently (AJ/PM, AJ/AM), cross-checked and disagreement resolved through discussion with a third reviewer.

The quality of quantitative studies was assessed using the Effective Public Health Practice Project (EPHPP) Quality Assessment Tool (24). This assesses six components of study quality: selection bias; study design; confounders; blinding; data collection methods; withdrawals and drop-outs (in before and after studies only). Each component was rated 1–3 to give a total global rating of weak, moderate, or strong quality.

Why assess the quality of studies?

Assessing the quality of studies is important because it guides the interpretation of findings. For example, if a study demonstrates a significant positive health impact, but it is of weak design then we would interpret findings with caution. This might be because bias has been brought into the study through a small number of children from one or two schools only and/or the data collection methods used are not valid or reliable.

When we assess the quality of the evidence, we can make judgements on confounding. Confounding relates to other factors which may influence the findings of the study, for example, the child's age, gender or socioeconomic status. It is important in any study that these are considered in the design (the group receiving nature-based ELC are matched to a control group with the same characteristics) or in the statistical analysis. If confounding has been considered, then we can have more confidence in the findings presented.

Finally, the type of study design is also factored in. Studies which assess outcomes at baseline in an intervention group and control group and then assess outcomes again at follow-up (before and after studies) are generally of stronger design and we can have more confidence in the findings. However, before and after studies can still be rated weak if there is bias or confounding has not been considered. Cross-sectional studies have a weaker design. This is because they only assess outcomes at one timepoint and we cannot be sure that findings reported are a result of attending nature-based ELC.

For qualitative data, the trustworthiness of the study was assessed using the Dixon-Woods (2004) checklist (25). This tool assesses whether research questions are clear and suited to qualitative enquiry, whether sampling, data collection and analysis are described and appropriate, if claims are supported by sufficient evidence and whether data is integrated, and whether the study makes a useful contribution to the review question(s). Qualitative studies were excluded if the research questions were not suited to qualitative inquiry or if the paper did not make a useful contribution to the review question.

See Appendix B for the EPHPP and Dixon-Woods quality assessment tool.

Step 6: Synthesising the data

Synthesis Without Meta-analysis (SWiM) was followed for reporting findings (26). For synthesising the findings, studies with the same exposure and reported on

similar outcomes were grouped and presented in summary tables. Outcomes were grouped into similar outcome domains (physical, cognitive, social emotional and environmental) and sub domains. SWiM aims to provide a summary of the effect direction and address whether evidence had favoured nature or favoured the comparison. A narrative synthesis was conducted to report on findings grouped by outcome domains with the better quality evidence prioritised in any conclusions drawn.

For qualitative studies, a thematic analysis of reported themes was conducted, grouping them into lower and higher order themes.

A logic model was created to summarise the findings of the qualitative and quantitative studies. The purpose of the logic model is to present a testable theory of change that will allow comparison and examination of how the different data types relate to each other and to enable readers to identify gaps for future research.

Step 7: Assessing the certainty of evidence

Assessing the certainty of evidence for each outcome allows to draw conclusions about our confidence that the observed findings reflect true associations and effects, and that future research is unlikely to change the results. The Grading of Recommendations, Assessment, Development and Evaluation (GRADE) framework was used to assess the certainty of the evidence for each of the assessed outcomes by judging the study quality, precision, consistency, and directness across studies (27). Risk of bias relates to the quality of all studies that assessed the same outcome and exposure. Precision refers to the range around an effect estimate where a small range indicates high precision. Consistency takes into account as to whether studies suggested conflicting results or not. GRADE was applied when there were two or more studies reported on the same outcome and exposure. The certainty of evidence was rated up or down depending on the risk of bias, precision and consistency across studies to provide an overall rating for the certainty of the evidence for each outcome: very low (true effect different from estimated effect, very likely to change with new evidence emerging), low, moderate and high (true effect is similar to estimated effect; unlikely to change with new evidence emerging) (27).

Quality of studies versus certainty of evidence:

Assessing the **quality of the studies** (see Step 5) relates to the design and conduct of the study. Judgements are made on selection bias, study design, confounders, blinding, data collection methods, withdrawals and drop-outs on each eligible quantitative study.

Whereas the **certainty of evidence** looks at a single outcome which has been reported in more than one study. Study quality (above and Step 5), precision, consistency, and directness are assessed across studies and provides a rating that enables us to draw conclusions about the findings reported. For example, if the certainty of evidence is low for a specific outcome, we need to be cautious in our interpretation of the findings and subsequently the recommendations.

Results

Results of the literature search

The results of the systematic literature search are summarised in Figure 1. In total, the search yielded 40,348 records, of which, 9,250 duplicates were removed. Of the remaining 31,098 articles, 29,729 irrelevant titles and abstracts were removed leaving 1,370 full text articles to be screened. 1,224 irrelevant articles were excluded (reasons detailed in Figure 1). Two potentially eligible papers were excluded because they could not be adequately translated (28, 29). 70 qualitative studies with no comparator (i.e. exposure, control group, pre/post) were excluded as were a further 11 after having their quality assessed. This left a total of 59 unique studies (representing 65 individual papers), of which 49 were included in the narrative synthesis (quantitative) and 9 were included in the thematic analysis (qualitative) and one study was included in both.

Figure 1. Results from the literature search

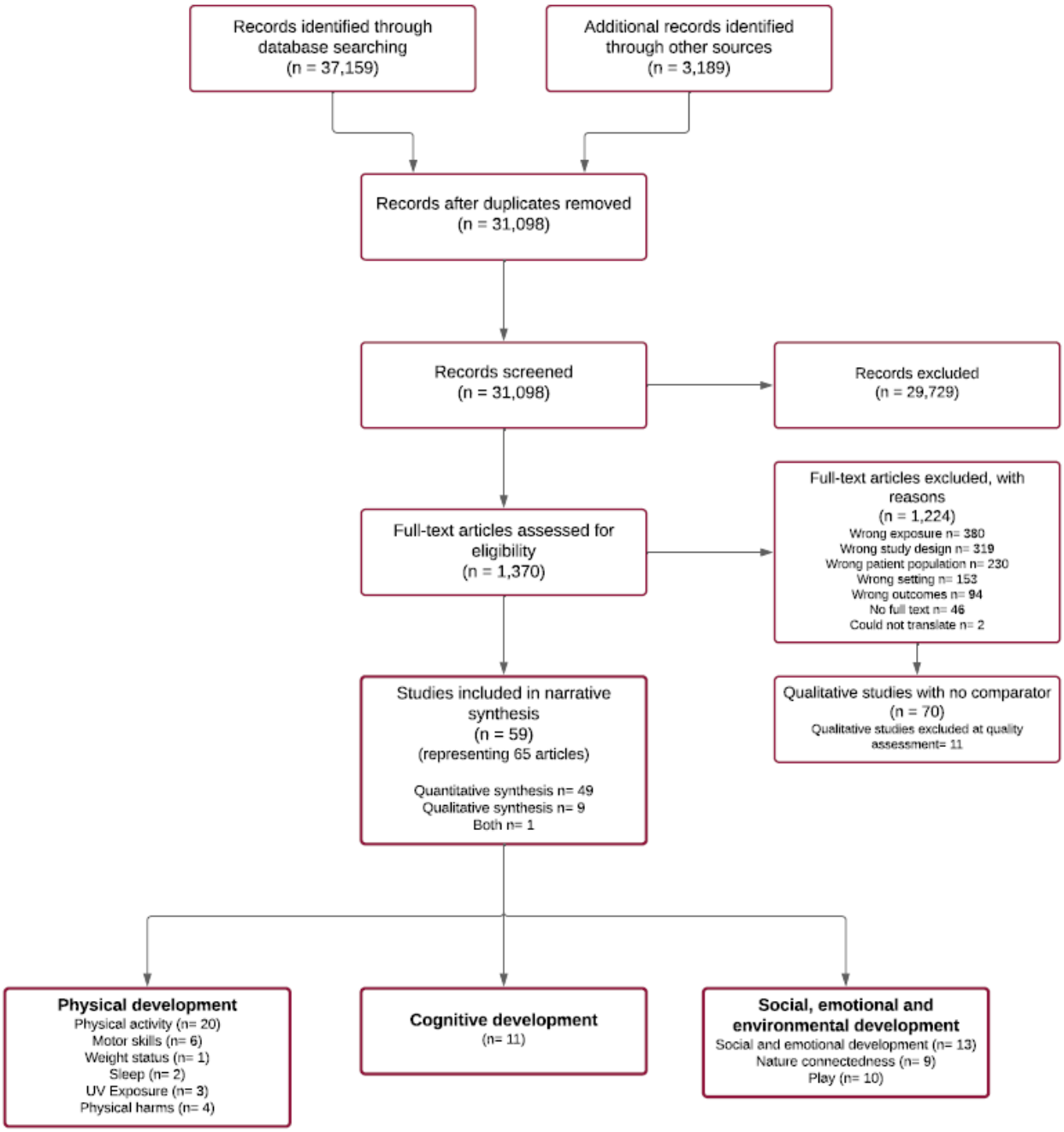
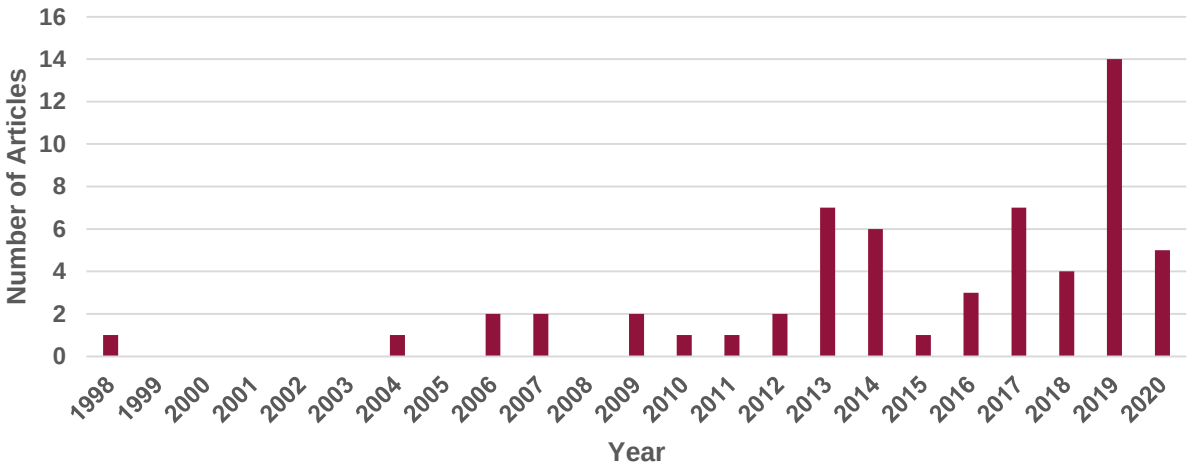


Figure 2 presents the year of publication for the 59 unique studies. Few studies were published between 1998-2012. Since 2013, there has been an increase in publications on this topic.

Figure 2. Year of publication per included study

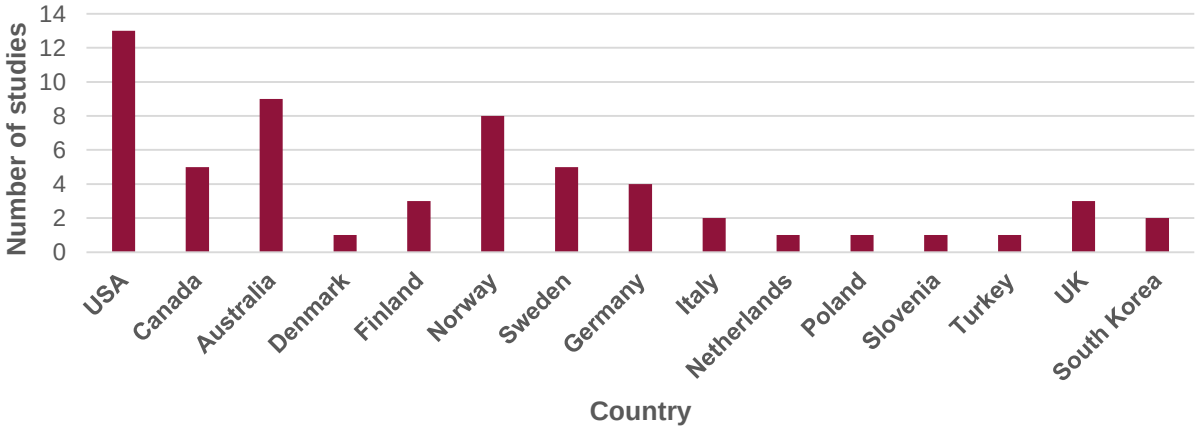


Characteristics of the eligible studies

Geographical location

Most of the studies were published in the USA (n=13), Australia (n=9) and Norway (n= 8). Only 3 studies were published in the UK, of which one study included data from Scotland. Figure 3 presents the number of studies included from each country.

