

Review Article

A narrative and systematic review of the behavioural, cognitive and emotional effects of passive nature exposure on young people: Evidence for prescribing change

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ABSTRACT

Health care providers are increasingly prescribing nature exposure to treat emotional, behavioural and cognitive difficulties of children who experience challenging personal and social circumstances. Correlational studies suggest these prescriptions have short-term potential. The capacity for nature exposure to promote long-term change is unclear. This paper presents the results of a systematic review exploring the ability of the natural environment to promote behavioural, cognitive or emotional change in young people. A systematic review of CINAHL, Medline, Scopus, Embase, PsychInfo produced 59,221 papers. Six met the review criteria. Synthesis suggested that passive nature exposure promotes positive changes in attention, memory and mood; little is known about behavioural changes and long-term outcomes. It is unknown how these changes translate to real world outcomes for children and how the effect of nature varies across different age groups. Overall, prescribing nature exposure for children appears advantageous. Randomised control trials and diverse qualitative methods using reliable outcome measures are needed to draw definitive conclusions.

1. Introduction

In 1941, Marvin M. Brooks addressed the American Nature Study Society in Dallas, Texas, to discuss the 'New York syllabus', which focused on nature study (Brooks, 1942). The purpose of Brooks' paper was to recommend the benefits of nature study for a child's ability to physically and psychologically adjust if war compelled a move from the city to the country. Recommendation 18 noted the importance of "growing flowers and sample vegetables as gifts to decorate homes to cheer up parents, friends and neighbours". This was one of the earliest propositions that exposure to nature will improve mood. Many of the

purposes Brooks' (1941) outlined are now entrenched in an evidence base including: conservation (Larson, Whiting, & Green, 2011), the development of creativity (van Rompay & Jol, 2016), nutrition education (Berezowitz, Bontrager Yoder, & Schoeller, 2015) and scientific education (Fägerstam & Blom, 2013). Since his address, there has been much research to suggest the benefits of nature across cognition and behaviour.

Increases in emotional and behavioural disorders in young people (Konowalek & Wolanczyk, 2018; Safer, 2018) are a trend that has been linked to growing urbanisation (Butler, Kowalkowski, Jones, & Raphael, 2012; Rudolph, Stuart, Glass, & Merikangas, 2014), reliance

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on psychopharmacological treatments (Rose, 2015) and the predominance of medicalised interventions (Faber Taylor & Kuo, 2011). To counter problematic urbanisation, urban planners are increasing the presence of nature in city design (Lennon & Scott, 2016). Furthermore, a growing evidence base is establishing that increased exposure to nature can favourably impact the health of young people (Gill, 2014; McCormick, 2017; Ming Kuo, 2013), and this effect has been compared to pharmacological treatments (Faber Taylor & Kuo, 2009). There has been a resurgence of interest in the benefits of exposure to nature, resulting in its prescription to children by some primary care providers in the US (Coffey & Gauderer, 2016). Therefore, it is important the effects of nature exposure on children are properly understood.

The purpose of this paper is to review the impact of passive nature exposure on child health and wellbeing. There are a variety of ways to engage with nature and research needs to specifically identify which form of engagement produces which benefit. It is important this passive engagement with nature is understood in isolation as active engagements with nature such as in sport or therapies includes several confounding variables. The structure of this paper therefore is as follows. First, we present a narrative review of the literature which includes an overview of previous reviews of nature-based research and a brief review of ‘active’ uses of nature. Then, it reviews the literature which explores differences between natural and non-natural environments and their effect on young people. We then report on our more specific systematic review of pre-post or longitudinal studies that have tested the ability of passive exposure to nature to facilitate change to the health of young people.