Figure 3. Publication by country



Study designs

Of the quantitative studies, the majority were cross-sectional (n= 22) and controlled cross-sectional (n= 13). Fewer were uncontrolled before and after (n= 6) and controlled before and after (n= 9). Of the cross-sectional studies, one was a mixed-methods and included in both the quantitative narrative synthesis (n=50 unique studies) and the qualitative thematic analysis.

Exposure – Nature

Studies were categorised into four main exposures: nature-based ELC (29 studies), naturalised playgrounds (13 studies), types of nature elements (15 studies) and garden-based interventions (2 studies). Table 1 presents an overview of these categories and their features.

Table 1. Overview of the exposure categories

Nature-based ELC	The ELC curriculum and environment have a strong emphasis on nature where children spend most of their time outdoors in naturalised areas such as woods, forest and/ or naturalised playgrounds. Educators are usually present and may lead on structured educational activities.
Naturalised playgrounds	Interventions which have enhanced the nature in the playground or studies which compare natural playgrounds to traditional playgrounds. Children would not typically spend as much time outdoors in these studies.
Types of natural elements	Studies which looked at the impact of specific natural elements, such as trees, vegetation, hills, grass etc., or specific features or quality of the playground. These studies tended to be controlled cross-sectional or cross-sectional in design.
Garden-based interventions	Studies which include an intervention predicated by a garden component within the ELC setting.

Exposure – Comparison

When studies included a comparison exposure (controlled before and after and controlled cross-sectional study designs only), it tended to be traditional ELC where children would spend less time outdoors and the outdoor playground environment included predominately manmade structures (slide, climbing frame, swings). In some instances, the comparison group may have included some nature through teacher-led eco interventions, or the playground may have included some nature (limited grass and trees). However, the comparison exposure was less than the experimental group.

Sample size and participant characteristics

For sample size and participant characteristics of each study, see Appendix C. Total sample size of the eligible quantitative and qualitative studies was 10,067. Sample sizes were generally small, the majority of controlled and uncontrolled before and after studies had fewer than 100 participants. Controlled cross-sectional and cross-sectional studies also tended to have small sample sizes, but there was a much larger range with one study including 1700 children (experimental n= 506; control n= 1201) (30) and another had less than 20 children (31). Sample size in the qualitative studies ranged from 75 (32) to 12 (33).

As per inclusion criteria, mean age of participants was always 2-7 years. One study assessed girls only (34), all other studies included both genders. Socioeconomic

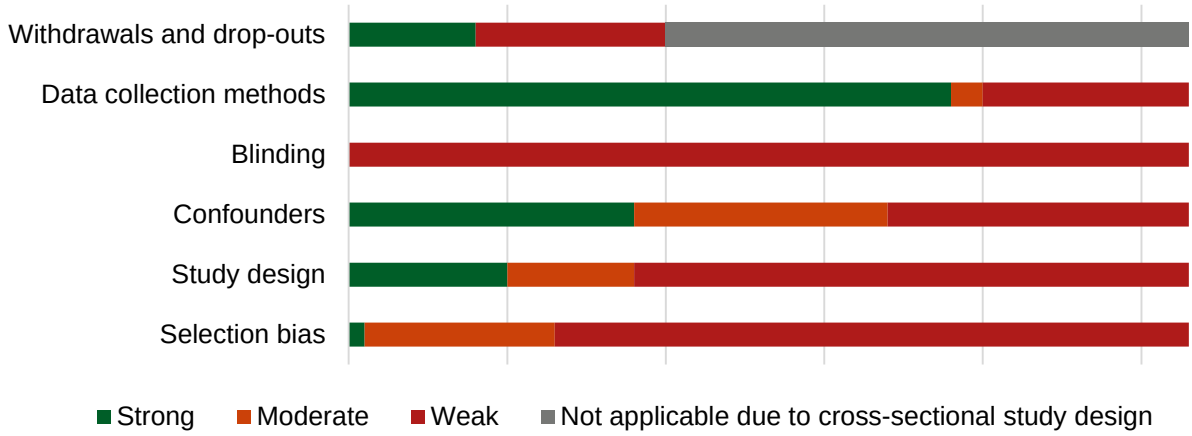
status (SES) was infrequently reported in the eligible studies, in instances when it was reported, SES was generally moderate to high (35-41).

Quality of included studies

Only four studies were of moderate quality (2= nature-based ELC settings, 1= naturalised playgrounds, 1= Types of natural elements) (36, 42-44) and the remaining were rated weak. Figure 4 presents the quality across all studies by assessment item. Studies were generally given a poor rating because participants were unlikely to be representative (selection bias), it was unclear whether the researchers or outcome assessors were aware of the research questions (blinding) and withdrawals and dropouts were not reported or was high (in before and after studies only). Study designs were also rated weak because most were controlled cross-sectional and cross-sectional studies. A weak rating is given to these types of studies because outcomes are assessed at a single timepoint only and so permits drawing conclusions about the causal link between nature exposures in ELC and health and wellbeing outcomes in children. Given the large amount of weak studies, it is important to interpret study findings with caution because it is difficult to know for certain if any possible benefits are as a result of attending nature-based ELC and not any other influencing factor.

See Appendix D for the quality of each quantitative study as assessed by the EPHPP tool.

Figure 4. Quality across all studies by assessment item



Main findings – Quantitative

Outcomes reported in eligible studies were grouped into three domains: physical development, cognitive development, and social, emotional and environmental development. Of these three higher level categories, we derived 9 sub-domains. Table 3 presents an overview of these (sub)domains and number of studies reporting on each outcome.

Table 3. Outcome domains and sub-domains (number of studies in bracket)

Physical development	Cognitive development	Social, emotional and environmental development
Physical activity (20)	Cognition and learning (11)	Social and emotional development (13)
Motor skills (6)		Nature connectedness (9)
Weight status (1)		Play (10)
Sleep (2)		
UV exposure (3)		
Physical harms (4)		

Before presenting findings for each outcome domain, a combined summary of the evidence will be presented first. Table 4 presents findings where outcomes were reported in more than one study for **nature-based ELC.** Similarly, Table 5 presents findings where outcomes were reported in more than one study for **Types of Natural Elements.** These tables report the certainty of evidence for each outcome, the number of studies grouped for each outcome and how many studies favoured the comparison and how many favoured nature. One colour block equates to one study (*unless the study favours neither nature or the comparison), dark green highlights the study favours nature and statistical significance (p<.05); light green favours nature, but no statistical significance; light red/pink favours comparison no statistical significance; and dark red favours comparison and statistical significance (p<.05).

Table 4. Nature-based ELC vs traditional ELC on Physical, Cognitive, and Social, Emotional and Environmental outcomes

Outcome	N of studies	Certainty of evidence	Favours comparison	Favours nature
Physical				
Sedentary time (mins/ ELC day	2	Moderate	O	G
MVPA (mins/ ELC day)	2	Moderate	O	G
Balance	3	Moderate	O	DG DG
Object Control	2	Moderate	O	G
Speed and agility	3	Moderate	R R O	
Illness	2	Very low	O	G
Cognitive				
Attention	3	Moderate	O	G G
Self-regulation / control	3	Low		G DG DG

Social, emotional and cognitive										
Social skills	3	Moderate				O	G	DG		
Social and emotional development	3	Moderate				O	G	G		
Attachment	2	Low				O	G			
Initiative	2	Low				O	DG			
Behavioural Problems	3	Moderate			R	O	G			
Nature Relatedness / biophilia	6*	Moderate					G	DG	DG	DG	DG
Environmentally responsible behaviour	3	Moderate			O	O	DG			
Awareness of nature	2	Low					G	G		
Play interaction	3	Moderate				O	DG	DG		
Play disruption	2	Moderate				R	DG			
Play disconnection	2	Moderate				R	DG			

Abbreviations: E= experimental; C= comparison; N= number; MVPA= moderate-to-vigorous physical activity; ELC= Early learning and childcare.

One colour block = one study.

* denotes where a study favours neither nature or comparison and is therefore not counted.

■ (dark green – DG) = favours nature and statistical significance (p<.05); ■ (green – G) = favours nature; ■ (orange – O) = favours comparison; ■ (red – R) = favours comparison and statistical significance (p<.05).

Table 5. Types of natural elements physical outcomes

Outcome	N of studies	Certainty of evidence	Favours comparison	Favours nature
Physical				
Sedentary time (mins/ ELC day	2	Very low	O	DG
MVPA (mins/ ELC day)	4*	Moderate	O	G G
Total PA (mins/ ELC day)	4*	Moderate		G G G
Step counts/ ELC day	2	Very low		G DG

Abbreviations: E= experimental; C= comparison; N= number; MVPA= moderate-to-vigorous physical activity; PA= physical activity ELC= Early learning and childcare.

One colour block = one study.

* denotes where a study favours neither nature or comparison and is therefore not counted.

■ (dark green – DG) = favours nature and statistical significance (p<.05); ■ (green – G) = favours nature; ■ (orange – O) = favours comparison.

The **quantitative** element of the review reported generally favourable findings on the role of nature-based ELC on children's physical, cognitive, social, emotional and environmental development compared with traditional ELC. The findings reported are dived into 3 categories:

i) **likely positive association** – positive health outcomes with most studies associated with nature-based ELC;
ii) **likely negative association** – negative health outcome with most studies associated with nature-based ELC; and
iii) **inconsistent** – unclear whether these studies favoured nature-based ELC or traditional ELC (i.e. not enough evidence).

The evidence suggested that there were no harms associated with attending nature-based ELC.

Based on very low and moderate evidence, playgrounds which included grassed areas, vegetation, natural elements, rocks, hills or shaded areas were **positively associated** with increased **total physical activity**, **moderate-to-vigorous physical activity (MVPA)** and **step counts** and **decreased sedentary time** during ELC.

Based on low and moderate evidence, compared to traditional ELC, nature-based ELC was **positively** associated with:

- **balance**
- **self-regulation** (ability to understand and manage behaviour)
- **nature relatedness** (or biophilia)
- **play interactions**

Based on moderate evidence, compared to traditional ELC, nature-based ELC was **negatively** associated with children's **speed and agility.**

Based on very low, low and moderate evidence, compared to traditional ELC, nature-based ELC had **inconsistent** findings on the following outcomes:

- object control skills
- attention
- social skills
- social and emotional development
- attachment
- initiative
- awareness of nature
- environmentally responsible behaviour
- illnesses
- behavioural problems (such as temper tantrums or hyperactivity)
- play disruption (aggressive and antisocial behaviours in play) and disconnection (withdrawn behaviour and nonparticipation in play)

Further analysis of the finding for each outcome domain will now be presented.

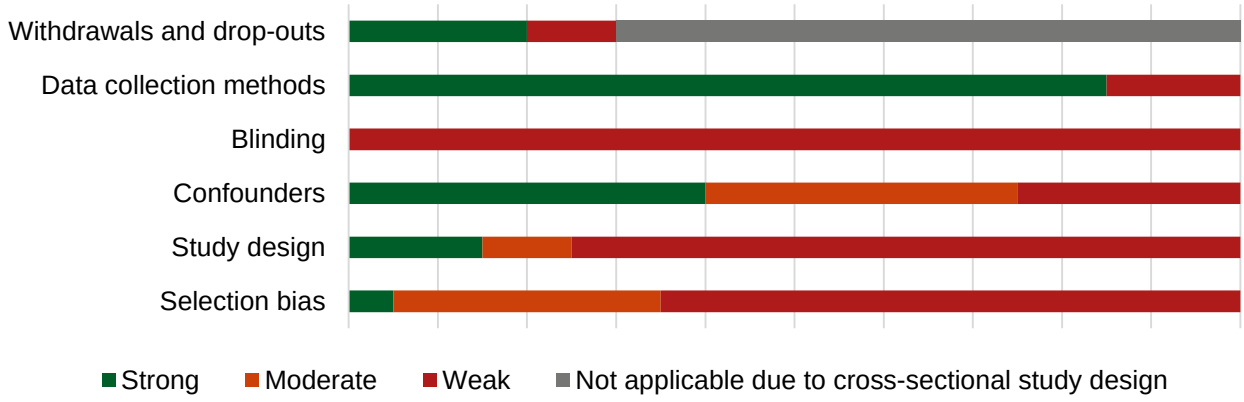
Outcome Domain 1 - Physical development

The physical development domain presents six related sub-domains: physical activity, motor competence, weight status, sleep, UV exposure and physical harms.

1. Physical Activity

Of the 20 articles reporting on physical activity, 15 studies used device-measured methods to record children's physical activity levels and sedentary time. The ActiGraph accelerometer was used in 12 studies (31, 39-42, 44-49), pedometers were used in two (50, 51) and Global Positioning System (GPS) devices were used once (52). The remaining 5 eligible studies used direct observational methods such as the Observational System for Recording Physical Activity in Children-Preschool (OSRAC-P) or Children's Activity Rating Scale (CARS) which codes varying physical activity intensities (38, 53-56) (see Appendix E). The methodological quality across the 20 studies that assessed physical activity is shown in Figure 5.

Figure 5. Quality across studies: Physical activity



1.1. Nature-based ELC settings

Table 5 presents the results from device-measured sedentary time (mins/ ELC day) and MVPA (mins/ ELC day) in eligible studies where these outcomes were reported in more than one study. Findings indicated that there was a positive health impact on sedentary time (mins/ ELC day) between children attending nature-based ELC and children attending traditional ELC (45), the other study demonstrated a negative health impact (46). Similarly, there were conflicting findings for time spent in MVPA (mins/ ELC day) with one study reporting 6 minutes more MVPA (mins/ ELC day) in children who attended nature-based ELC (45) and the other showing 15.5 minutes less MVPA (mins/ ELC day) compared to children attending a typical ELC (46).

Table 5. Nature-based ELC and types of natural elements on physical activity

Study ID	Study Design	Sample size (E/C)	Favours comparison	Favours nature
Nature-based ELC				
Sedentary time (mins/ ELC day)				
Müller et al (2017)[45]	Controlled before & after	43 / 45		G
Fyfe-Johnson et al (2019)[46]	Controlled cross-sectional	20 / 13	O	
MVPA (mins/ ELC day)				
Müller et al (2017)[45]	Controlled before & after	43 / 45		G
Fyfe-Johnson et al (2019)[46]	Controlled cross-sectional	20 / 13	O	
Types of Natural Elements				
Sedentary time (mins/ ELC day)				
Määttä et al (2019b)[41]	Cross-sectional	655		DG
Sugiyama et al (2012)[49]	Cross-sectional	89	O	
MVPA (mins/ ELC day)				

Ng et al (2020)[44]	Controlled before & after	159 / 138	/ /
Christian et al (2019)[39]	Cross-sectional	678	G
deWeger (2017)[47]	Cross-sectional	274	G
Sugiyama et al (2012)[49]	Cross-sectional	89	O
Total PA (mins/ ELC day)			
Ng et al (2020)[44]	Controlled before & after	159 / 138	/ /
Christian et al (2019)[39]	Cross-sectional	678	G
deWeger (2017)[47]	Cross-sectional	274	G
Määttä et al (2019)[40]	Cross-sectional	864	G
Step counts/ ELC day			
Boldemann et al (2006)[50]	Cross-sectional	199	DG
deWeger (2017)[47]	Cross-sectional	274	G

Abbreviations: E= experimental; C= comparison; N= number; MVPA= moderate-to-vigorous physical activity; PA= physical activity; ELC= Early learning and childcare.

One colour block = one study.

■ (dark green – DG) = favours nature and statistical significance (p<.05); ■ (green – G) = favours nature; ■ (orange – O) = favours comparison; ■ (grey – //) = favours neither nature or control, or statistics not presented.

Controlled before & after studies – difference between experimental and control group at follow-up (unless stated). Uncontrolled before & after studies – change since baseline (unless stated). Controlled cross sectional – difference between experimental and control (unless stated). Cross-sectional – positive, negative or no association.

For outcomes that could not be grouped together in the effect direction plot, findings of one weak study suggested children who attended nature ELC engaged in less habitual (mins/day) light physical activity and MVPA and more sedentary time compared to the control across the full week, weekday and weekend (46). The two studies using direct observational methods to assess physical activity in nature ELC found that children in the nature kindergarten were less stationary and engaged in more slow-easy and moderate physical activity compared to the control (38, 53).

1.2. Naturalised playgrounds

Studies for this exposure could not be grouped together because a single outcome was not reported in more than one study. Findings of one intervention study where the playground was enhanced to include more natural elements indicated a positive impact on MVPA and a statistically significant impact on PA and non-sedentary PA

assessed using direct observation (54). In another intervention study, device measured MVPA significantly decreased from baseline to follow-up by 1.32 minutes (42). The other three cross-sectional studies found CPM (a measure of total PA) were similar across a natural and traditional playgrounds (31) and gait/cycles (similar to step counts) were lower in a nature playground (51), but children covered a greater distance (km) (52).

1.3. Types of natural elements

Table 5 presents the results from device-measured sedentary time (mins/ ELC day), MVPA (mins/ ELC day), total physical activity (mins/ ELC day) and step counts (ELC day) in eligible studies where these outcomes were reported in more than one study. Four studies looked at device measured MVPA (mins/ ELC day), of which one study reported non-significant difference for natural elements between the experimental and control groups (44), two studies favoured nature (39, 47) and one study showed no association (49). Grassed areas were positively and significantly associated with MVPA (44). Higher vegetation (height in metres) (39), natural elements (47), gradient and shade had a positive, but non-significant, association with MVPA (49). In another study, natural surfaces were found to be significantly associated with less MVPA, and vegetation did not have a favourable association with MVPA (49).

In the four studies that looked at total device measured physical activity (mins/ ELC day), three favoured the respective types of natural elements and one study reported non-significant differences for natural elements between the experimental and control groups (44). Grassed areas were positively and significantly associated with total physical activity (44). Vegetation, natural elements, grass, and rocks had a positive association with total PA, but these were non-significant (39, 40, 47). Forest and trees were negatively associated with total physical activity (mins/ ELC day) (40).

Higher frequency of nature trips was significantly associated with lower levels of sedentary time (mins/ ELC day) (41). Similarly, gradient (such as hills) and shade showed an association with lower levels of sedentary time (mins/ outdoor time), but “mostly natural surfaces” and vegetation were associated with increased sedentary time (all non-significant) (49).

Step counts were found to be significantly associated with high environment score (playgrounds which had a large outdoor area, trees and shrubbery, and integrated play areas with vegetation) (50) and natural elements (47).

Additional findings (not presented in Table 5), indicated that natural elements were significantly and positively associated with a reduction in percent time spent in habitual sedentary time, and increased MVPA and CPM (57). Vegetation and hilly landscape were significantly associated with a reduced percent time in MVPA (ELC day) (48). Hilly landscape was also associated with reduced percent time in MVPA, but this was non-significant (48). There was a positive, but non-significant association with nature and PA assessed using direct observation (55) . Finally,

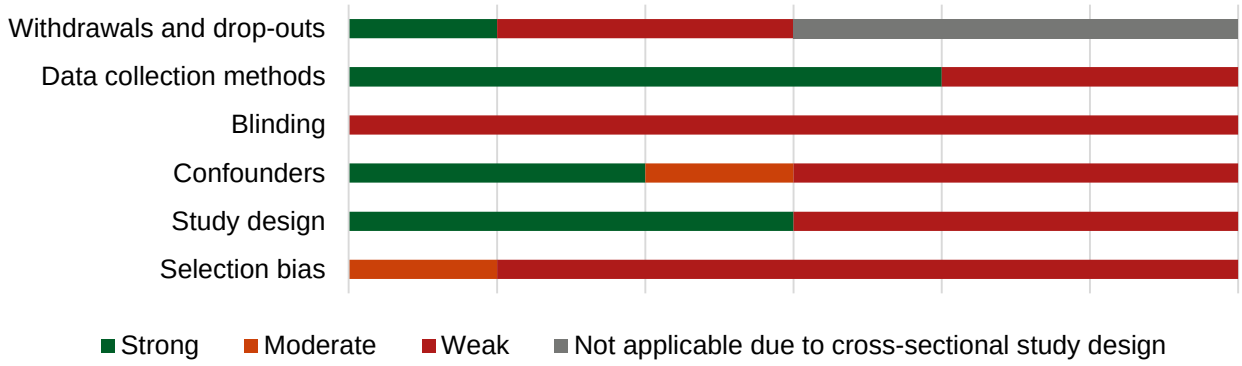
there was no association between nature and observations of high wellbeing and PA assessed using direct observation (56).

Full results for physical activity can be found in Appendix E.

2. Motor competence

Motor competence refers to the child's ability to perform a range of movement skills, such as running, jumping, catching and throwing. These are important as they enable children to engage in physical activity throughout their life course. Six studies assessed outcomes related to motor competence and all examined the effect or association of nature-based ELC on outcomes related to children's motor competence (18, 45, 58-63). Figure 6 presents the quality of studies assessing motor competence by assessment item for methodological quality.

Figure 6. Quality across studies: Motor competence



2.1. Nature-based ELC Settings

Studies explored a range of outcomes related to motor competence. Three studies assessed a range of motor or fundamental movement skills, such as jumping, running, balance and strength (18, 59-62). Motor competence was reported more broadly in three studies (45, 58, 61). Practitioner perspectives of children's physical development was reported in one study (63).

Table 6 presents the results from motor competence (balance, object control skills, and speed and agility) in eligible studies where these outcomes were reported in more than one study. Findings suggested that in two studies, balance was significantly better in children who attended nature ELC compared to children who attended traditional settings (18, 59, 60, 62). Whereas, one study found that children who attended traditional settings performed better (61). There were mixed findings for object control skills (catching, throwing, dribbling) (45, 61) and children in nature ELC performed worse in the shuttle run test (test of speed and agility) in all three studies (two significant, one non-significant) (18, 59-62).

Additional findings reported that body function, gross motor skills and fine motor skills were better in children who attended nature ELC compared to the control, but

these differences were non-significant (58). Similarly, locomotor skills (running, skipping, hopping) were significantly better in nature ELC compared to traditional ELC (45). However, how children perceive their own motor competence was marginally lower in children who attended nature ELC compared to the comparison (45). One study indicated that total motor competence (manual dexterity, ball skills and balance) was worse in children who attended nature ELC compared to children who attended traditional ELC (61), but this difference was not statistically significant.

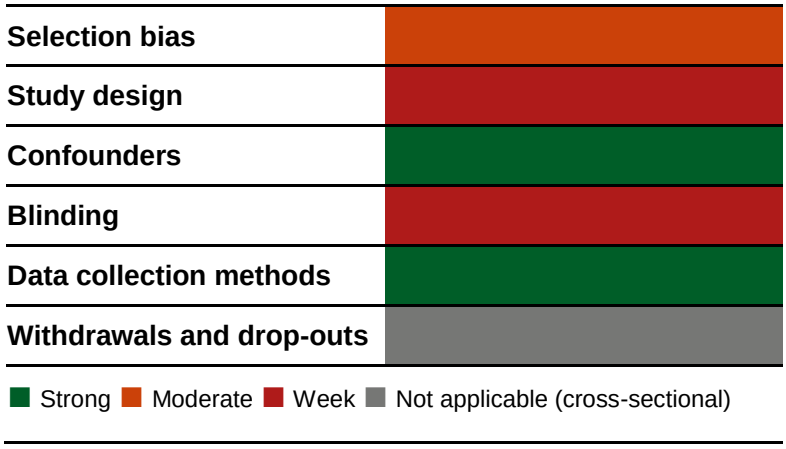
Children who attended nature ELC also performed better across a number of skills. At follow-up, children performed significantly better at skipping compared to children who attended a traditional setting (18, 59, 60). In another study, children from nature ELC performed significantly better at hanging on a pull up bar (strength), jumping left/right and one-leg jump (left foot only) compared to urban and rural children who attended traditional ELC (62). However, total motor fitness scores were found to be significantly lower in children who attended nature ELC compared to control schools (61).

Full results for motor competence can be found in Appendix E.

3. Weight status

Weight status was assessed in only one cross-sectional study which compared BMI and waist circumference in children from schools with high environment quality (i.e. large space, vegetation, tress etc.) compared to low environment quality (64). Figure 7 presents the quality of the study assessing weight status by assessment item for methodological quality.

Figure 7. Quality across studies: Weight status



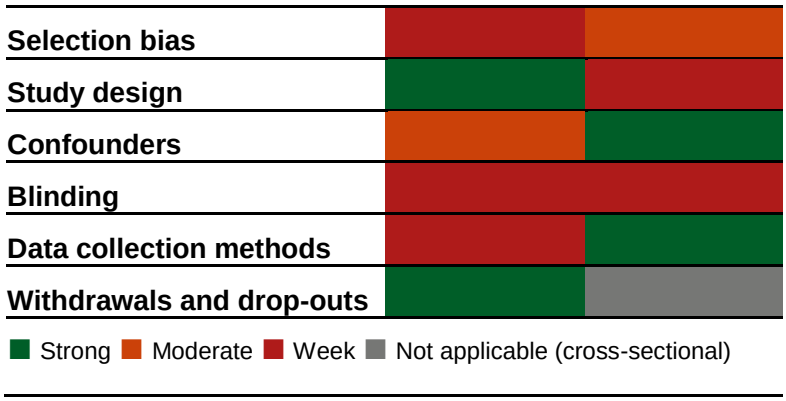
3.1. Types of natural elements

Findings from this study suggested that outdoor environment quality was not significantly associated with BMI or waist circumference (64). However, prevalence of overweight and waist circumference were lower in the higher environment quality group compared to the lower quality (64).

4. Sleep

Sleep was assessed in two studies, of which one was a controlled before and after which compared sleep time and quality in children from a nature-based ELC compared to a traditional ELC (36). The other study was cross-sectional and compared sleep duration in high quality versus low quality outdoor environments (64). These studies could not be combined and presented in a summary table because the exposures and study designs were different. Figure 8 presents the quality of studies assessing sleep by assessment item for methodological quality.