2. Narrative review of nature-based research

Previous reviews have investigated the impact of the natural environment on health. Although not exclusive to young people, Ming Kuo (2013) concluded that any type of exposure to nature, in any quantity, was beneficial and “the greener the better”, but also that even “measly, unexciting forms of nature” are worthwhile. McCurdy, Winterbottom, Mehta, and Roberts (2010) reviewed nature’s effects on young people and came to a wide range of conclusions including: nature can benefit attention-deficit hyperactivity disorder (ADHD) symptoms, improve wellbeing, decrease stress, and decrease childhood obesity risks through increased physical activity.

Chawla (2015) reviewed the outcomes of nature engagement on children in terms of a ‘capabilities approach’. Specifically, Chawla investigated the benefit of engaging with nature on children’s wellbeing in terms of its effects on their ability to flourish, or fully realise their capabilities. In an extensive review, she listed several physical outcomes of exposure to nature but also identified cognitive functioning and self-control (e.g. ADHD symptoms, academic outcomes) and physiological wellbeing (e.g. mental and emotional health, depression, happiness, stress). She emphasised that the risks of prescribing nature exposure are minimal and repeated Frumkins’ (2012) call to action by recommending natural areas be available throughout society, around homes and schools, and as trails and passageways such as in greenways and parks.

McCormick (2017) reviewed the association between green space and child mental wellbeing. Including 12 studies focused on children below 18 years, she found that access to nature was associated with several outcomes including mental wellbeing, attention, social support, behaviour, school performance and the management of ADHD symptoms. She recommended that health care providers should promote outdoor play and that green spaces should be developed in schools and hospitals. However, she concluded that the question of how access to nature may affect children over time remains unanswered.

To summarise, these reviews suggest that nature exposure promotes the health and wellbeing of young people in the short-term. Although the long-term benefits are not clear (Gill, 2014; McCormick), the risks of prescribing nature exposure are minimal making it worth continuing

(Chawla, 2015). Further, care providers and policy-makers are increasingly recommending exposure to nature for young people (Coffey & Gauderer, 2016). Consequently, establishing and understanding the evidence-base for the effectiveness of passive exposure to nature on the long-term health and wellbeing of young people is important. Establishing definitive conclusions around the long-term effectiveness of passive nature exposure for young people is not possible as a rigorous synthesis of evidence has yet to be conducted. No reviews have yet focused on how passive exposure to nature may affect long-term outcomes on the behaviour and/or emotional wellbeing of young people. This paper will (i) establish the state of the evidence-base for passive nature exposure, (ii) highlight research gaps and (iii) provide a systematic review of how passive nature exposure may promote change over time in young people.

2.1. Active and nature-integrated interventions

Passive relationships with nature are those where activities take place in a natural environment which itself is not actively integrated or consciously used in an activity. In contrast to this approach, there are several activities and therapies where nature plays an important active role. For example, horticultural therapy, wilderness therapy and adventure therapy deliberately use nature as a therapeutic tool and are often used as an adjunct to other therapies. There are several reviews exploring wilderness or adventure therapy that have documented positive changes in mental health, emotional health, social health, and in behaviours such as substance abuse, recidivism and in academic success (Bedard, Rosen, & Vacha-Haase, 2003; Bowen, Neill, & Crisp, 2016; Fernee, Gabrielsen, Andersen, & Mesel, 2017; Wilson & Lipsey, 2000). However, it remains unknown as to whether this impact was associated with nature itself, physical activity or social connections. Other studies have focused on the impact of gardens/gardening and have demonstrated positive outcomes including improved social relationships, family connections, mental-health, learning, and self-esteem (Blair, 2009; Jiang, 2014; Ohly et al., 2016). Forest schools are growing in popularity. These schools use nature in the teaching and learning material. Reported effects include increased self-confidence and self-esteem, social skills, language and communication, motivation to learn and physical skills (Cumming & Nash, 2015; Elliott & Chancellor, 2014; O’Brien, 2009; Smith, Dunhill, & Scott, 2017). These interventions represent the integrated use of nature, where the relationship with nature is an active explicit component of the program and is used as a learning tool. In therapeutic contexts, nature has been integrated into practice by extending the counsellor-client relationship to include the human-nature relationship and using nature and natural materials as props (Davis & Atkins, 2009; Sackett, 2010; Swank & Shin, 2015). Case studies with young children (6–8 years old) report behavioural improvements, improved on-task behaviour, reduced negative attention-seeking and mood improvements associated with nature-based therapy (Swank & Shin, 2015). However, it is equally likely that the counselling relationship may have produced similar results using non-natural tools or props (e.g., play therapy).