Figure 8. Quality across studies: Sleep



4.1. Nature-based ELC Settings

In the controlled before and after study, sleep was assessed using the Children's Sleep Habits Questionnaire (CSHQ) which assesses eight sleep domains: bedtime resistance, sleep onset delay, sleep duration, sleep anxiety, night wakings, parasomnia, sleep-disordered breathing, and daytime sleepiness (36). Total sleep time was also reported. Findings indicated that Total CSHQ score, sleep disordered breathing and daytime sleepiness was significantly better in the children who attended nature-based ELC compared to traditional. All other domains were better but statistically non-significant. Total sleep time was also higher in children who attended nature-based ELC (10.5 hours ± 1.0 vs 10.4 ± 0.9) (36).

4.2. Types of natural elements

Mean sleep time (minutes) was also reported to be higher in ELC settings which had a higher environment score (658 minutes ± 44) compared to a lower environment score (642 ± 32) and this association was also significant. High environment scores relate to playgrounds which have a large space, trees, vegetation, hilly terrain and integrate natural elements with play structures.

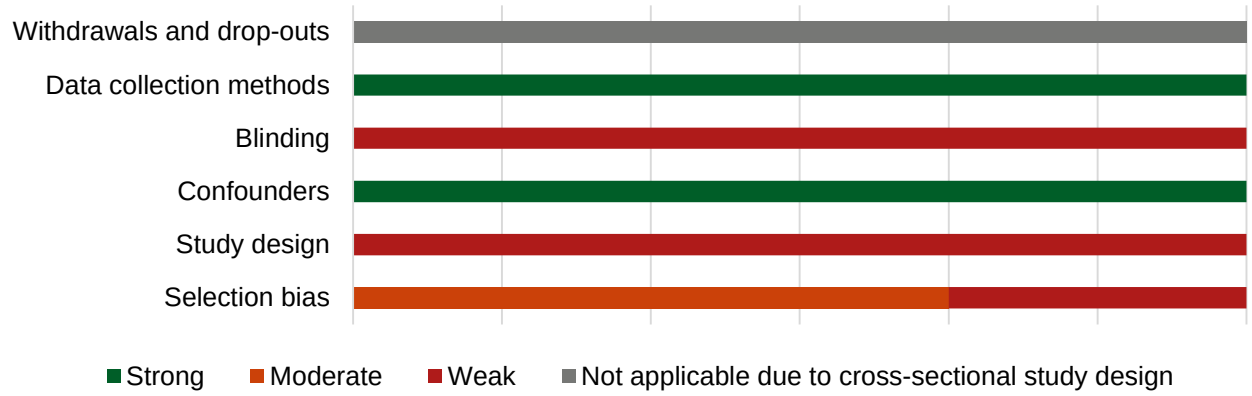
5. UV Exposure

5.1. Types of natural elements.

UV Exposure was assessed in three cross-sectional studies, of which two were conducted in Sweden and one in Australia (39, 50, 65). These studies examined

the association between high environmental quality (i.e. large space, vegetation, tress etc.) versus low quality. All three studies found UV exposure was lower and significantly associated with environmental quality (39, 50, 65). UV exposure was lower in areas where vegetation and trees were more integrated into the playground. Figure 9 presents the quality of studies assessing UV exposure by assessment item for methodological quality.

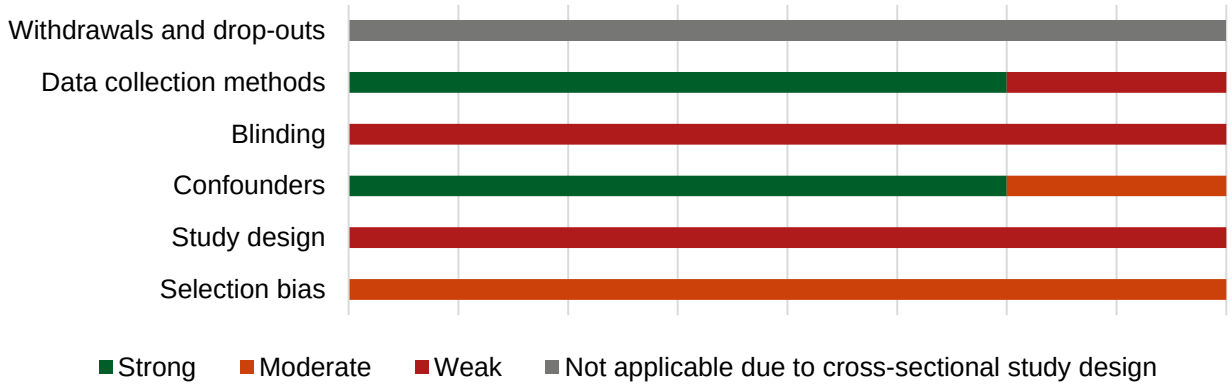
Figure 9. Quality across studies: UV exposure



6. Harms

Possible harms and negative consequences of nature-based ELC was assessed in three controlled cross-sectional studies (30, 37, 66), and the association between environment quality was assessed in one cross-sectional study (64). The quality across the four studies reporting harms is shown in Figure 10.

Figure 10. Quality across studies: Harms



6.1. Nature-based ELC settings

Table 6 presents the results from illness and sickness in eligible studies where these outcomes were reported in more than one study in nature ELC compared to traditional ELC (37, 66). **Illnesses and sickness absenteeism** were reported as the number of days the child was absent from school as reported by their teacher or parent (37, 66). One study reported fewer illness episodes in the nature-based ELC compared to the traditional ELC (non-significant) (37). The other found that

sickness absenteeism was lower in regular ELC compared to nature-based ELC, but again this was non-significant (66).

Total **minor injuries** (wound/cut, sprain, bite) were also explored, and differences were found between genders. Boys in nature ELC had less (non-significant) minor injuries compared to boys who attended traditional ELC (37). Whereas girls who attended nature ELC had significantly higher minor injuries than girls who attended traditional education (37). **Tick bites and borreliosis** (or Lyme's Disease) were also significantly more prevalent in nature ELC in Germany compared to traditional ELC (30). 73% of children who attended nature-based ELC reported presence of at least one tick bite versus 27% in the control (30). Similarly, 2% of children who attended nature-based ELC reported presence of Lyme Disease versus 0.4% of control children (30). It is likely that children in nature-based ELC spend more time outdoors and so have greater exposure to ticks.

6.2. Types of natural elements

Another study explored the association between **illness symptoms** (runny nose, cough fever, respiratory problems etc.) and high quality versus low quality environment. There was no association between environment quality and symptoms (64).

Table 6. Nature-based ELC vs traditional ELC on motor competence and physical harms

Study ID	Study Design	Sample size (E/C)	Favours comparison	Favours nature
Balance				
Ene-Voiculescu & Ene-Voiculescu (2015)[18, 59, 60]	Controlled before & after	46 / 29		DG
Lysklett et al (2019)[61]	Controlled cross sectional	43 / 49	O	
Scholz & Krombholz (2007)[62]	Controlled cross-sectional	45 / 84		DG
Object Control				
Müller et al (2017)[45]	Controlled before & after	43 / 45		G
Lysklett et al (2019)[61]	Controlled cross sectional	43 / 49	O	
Speed and agility				
Ene-Voiculescu & Ene-Voiculescu (2015)[18, 59, 60]	Controlled before & after	46 / 29	O	
Lysklett et al (2019)[61]	Controlled cross sectional	43 / 49	R	
Scholz & Krombholz (2007)[62]	Controlled cross-sectional	45 / 84	R	
Illness				
Frenkel et al (2019)[37]	Controlled cross-sectional	71 / 70		G

Moen et al (2007)[66]	Controlled cross-sectional	267 / 264		O	

Abbreviations: E= experimental; C= comparison; N= number; ELC= Early learning and childcare.

One colour block = one study.

■ (dark green – DG) = favours nature and statistical significance (p<.05); ■ (green – G) = favours nature; ■ (orange – O) = favours comparison; ■ (red – R) = favours comparison and statistical significance (p<.05).

Controlled before & after studies – difference between experimental and control group at follow-up (unless stated). Uncontrolled before & after studies – change since baseline (unless stated). Controlled cross sectional – difference between experimental and control (unless stated). Cross-sectional – positive, negative or no association.

Summary of physical domain

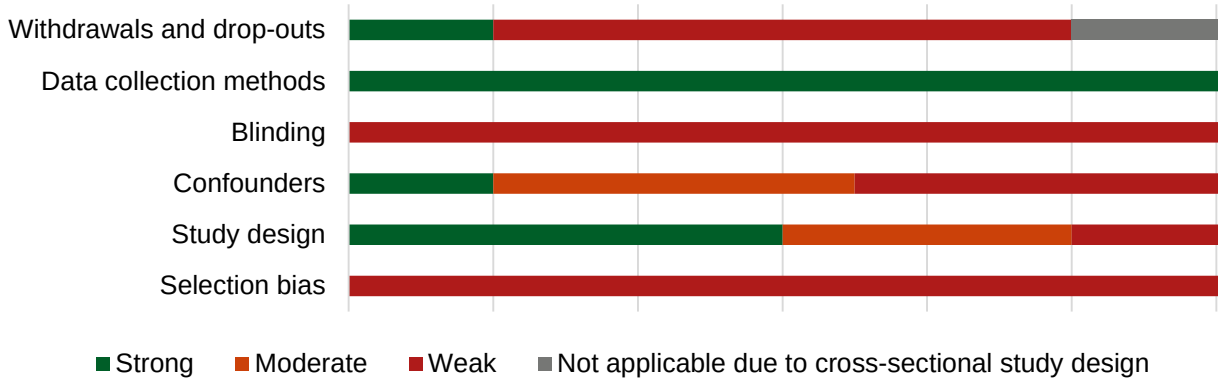
In summary, it is unclear whether nature-based ELC have a positive effect on children's **sedentary time** and **moderate-to-vigorous physical activity (MVPA)** during the ELC day. However, evidence suggested that specific natural elements: grass, hills, vegetation and rocks had a positive association with ELC day **MVPA**, **total physical activity** and reduction in **sedentary time**, whereas trees may limit physical activity levels. Findings for motor competence were mixed: generally **balance** was better in children who attended nature ELC, but they performed worse in a test of **speed and agility** compared to children from traditional ELC. Findings for **object control skills** and **illnesses** were inconsistent.

Outcome Domain 2 - Cognitive development

7. Cognition and learning

A total of 11 studies (representing fifteen papers) included a cognitive or learning related outcome. Seven studies looked at the associations of nature ELC (34, 35, 45, 46, 58, 63, 67-71). Only one cross-sectional study had a naturalised playground exposure which compared outdoor green spaces to indoors (72), one study looked at high environment versus low environment (natural elements) (73) and two utilised garden-based interventions (74, 75). The quality across the studies reporting on cognition and learning is shown in Figure 11.

Figure 11. Quality across studies: Cognition and learning



7.1. Nature-based ELC settings

Table 7 presents the results for cognitive development in eligible studies where these outcomes were reported in more than one study. Two studies found a favourable association with children's attention in nature-based ELC compared to traditional ELC (45, 46, 67, 68). There was a positive trend for self-regulation (ability to understand and manage behaviour) across three studies, with two studies reporting significantly higher scores in children who attended nature ELC compared to children who attended traditional settings (35, 45, 67, 70).

Table 7. Nature-based ELC vs traditional ELC on cognitive and learning outcomes

Study ID	Study Design	Sample size (E/C)	Favours comparison	Favours nature
Attention				
Burgess & Ernst (2020)[67, 68]	Controlled before & after	84 / 24		G
Müller et al (2017)[45]	Controlled before & after	43 / 45	O	
Fyfe-Johnson et al (2019)[46]	Controlled cross-sectional	20 / 13		G
Self-regulation / control				
Cooper (2018)[35]	Controlled before & after	13 / 11		G
Müller et al (2017)[45]	Controlled before & after	43 / 45		DG
Ernst et al (2019)[67, 70]	Uncontrolled before & after	78		DG

Abbreviations: E= experimental; C= comparison; N= number; ELC= Early learning and childcare.

One colour block = one study.

■ (dark green – DG) = favours nature and statistical significance (p<.05); ■ (green – G) = favours nature;

■ (orange – O) = favours comparison

Controlled before & after studies – difference between experimental and control group at follow-up (unless stated). Uncontrolled before & after studies – change since baseline (unless stated). Controlled cross

sectional – difference between experimental and control (unless stated). Cross-sectional – positive, negative or no association.

Two of the included studies looked at the association between nature ELC and executive functions of which one examined three domains: working memory, attention (presented above) and inhibition (45) and the other study tested overall executive function (cognitive flexibility, inhibitory control and working memory) (67, 69). Findings indicated there were small improvements in working memory and association with inhibition (45). Overall executive function score was higher in the nature ELC compared to the control, but this was non-significant (67, 69). In another study, cognitive development was lower in nature- based ELC and teacher perception of language development was higher; however, these differences were non-significant (58). There was also no significant differences in the nature ELC compared to the control for communication (35). Total learning behaviours - assessed across three dimensions: attention, competence motivation and attitudes - was measured in another study (67, 68). Children who attended nature ELC had a higher total score compared to traditional ELC, indicating better learning behaviours but this was non-significant. However, kindergarten readiness (counting, rhyming, recognition) was lower in children who attended nature ELC than those who attended a traditional setting (34). There were marginal differences in curiosity scores in children who attended nature ELC compared to the control group (67). Finally, there were significant improvements in areas of creativity (fluency originality and imagination in children who attended nature ELC.

See appendix E for full findings related to the cognitive domain.

7.2. Naturalised playgrounds

The one eligible study utilised a visual spatial task (an indicator of children's direct attention) to determine if there was a difference in children who had been exposed to playground green spaces for free play compared to children who were indoors (72). Findings suggested that children who had been exposed to free play in green space gained higher visual spatial accuracy scores compared to children in the indoors setting (72).

7.3. Types of natural elements

One eligible study looked at attention in relation to ELC which had a high-quality environment (i.e. large space, vegetation, tress etc.) to those which had a low-quality environment (73). Findings indicated that the two domains of attention: hyperactivity and inattention were lower in schools with high quality environments and inattention was significantly associated (73).

7.4. Garden-based interventions

The two eligible garden-based intervention studies assessed varying outcomes. One study looked at scientific attitudes and abilities (74) and the other study

assessed delay gratification (self-regulation) and visual motor integration (hand-eye coordination) (75). All subcategories of scientific attitudes and abilities significantly improved from baseline to follow-up (measured one week after a 24 week intervention) (74). Delay gratification (self-regulation) and visual motor integration did not significantly improve from baseline to follow-up (75).

Summary of cognitive domain

Findings indicated that for **attention,** two studies demonstrated positive health impacts and one study showed a negative health impact. More evidence supported **self-regulation** (ability to understand and manage behaviour) with three studies demonstrating a positive health impact for children attending nature-based ELC compared to children attending traditional ELC.

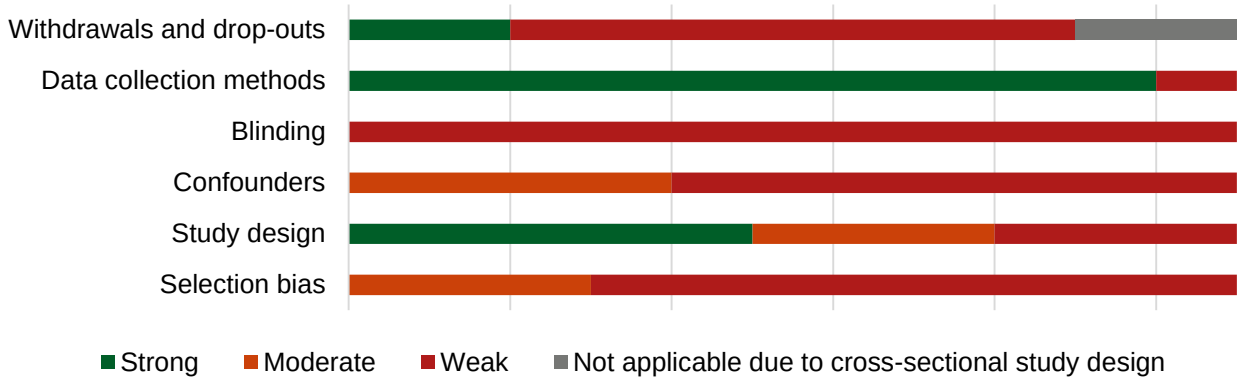
Outcome Domain 3 - Social, emotional and environmental development

The social, emotional and environmental development domain presents three related outcomes: social and emotional, nature connectedness and play.

8. Social and emotional outcomes

A total of thirteen studies included an outcome related to social and emotional development, of which four studies were controlled before and after (34, 35, 45, 58), four were uncontrolled before and after (42, 54, 70, 74), one was a controlled cross-sectional (46) and the remaining four were cross-sectional (55, 63, 64, 72). The quality across the thirteen studies reporting on social and emotional outcomes is shown in Figure 12.

Figure 12. Quality across studies: Social and emotional development



8.1. Nature-based ELC settings

Table 8 presents the results for social and emotional outcomes in eligible studies where these were reported in more than one study. This included social skills, social and emotional development, attachment (child's ability to promote and maintain positive connections with others), initiative (child's ability to use independent thought and action), and behavioural problems. For social skills

(including prosocial behaviour, social responsibility), two of the three studies reported higher scores in children who attended nature ELC (34, 45, 46). Similarly, social and emotional development was higher (all non-significant) in children who attended nature ELC compared to traditional ELC in two studies (35, 46, 58). Findings for attachment and initiative were mixed across two studies (35, 67). Children from nature ELC also exhibited higher behavioural problems across two studies (34, 45) and another study suggesting behavioural problems were lower in children who attended nature ELC (46).

In addition, resilience was assessed in one study, which found that total protective factors as reported by the parent and teacher significantly improved from baseline to follow-up (67, 70).

Table 8. Nature-based ELC vs traditional ELC on social and emotional outcomes

Study ID	Study Design	Sample size (E/C)	Favours comparison	Favours nature
Social skills				
Cordiano et al (2019)[34]	Controlled before & after	12 / 14	O	
Müller et al (2017)[45]	Controlled before & after	43 / 45		DG
Fyfe-Johnson et al (2019)[46]	Controlled cross-sectional	20 / 13		G
Social and emotional development				
Agostini et al (2018)[58]	Controlled before & after	41 / 52		G
Cooper (2018)[35]	Controlled before & after	13 / 11	O	
Fyfe-Johnson et al (2019)[46]	Controlled cross-sectional	20 / 13		G
Attachment				
Cooper (2018)[35]	Controlled before & after	13 / 11	O	
Ernst et al (2019)[67, 70]	Uncontrolled before & after	78		G
Initiative				
Cooper (2018)[35]	Controlled before & after	13 / 11	O	
Ernst et al (2019)[67, 70]	Uncontrolled before & after	78		DG
Lower behavioural problems				
Cordiano et al (2019)[34]	Controlled before & after	12 / 14	R	
Müller et al (2017)[45]	Controlled before & after	43 / 45	O	
Fyfe-Johnson et al (2019)[46]	Controlled cross-sectional	20 / 13		G

Abbreviations: E= experimental; C= comparison; N= number; ELC= Early learning and childcare.

One colour block = one study.

■ (dark green – DG) = favours nature and statistical significance (p<.05); ■ (green – G) = favours nature; ■ (orange – O) = favours comparison; ■ (red – R) = favours comparison and statistical significance (p<.05).

Controlled before & after studies – difference between experimental and control group at follow-up (unless stated). Uncontrolled before & after studies – change since baseline (unless stated). Controlled cross sectional – difference between experimental and control (unless stated). Cross-sectional – positive, negative or no association.

8.2. Naturalised playgrounds

Three studies with naturalised playgrounds included outcomes related to children's social and emotional wellbeing. Two studies implemented interventions aimed at enhancing the nature in the playground (42, 54) and the other compared free play in ELC green spaces compared to indoors (72). All studies assessed social skills and interactions, of which one found an improvement from baseline to follow-up and the other found positive associations between social interactions and free play in nature playgrounds (42, 72). However, another study reported significantly more negative teacher and children interactions (54). Children's strengths and difficulties, as measured using the strengths and difficulties questionnaire, improved from baseline to follow-up (42) and stress was lower in free play in nature playgrounds compared to free play indoors (72).

8.3. Types of natural elements

Two studies assessed whether nature was associated with aspects of social and emotional wellbeing. One study assessed whether nature was related to children's emotional wellbeing as assessed by the Leuven Well-being Scale (55). It was found that nature was a statistically significant predictor of emotional wellbeing (55). The other study assessed stress by measuring cortisol levels and found that higher quality environments (i.e. large space, vegetation, tress etc.) increased children's stress levels compared to low quality environments (64).

8.4. Garden-based interventions

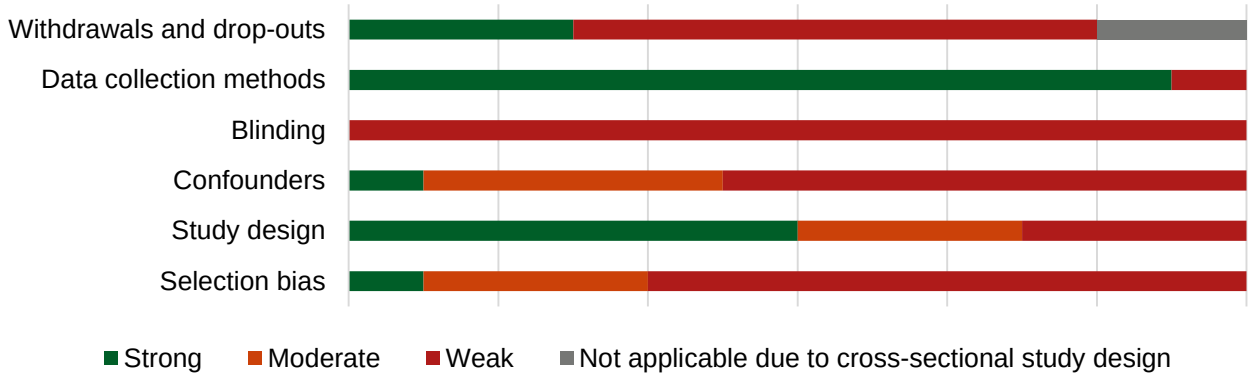
This study aimed to determine the effects of a horticulture intervention on emotional intelligence and prosocial behaviour (74). There was a significant and positive effect of the intervention on both of these outcomes from baseline to follow-up (74).

See appendix E for full results on social and emotional wellbeing.

9. Nature connectedness

Nine studies looked at the impact of attending nature ELC on nature connectedness, of which three studies were controlled before and after (43, 45, 58), two were uncontrolled before and after (76, 77), three were controlled cross-sectional (78-80) and one was cross-sectional (63). The quality across the nine studies reporting on nature connectedness outcomes is shown in Figure 13.

Figure 13. Quality across studies: Nature connectedness



9.1. Nature-based ELC settings

Table 9 presents the results for nature connectedness in eligible studies where these outcomes were reported in more than one study. Six studies assessed nature relatedness (or biophilia) and five studies reported higher scores in children who attended nature ELC, of which four studies were significant (43, 45, 77-79). One study showed no difference (80). For environmentally responsible behaviour, two studies showed a negative health impact (43, 45), although differences between children who attended nature-based ELC and traditional ELC were marginal (43, 45). One study also reported higher scores in children who attended nature ELC (78). Finally, in two studies, awareness of environment was higher in children who attended nature ELC compared to traditional settings (58, 78).

There were also improvements in knowledge and skills of nature in children who attended an educational intervention (76) and awareness of the surrounding environment was higher children who attended nature ELC (58).

Table 9. Nature-based ELC vs traditional ELC on nature connectedness

Study ID	Study Design	Sample size (E/C)	Favours comparison	Favours nature
Nature Relatedness / biophilia				
Elliot et al (2014)[43]	Controlled before & after	21 / 22		DG
Müller et al (2017)[45]	Controlled before & after	43 / 45		G
Yilmaz et al (2020)[77]	Uncontrolled before & after	40		DG
Barrable et al (2020)[78]	Controlled cross-sectional	141 / 110		DG
Giusti et al (2014)[79]	Controlled cross-sectional	11 / 16		DG
Rice & Torquati (2013)[80]	Controlled cross-sectional	68 / 46	/	/
Environmentally responsible behaviour				
Elliot et al (2014)[43]	Controlled before & after	21 / 22	O	
Müller et al (2017)[45]	Controlled before & after	43 / 45	O	

Barrable et al (2020)[78]	Controlled cross-sectional	141 / 110		DG	
Awareness of nature / environment					
Agostini et al (2018)[58]	Controlled before & after	41 / 52		G	
Barrable et al (2020)[78]	Controlled cross-sectional	141 / 110		G	

Abbreviations: E= experimental; C= comparison; N= number; ELC= Early learning and childcare.

One colour block = one study.

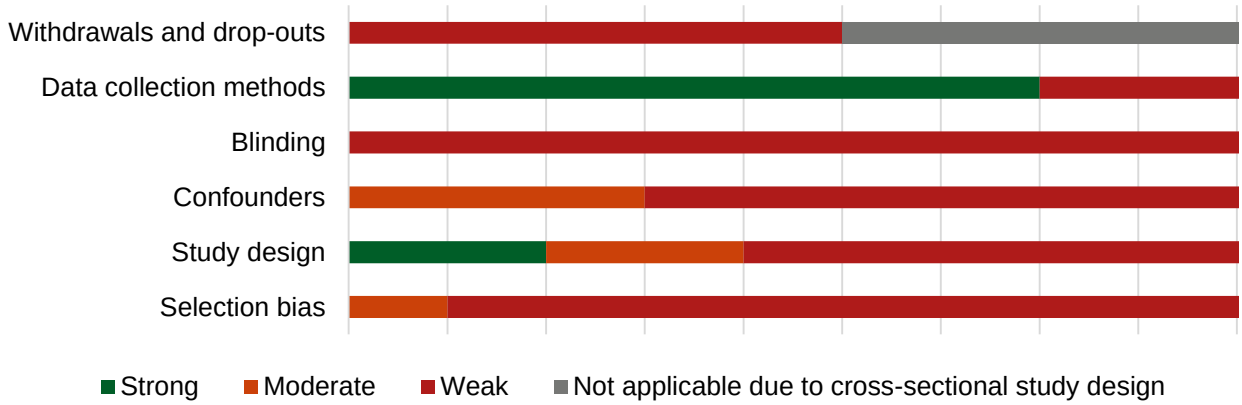
■ (dark green – DG) = favours nature and statistical significance (p<.05); ■ (green – G) = favours nature; ■ (orange – O) = favours comparison; ■ (grey – //) = favours neither nature or control, or statistics not presented.

Controlled before & after studies – difference between experimental and control group at follow-up (unless stated). Uncontrolled before & after studies – change since baseline (unless stated). Controlled cross sectional – difference between experimental and control (unless stated). Cross-sectional – positive, negative or no association.

10. Play behaviour

A total of ten studies included an outcome related to children's play behaviour, of which three studies were controlled before and after (34, 58, 67, 68), one was uncontrolled before and after (42), three were controlled cross-sectional (81-83) and three were cross-sectional (84-86). The quality across the ten studies reporting on play behaviour outcomes is shown in Figure 14.

Figure 14. Quality across studies: Play behaviour



10.1. Nature-based ELC settings

Table 10 presents the results for play behaviour in eligible studies where these outcomes were reported in more than one study. Three studies assessed play interaction, two demonstrated significantly higher play interactions in children who attended nature ELC and one showed less (34, 67, 68, 81). Findings for play disconnection and disruption were mixed (34, 67, 68).

Overall play development and pretend play was higher in nature ELC compared to traditional settings (34, 58).

Table 10. Nature-based ELC vs traditional ELC on play behaviour

Study ID	Study Design	Sample size (E/C)	Favours comparison	Favours nature
Play interaction				
Cordiano et al (2019)[34]	Controlled before & after	12 / 14	O	
Burgess & Ernst (2020)[67, 68]	Controlled before & after	84 / 24		DG
Robertson et al (2020)[81]	Controlled cross-sectional	15 / 15		DG
Play disruption				
Cordiano et al (2019)[34]	Controlled before & after	12 / 14	R	
Burgess & Ernst (2020)[67, 68]	Controlled before & after	84 / 24		DG
Play disconnection				
Cordiano et al (2019)[34]	Controlled before & after	12 / 14	R	
Burgess & Ernst (2020)[67, 68]	Controlled before & after	84 / 24		DG

Abbreviations: E= experimental; C= comparison; N= number; ELC= Early learning and childcare.

One colour block = one study.

■ (dark green – DG) = favours nature and statistical significance (p<.05); ■ (green – G) = favours nature; ■ (orange – O) = favours comparison; ■ (red – R) = favours comparison and statistical significance (p<.05).

Controlled before & after studies – difference between experimental and control group at follow-up (unless stated). Uncontrolled before & after studies – change since baseline (unless stated). Controlled cross sectional – difference between experimental and control (unless stated). Cross-sectional – positive, negative or no association.

10.2. Naturalised playgrounds

Five studies with naturalised playgrounds included outcomes related to children's play behaviours. One study was an intervention where children were measured prior to their playgrounds being modified to include more nature and again once the renovations were completed (42). The other studies compared play in natural versus traditional playgrounds (82-85). The intervention study found significant improvements in playing with natural elements from baseline to follow-up (42). There was also more risky play, solitary play and more prosocial and less antisocial behaviours observed in their play (42). There was also evidence across studies to indicate that children engaged in more creative and imaginative play. Dramatic play was significantly higher in natural playgrounds compared to manufactured ones (82). In another study, in the natural playground children engaged in longer

episodes of sociodramatic play episodes compared to children from the traditional playground and were more likely to engage in object substitutions, explicit metacommunication (nonverbal cues such as tone of voice, body language etc.) imaginative transformations (85). Functional and constructive play was also higher, but creative and imaginative play was low across playgrounds with natural areas and those with no natural areas (84). However, another study demonstrated that functional and imaginative play tended to be higher in traditional playground compared to natural ones (83).

10.3. Types of natural elements

One study looked at cognitive play (functional, constructive, exploratory, dramatic, games with rules) across natural, mixed and manufactured zones in playgrounds. Compared to the mixed and traditional zones, the natural area afforded greater dramatic, exploratory and constructive play (86).

Summary of social, emotional and environmental development

In summary, across a small number of studies, findings were inconsistent for **social skills, social and emotional development, attachment, initiative** and **behavioural problems.** Evidence for the environmental domain indicated positive associations with **nature relatedness**. Findings for **awareness of nature** and **environmentally responsible behaviour** were inconsistent. There was also an indication that **play interaction** was higher in children who attended nature ELC compared to traditional ELC. Findings for **play disruption** and **disconnection** were inconsistent.

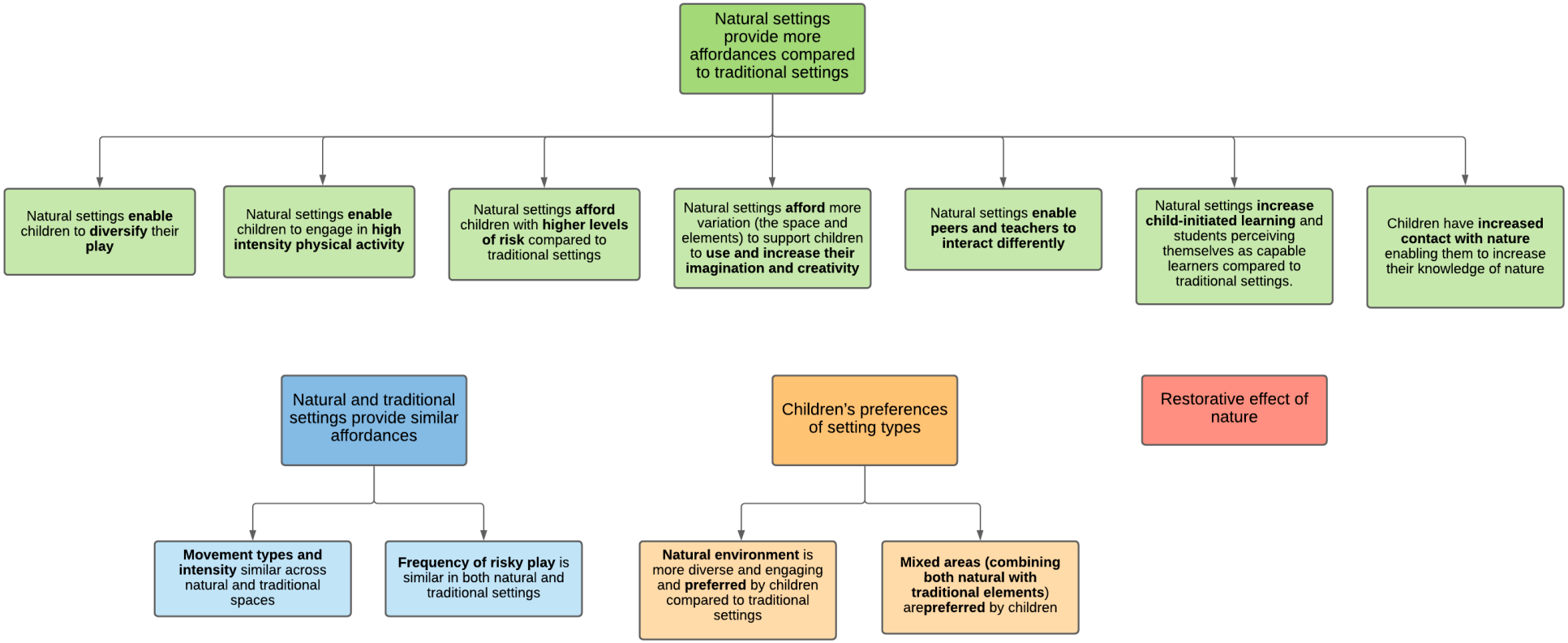
Main findings – Qualitative research studies

There were ten studies included in the thematic analysis (see Appendix C and E for characteristics and findings of included studies), of which, six studies involved nature-based ELC, three studies were naturalised playgrounds and one study included natural elements. A combination of direct observation and interviews (predominately with educators) were the most commonly used methods to collect data.

Findings from the thematic analysis indicated four main themes (presented in Figure 15):

1. Natural ELC settings provide more affordances compared to traditional ELC settings
2. Natural and traditional ELC settings provide similar affordances
3. Children’s preferences of setting types
4. Restorative effect of nature

Figure 15. Overview of the four main themes from the thematic analysis



Theme 1: Natural ELC settings provide more affordances compared to traditional ELC settings

This theme included a number of sub-themes all relating to the different affordances that nature provides compared to traditional settings, including: diversifying play; high intensity physical activity; risk; increased imagination and creativity; peer and teacher interactions; child-initiated learning and perception of learning, and increase their knowledge of nature.

The majority of studies (n=7) indicated that nature afforded children with the opportunity to engage in a range of play types (32, 33, 86-90). This is important for movement and physical activity but also supports social interaction and creativity. Related to diversifying play, two studies reported that nature enables children to engage in high intensity physical activity (89, 91). Similarly, two studies suggested that nature setting afford higher levels of risk (90, 92), but not necessarily higher frequency of risky play (see Theme 2).

> *"High physical-motor levels are created, the children jump down and run back up. They talk, shout and laugh. Three of the girls jump together and try to land in differing ways. They hold hands and try to jump together from the small knoll. There is laughter. They are eager and enduring. The small knoll has many opportunities for variation, in height and width, which invite challenges suitable for each child's resources. The children have visual, verbal and physical contact with each other. The top of the knoll provides an overview. Some find it scary the first time they try, but together they challenge each other, supporting and encouraging each other. The children decide how much they will participate and how they jump, and how they wish to solve the challenges offered by the knoll" (91).*

> *"I like playing in the fallen logs and trees on the playground; it is so much fun, but a bit scary too! I like the big pile of sticks and logs that we made – it is for another fort that is going to be really high off the ground." (92).*

Findings from this theme also indicated the importance of the natural environment for increasing imagination and creativity (86, 88, 92), increasing contact with nature (33, 88, 89) and enabling children to interact with peers and teachers differently (33, 88, 91, 92). Another theme noted that natural settings increase child-initiated learning and student perceiving them as capable learners (33, 86, 93).

> *"[CogG] has poor concentration, sees herself as the baby, finds it difficult to sit and listen to story. She is extremely lacking in confidence … shy … she won't look at you indoors. With child-led learning she is totally engrossed and remains on task. Outside is the best learning environment for her … she remains on task. When outside she will come over and say 'I like this' and 'I like doing that', 'this is my favourite place." (93)*

Theme 2: Natural and traditional settings provide similar affordances

This theme included two sub-themes a) movement types and intensity are similar across natural and traditional spaces and b) frequency of risky play is similar in both natural and traditional settings. This theme indicated that two related outcomes: physical activity and risky play are similar no matter the playground type (nature or traditional). Sandseter (2009) noted that children will always seek risk no matter the playground type, but natural areas provide the opportunity for greater risk (see Theme 1) (90). Similarly, in another study movement types and intensity did not vary in natural playgrounds compared to traditional playgrounds (32). However, this was found it one study only. Theme 1 indicated that natural settings enable children to engage in high intensity physical activity and to diversify their play.

Theme 3: Children's preferences of setting types

This theme included two sub-themes a) natural environment is more diverse and engaging and preferred by children compared to traditional settings and b) mixed areas (combining both natural with traditional elements) are preferred by children.

Two studies indicated that children preferred the natural environment compared to the traditional (91, 92) and one indicated they preferred mixed-areas (86). Based on the three studies, it appears that children at minimum prefer their playground somewhat naturalised.

> *"I like going outside and playing! I like playing with my friends, Sydney and Megan. We play hide and seek on the playground and hide in the forest in the logs and trees. I like outside [in nature] because it's so fun and I really like to play. Sometimes I play with my sister too; I like all the colours outside and all the space." (92)*

Theme 4: Restorative effect of nature

Two studies indicated the benefits of the natural environment for having a restorative effect on children (88). The experiences and exposure to nature enabled children to be energetic and engage in a variety of play types, but it was noted that these experiences supported them to sleep easier and restore their energy levels.

> *"Now it's become very difficult to finish playing. They would rather continue, and those who need to take a nap, they've had a nice, long time outdoors and nice games so they fall asleep more easily, and it affects their energy in the afternoon. Some children have very long days here. They come in the morning and stay until five o'clock; they seem to be somehow energetic and lively in the yard. This is new for us. The contrast to the previous yard is so great that the effects can be seen here very quickly." (89)*

Summary of qualitative evidence

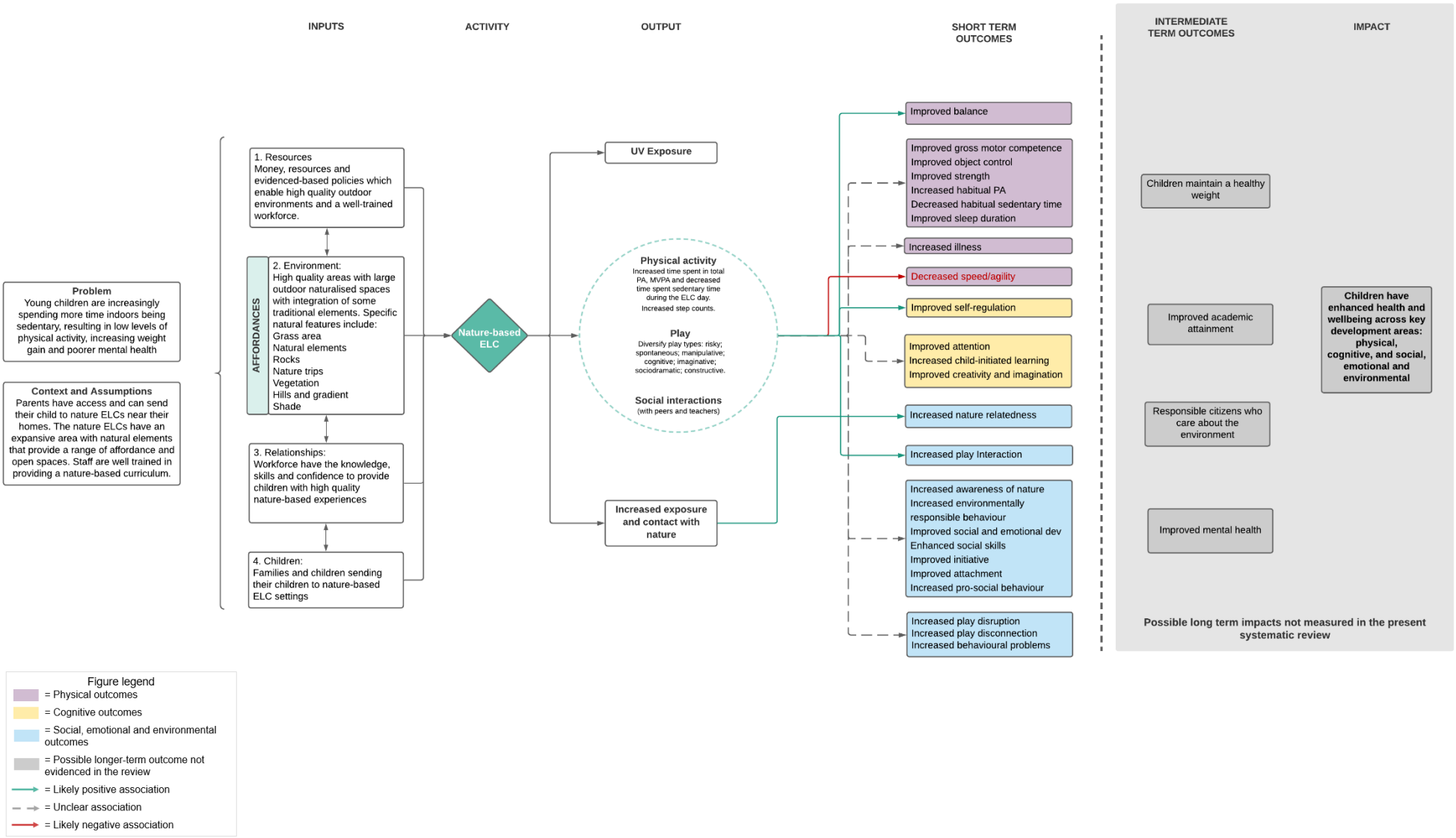
Findings from the qualitative evidence suggests that compared to traditional settings, the natural environment affords many more opportunities for children to be physically active, play and interact with their peers. Natural settings are also important for providing restoration for children. Children also prefer settings which integrate some nature either a full naturalised playground or a mixed area. A small number of studies indicated that movement and risky play were similar no matter the setting type.

Logic model

Figure 16 presents a logic model of the combined quantitative and qualitative evidence. The purpose of this logic model is to present what is required for a nature-based ELC to function (the **inputs**), what are the direct environmental and child level **outputs** and what the possible short and intermediate term **outcomes** might be for children.

We could only draw conclusions on short term outcomes because studies did not assess the longer term impacts of nature-based ELC. We propose what the longer-term outcomes and impact (grey box) might be based on other evidence (detailed in the discussion). Based on the evidence we could not draw specific conclusions on what the possible causal pathways might be, but this logic model can act as a hypothesis of what the benefits are for children and what has caused these benefits.

Figure 16. Logic model from the combined quantitative and qualitative evidence



Discussion

This systematic review aimed to synthesise existing global literature to examine whether attending nature-based ELC influenced children's physical, cognitive, and social and emotional development. This was a comprehensive review of a large body of both quantitative and qualitative evidence.

Key findings

Findings from the **quantitative** evidence suggested predominately positive associations across a number of outcome domains and sub-domains. These are summarised below.

Based on very low and moderate evidence, playgrounds which included grassed areas, vegetation, natural elements, rocks, hills or shaded areas were **positively associated** with increased **total physical activity**, **moderate-to-vigorous physical activity (MVPA)** and **step counts** and **decreased sedentary time** during ELC.

Based on low and moderate evidence, compared to traditional ELC, nature-based ELC was **positively** associated with:

- **balance**
- **self-regulation** (ability to understand and manage behaviour)
- **nature relatedness** (or biophilia)
- **play interactions**

Based on moderate evidence, compared to traditional ELC, nature-based ELC was **negatively** associated with children's **speed and agility.**

Based on very low, low and moderate evidence, compared to traditional ELC, nature-based ELC had **inconsistent** findings on the following outcomes:

- object control skills
- attention
- social skills
- social and emotional development
- attachment
- initiative
- awareness of nature
- environmentally responsible behaviour
- illnesses
- behavioural problems (such as temper tantrums or hyperactivity)
- play disruption (aggressive and antisocial behaviours in play) and disconnection (withdrawn behaviour and nonparticipation in play)

Findings from the **qualitative** (e.g. practitioner reported feedback) element of the review also generally reported positive findings:

- Nature affords many more opportunities for children to be active, diversify their play, engage in risky play, interact with peers and teachers, increase their creativity and enable child-initiated learning compared to traditional settings.
- Nature-based ELC affords opportunities for children to be physical activity, to engage in diverse types of play and interact with peers. This combination is likely to have an impact on a range of physical, cognitive, and social and emotional outcomes (logic model).
- Children prefer settings which integrate some nature either a full naturalised playground or a mixed area. A small number of studies indicated that movement and risky play were similar no matter the setting type.

Strengths and limitations of the review process & evidence

This was a comprehensive review of global **quantitative** and **qualitative** evidence on the impact nature-based ELC on children's health, wellbeing and development. The review was guided by a steering group which consisted of experts in this area from research, policy and practice. These experts were involved throughout the project to ensure relevancy across disciplines. The review also involved international co-authors who supported data screening, translation of papers and providing important country specific contexts to ensure all global evidence was captured. A total of nine databases were searched and not restricted by publication year or language. Searches extended to websites and non-published research, and

experts from policy, practice and research were contacted to provide evidence. We included all study designs and not just the “gold standard” to ensure this review provided an overview of the best available evidence to date. The review was registered to PROSPERO, an online systematic review registry, and a protocol published to BMC Systematic Reviews (22). Strict systematic review procedures were followed ensuring rigour at each step. Full text articles were screen and study quality were assessed independently by two reviewers.

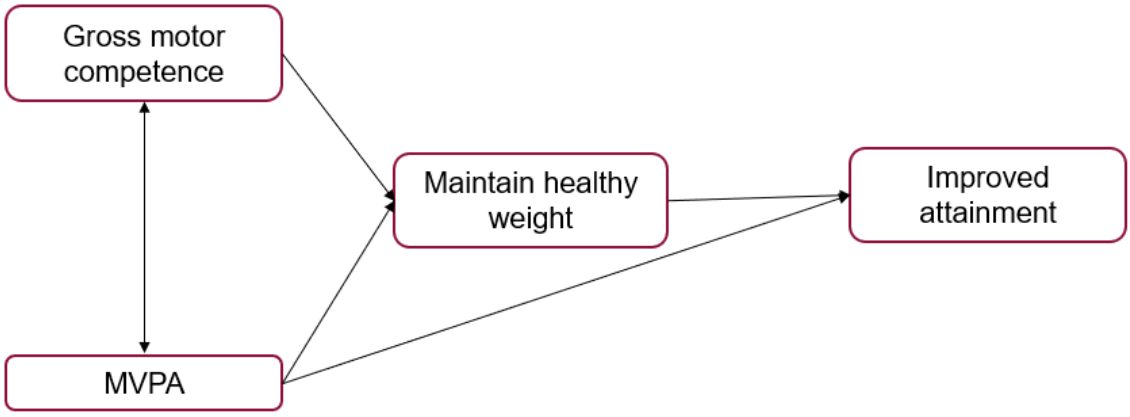
However, we were unable to screen titles and abstracts or extract data in duplicate. This was mitigated by screening 10% of the titles and abstracts, and data were checked by a second reviewer. The EPHPP tool used to assess quality was modified slightly to ensure relevancy for the present review, but this may have reduced the validity and reliability of the tool. Strength and limitations of the evidence - 59 unique studies (representing 65 articles) were included in this review, of which, nine were controlled before and after designs. Eligible studies were conducted across 15 countries ensuring global relevancy of the report. Studies also tended to use reliable and valid methods for assessing the outcomes which gives greater confidence in the findings presented. However, the majority of these studies were cross-sectional or controlled cross-sectional with small sample sizes meaning that we cannot be certain that any results found were because of the exposure. Studies were predominately rated weak because the children and ELC settings were unlikely to be representative, it was unclear whether the researchers or outcome assessors were aware of the research questions (potentially introducing bias into the study) and withdrawals and dropouts were not reported or was high.

Implications for future research

To enhance the evidence base, future research should focus on well-designed controlled studies with larger sample sizes and robust valid and reliable measures for assessing a range of physical, cognitive, social, emotional, and environmental outcomes. This would help to understand whether benefits and possible harms are a result of attending nature-based ELC and not any other factor.

The studies included in the review only explored the short-term impacts of attending nature-based ELC (see logic model) meaning that we were unable to draw specific conclusions about possible longer-term benefits. However, we know from other literature how pathways may be drawn between the short and intermediate-term outcomes. For example (see Figure 17), previous systematic reviews have suggested that gross motor competence (movements which require the whole body such as running or jumping) is positively associated with physical activity levels in childhood and adolescence (94, 95). This relationship is bi-directional as physical activity is also associated with better motor competence (14). Young children who engage in higher levels of physical activity, particularly MVPA, are more likely to have a healthy weight (14); and obesity is both a cause and consequence of low levels of MVPA (96). Finally, evidence is suggestive of MVPA being positively associated with academic attainment (97) and higher levels of obesity being associated with lower attainment (98). This is just one example, but similar pathways exist for other short and intermediate-term goals.

Figure 17. Example of a pathway between short and intermediate-term outcomes



Longitudinal studies that explore the impact of attending nature-based ELC over a longer period, e.g. into primary school, would a) enable us to understand the longer-term impacts and b) support continuity of policy in primary school education to ensure children continue to receive outdoor natural experiences. This is important because in Scotland the majority of children who attend nature-based ELC settings will transition into a traditional primary school setting that may offer predominately indoor and more sedentary education. This may result in children who attended nature-based ELC finding the transition more difficult, with any possible improvements gained from the nature-based experiences potentially diminishing over time.

Finally, the evidence base in the UK is limited. Only three studies were included in this review, of which, only one collected data in Scotland. As nature-based ELC increases in Scotland, it is important that more robust evidence (as described above) is collected to understand the impacts on children's health, wellbeing and development. Although evidence from other counties can be informative, each country has different policy, environmental and cultural contexts which may not translate. Examples include the weather, funding structure and country specific cultures (for example, aversion to being outdoors in poor weather or pervasive use of screen time). Most of the studies included in the review were conducted in the US or Australia where the climate is not comparable to Scotland. Similarly, many were also conducted in Norway which has a strong cultural emphasis on being outdoors in nature – the term "Friluftsliv" (translated "free air life") relates to the strong connection Norwegians have to nature (99). Finally, understanding the specific funding structure in Scotland is also an important factor. Many nature-based ELCs are still private meaning there is not equitable access for all children, although nature-based approaches are increasing through satellite and indoor/outdoor approaches in local authority ELCs.

Summary – Identified research gaps:

1. The evidence base is compounded by studies which have small sample sizes, are not controlled and use weak study designs (cross-sectional). This limits the conclusions we can draw from the evidence. Future research

should be higher quality with stronger controlled designs and larger sample sizes to enable us to draw stronger conclusions on the impact of nature-based ELC on children's health, wellbeing and development.

2. None of the studies included assessed the longer-term impact of nature-based ELC on children's physical, cognitive, social, emotional and environmental development. By conducting longitudinal research, we will be able to understand more about the possible impacts of nature-based ELC and the mechanisms by which improvements occur.
3. The evidence base in Scotland and the UK is limited – only one study in the review was conducted in Scotland. Given the current focus on expanding nature-based ELC provision, it is important that more high quality research is conducted in Scotland to understand specific contexts (policy, environment and culture) and benefits (or harms) to children.

Implication for policy and practice

Based on very low to moderate quality evidence (with low number of children and studies across different outcomes), findings are supportive of nature-based approaches in ELC settings, with no findings suggesting harms to children. Across most outcomes, the findings generally favour nature compared to the comparison (traditional ELC). Only one outcome, **speed and agility**, was negatively associated, and this was across a small number of studies. **Balance**, **self-regulation**, **nature relatedness** and **play interactions** were positively associated with nature-based ELC compared to traditional ELC.

In Scotland there are three delivery models: outdoor (or nature-based ELC); indoor/outdoor (children move freely from indoors to outdoors); and satellite (taken to another setting for nature-based experiences). Table 11 presents the type of ELC provided per study for each outcome category where there were positive associations. The majority of studies used an outdoor approach, five studies used a satellite approach and one indoor/outdoor. It is important to highlight that irrespective of approach, in studies with favourable outcomes, children were exposed to large amounts of nature on almost a daily basis. For example, for studies that used a satellite approach, children had daily trips (18, 43, 59, 60, 79) meaning children spent most of their time outdoors in nature. Similarly in the study with the indoor/outdoor approach (35), children were allowed outdoors when they wanted but also participated in a weekly forest programme. It is important to highlight that these studies were conducted in countries which may have a better climate than Scotland meaning that it is perceived to be easier to be outdoors daily. However, across indoor/outdoor and satellite settings in Scotland, with support from the practitioners, it might be useful to quantify how regularly children are outdoors in nature to understand whether this can be improved. Findings from this report are important in providing evidence for expansion of free ELC entitlement; however, if nature-based approaches continue to increase in Scotland, these should be supported by robust research (as detailed in the previous section) to understand more about the impacts and any possible causal pathways.

Table 11. Positive outcomes grouped by type of nature-based ELC provision.

Outcome	Study	Description of nature-based ELC	Scottish ELC category	Discussions and implications
Balance	Ene-Voiculescu & Ene-Voiculescu (2015), Norway [18, 59, 60]	Children used the forest next to the ELCs every day for 1-2 hours throughout the year when they attended kindergarten. The small forest (7.7 hectares) consisted of mixed woodland vegetation, some open spaces of rocks and open fields and meadows in between. Occasionally they used the outdoor playground inside the ELCs.	Satellite	Nature-based ELC was significantly positively associated with balance in two out of three studies. All three studies used highly naturalised settings which are likely to afford opportunities for children to develop their balance (rocks, logs etc). It was unclear why the third study (Lysklett) was not positively associated with balance given the exposure was similar across these studies.
	Scholz & Krombholz (2007), Germany [62]	Forest kindergarten.	Outdoor	
	Lysklett et al (2019), Norway [61]	Nature-based ELCs located close to a large recreational area, with woods, lakes and tracks just outside the city centre. They used the nearby nature area for hiking and playing least three times, per week	Satellite	
Self-regulation	Cooper (2018), England [35]	Forest school sessions run by two trained leaders which operate for 10 week cycles on Tuesday AM and PM (2 hours each). Children attend either the AM or PM session. The forest school consists of trees and vegetation, a seating area made from logs, a mud kitchen using old crates and a tyre, a greenhouse and pond. The forest school is located on site and when children do not have forest school sessions outdoors, they have a " free flow" environment where children are allowed outside when they want.	Indoor/ outdoor	Nature-based ELC was positively associated with self-regulation in three studies (significant in two). All three studies had a high exposure to nature where children spend the majority of their time outdoors.
	Ernst et al (2019), USA [68, 70]	The ELCs utilised a combination of wild natural settings spaces that were minimally managed and natural playscapes designed specifically for nature play. The majority of time spent was in free play outdoors in unmaintained or minimally maintained natural settings regardless of weather conditions (approximately four to five hours per day). Children at both groups had one to two hours of daily outdoor playtime (weather permitting) in a maintained outdoor space that contained playground equipment.	Outdoor	
	Müller et al (2017), Canada [45]	Nature kindergarten.	Outdoor	
Nature relatedness	Müller et al (2017), Canada [45]	Nature kindergarten.	Outdoor	Nature-based ELC was positively associated with nature relatedness in

	Elliot et al (2014), Canada [43]	A two-year pilot project in which 22 students would spend the mornings from 9:00 to 11:45 outside their school, exploring their local natural environment.	Satellite	three studies (significant in four). These studies used a combination of outdoor and satellite sessions, indicating that any increased exposure to nature may improve nature relatedness. One study (Rice & Torquati) found neither favourable nor unfavourable associations.
	Yilmaz et al (2020), Turkey [77]	Children visited a natural, unstructured area for one day in a week for four consecutive weeks. The education programme consisted of 12 semi-structured activities (3 per week). In addition, children also had 30 minutes' walk near a natural pond when they visit the setting each week and each week, children had 30 minutes unstructured free play time to discover the natural environment.	Satellite	
	Barrable et al (2020), UK (England, Scotland, Wales) [78]	ELCs that have a continuous outdoor provision, with no permanent indoor access and children are outdoors for the whole duration of the ELC day.	Outdoor	
	Giusti et al (2014), Sweden [79]	ELCs were assessed on their frequency of natural experiences. Each ELCs was ranked according to the highest frequency of use of the greatest variety of nature experiences in its surroundings. This included ten ELC's with the most frequent use of all nature experiences.	Satellite	
	Rice & Torquati (2013), USA [80]	The nature ELCs featured: vegetation, gardens, areas for digging in soil, sand, and "loose parts" (sticks, seeds, pinecones etc) and other naturally occurring objects that children used in their play. Climbing structures and pretend play structures such as a boat or a playhouse were also included.	Outdoor	
Play interactions	Burgess & Ernst (2020), USA [67, 68]	See Ernst et al (2019)	Outdoor	Nature-based ELC was significantly positively associated with play interaction in two studies. These settings are highly naturalised where children spend most of their time outdoors. One study found a negative association (Cordiano); however, in this study children also spend most of their time outdoors in nature.,
	Robertson et al (2020), Australia [81]	ELC located in a rural area and consisted of a small traditional playground area (sand pit, obstacle course etc.) and a larger open ended nature area consisting of trees, shrubbery, grass, natural loose-parts). It has a highly naturalised area towards the rear that was rich in natural elements including small and large shrubbery, and larger tree and vegetation	Outdoor	
	Cordiano et al (2019), USA [34]	Outdoor ELC programme involved children spending five mornings per week at the school's outdoor campus. The children were outdoors in the forest for 90% of the school day.	Outdoor	

There are key environmental features that appear particularly important for increasing total PA and MVPA, reducing sedentary time, supporting risky play and diversifying play types, enabling different human interactions and supporting creativity. These tend to be a combination of grassed areas, vegetation, natural elements, grass, rocks, hills and shaded areas. It is important, where possible, that ELC settings afford these natural features, possibly with a combination of traditional elements (such as open space) which may enhance other outcomes. Furthermore, some qualitative evidence highlighted that children may prefer playgrounds with a mixture of nature and traditional spaces. This evidence builds on the Scottish Government's "Out to Play - creating outdoor play experiences for children: practical guidance" (20) and could support a future revised version of this document.

The majority of studies included in the review did not look at the role of the practitioner specifically. However, the evidence suggests that nature is likely to afford opportunities for children to interact differently with their peers and practitioners. Practitioners are likely to influence the experiences children have in nature-based ELC by ensuring that children have opportunity to be outdoors in nature to enable them to play, be physically active and interact with each other. It is important that practitioners understand the importance of promoting being outdoors in nature and related benefits possibly through targeting training and removing barriers.

Suggested recommendations

1. Ensure that ELCs have a rich and varied environment that includes a combination of grassed areas, vegetation, natural elements, rocks, hills and/ or shaded areas. These appear particularly important for encouraging physical activity, diversifying play types and enabling human interactions which are important for childhood development.

2. Ensure that all children can access nature across all setting types: outdoor; indoor/outdoor; satellite. In studies where there was a likely association, evidence from this review suggested that both indoor/outdoor and satellite approaches provided children with high exposure to nature. Therefore, it is important to understand **how much and how regularly** (daily, weekly, etc) children are exposed to/engage with nature across each setting.

3. To aide future policy development in Scotland, it is important that researchers work collaboratively with practitioners and policy makers to establish **what** child and ELC level outcomes should be measured and **how** we can best collect data on these. By embedding robust evaluation practices, we can generate stronger evidence on the impact of nature-based ELC in Scotland.

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List of abbreviations

BMI = Body mass index
CARS = Children's Activity Rating Scale
CPM = Counts per minute
EPHPP = Effective Public Health Practice Project
GRADE = Grading of Recommendations, Assessment, Development and Evaluation
ELC = Early learning and childcare
ERIC = Education Research Information Centre
Mins = Minutes
MVPA = Moderate to vigorous physical activity
OSRAC-P = Observational System for Recording Physical Activity in Children-Preschool
PA = Physical activity
PI(E)COS = Population, Intervention or Exposure, Comparison, Outcome, Study design
Study ID = Study identifier
SWiM = Synthesis without Meta-analysis
UV = Ultraviolet

Glossary

Term	Definition
Randomized control trial (RCT)	A study in which a number of similar people are randomly assigned to 2 (or more) groups to test a specific drug, treatment or other intervention. One group (the experimental group) has the 'intervention' being tested (e.g., nature-based ELC), the other (the comparison or control group) has an alternative intervention, a dummy intervention (placebo) or no intervention at all (i.e. usual practice such as traditional ELC). The groups are followed up to see how effective the experimental intervention was. Outcomes are measured at specific times and any difference in response between the groups is assessed statistically.

Randomisation	Assigning people in a research study to different groups without taking any similarities or differences between them into account. For example, it could involve using a random numbers table or a computer-generated random sequence. It means that each individual (or each group in specific types of designs) has the same chance of having each intervention. This is a very important step to reduce bias in the cause-effect relationship by distributing measured and unmeasured participant characteristics randomly between groups.
Controlled Before & After study (CBA)	The allocation of participants to the intervention or control group is not randomised. The key outcome is assessed among the same study population before and after receipt of the intervention. The change in outcome is compared with the same outcome measurements and changes in a suitable comparison group acting as a control group who have not received the intervention. The key outcome is assessed at the same time points in the intervention and the control group. This design may be referred to as a non-randomised controlled trial or quasi-experimental study
Uncontrolled Before & After Study	Similar to the CBA design but with one major difference: no control group is included to act as a comparator for those who received the 'intervention'.
Longitudinal study	A study of the same group of people at different times. This contrasts with a cross-sectional study, which observes a group of people at one point in time.
Retrospective study	A research study that focuses on the past and present. The study examines past exposure to suspected risk factors for the disease or condition. Unlike prospective studies, it does not cover events that occur after the study group is selected.
Cross-sectional study	A 'snapshot' observation of a group of people at one time point. Can be a study that examines the relationship between an exposure (e.g. nature-based ELC or natural elements) and outcomes of interest (e.g. health indicator) at one time point.
Controlled cross-sectional study	A study that examines the relationship between the exposure and outcomes of interest at one time point in two or more groups (e.g. naturalised playground and traditional playground).
Statistical Significance	A statistically significant result is one that is assessed as being due to a true effect rather than random chance. See P value.
P-value	The p value is a statistical measure that indicates whether or not an effect is statistically significant. For example, if a study comparing 2 treatments (e.g. nature-based ELC vs traditional ELC) found that 1 seems to be more effective than the other, the p value is the probability of obtaining these results by chance. By convention, if the p value is below 0.05 (that is, there is less than a 5% probability that the results occurred by chance), it is considered that there probably is a real difference between treatments. If the p value is 0.001 or less (less than a 0.1% probability that the results occurred by chance), the result is seen as highly significant. However, a statistically significant difference is not necessarily practically significant. For example, nature-based ELC might increase children's levels of physical activity statistically significantly more than traditional ELC. But, if the difference in the average time spent in physical activity is 1 minute, it may not be practically significant. If the p value shows that there is likely to be a difference between treatments, the confidence interval describes how big the difference in effect might be.

[1] available from https://www.nice.org.uk/Glossary

Table of figures

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