In these studies, nature is so inextricably combined with other activities that it is impossible to determine what factors account for positive impacts. To advance understanding of nature-based therapies, Fernee et al. (2017) highlighted the need to isolate the role of nature alone; providing impetus for this review. Although any exposure to nature may be useful (Ming Kuo, 2013), it is important to determine the effects of passive exposure to nature and then determine the added benefit gained from active interventions.

2.2. Research with passive-nature exposure as the primary focus

Promisingly, some research has suggested that increasing passive nature exposure in childhood may have immediate cognitive, behavioural and emotional benefits in children that may even translate into

benefits in adulthood (Jones, 2012). Attention Restoration Theory (ART) states that natural environments are ideal for the support and restoration of attentional function (Kaplan & Kaplan, 1989; Kaplan, 1983). Not surprisingly then, nature exposure is often sought as a potential solution for children with ADHD. Indeed, parents report their children as having less severe symptoms when they are in greener play areas and as functioning better after activities in greener settings (Faber Taylor & Kuo, 2011; Faber Taylor, Kuo, & Sullivan, 2001). Kuo and Faber Taylor (2004) presented evidence from a nationwide sample of 452 households finding this result was stable across age, sex, income, community, geographic region and diagnosis. Faber Taylor and Kuo (2009) studied the effect of nature exposure on a sample of young people diagnosed with ADHD. They compared performance on several attention tasks before and after a walk in either i) urban park, ii) neighbourhood residential area and iii) downtown. They found performance of the digit span backward test significantly improved following a walk in a park but not after walking in the other two settings. Interestingly, at the time of publishing, they reported comparable effect sizes to two pharmaceutical treatment studies, suggesting that exposure to nature may have a significant therapeutic benefit on cognitive performance.

Schutte, Torquati, and Beattie (2017) studied young people without ADHD. They also wanted to examine the effects of nature on restoration of attention, working memory and inhibition in younger students than previous studies (67 students, age range of 4–8 years). They concluded that attentional control was better following a nature walk than an urban walk but that there was no difference in inhibition. Effects on working memory were only partially significant but they did find a difference where boys performed better on spatial working memory task following a nature walk and girls showed no difference. Due to the lack of a baseline measure following attention depletion tasks, they could not conclude that the observed effects were due to the restorative effects of nature. Alternatively (or perhaps additionally), the urban walk was more depleting of attentional capacities. The study could not distinguish between these two mechanisms. Amoly et al. (2014) found similar outcomes in a study of 2111 school children where ADHD and other behavioural symptoms were associated with less use of green and blue space. Finally, Markevych et al. (2014a) found distance to green space was positively associated with greater levels of hyperactivity problems in males in a sample of 1932 children.

Wells and Evans (2003) analysed parent-report and child self-report rating to determine the effects of nearby nature on the impact of life stress among children in a rural area. The findings suggested that higher levels of nearby nature provided a greater buffer to life stressors for children. Similarly, Feda et al. (2015) found access to parks was a buffer against stress for urban children. Furthermore, a recent twin study found evidence that access to green space was linked with less depression (Cohen-Cline, Turkheimer, & Duncan, 2015) although they did not find the same association with stress. Contrastingly, Feda et al. (2015) found surrounding green space was associated with less stress. This discrepancy may be linked to the different ways of measuring surrounding green space (Cohen-Cline et al., 2015); be it distance to green urban parks (Feda et al., 2015) or satellite imagery (Cohen-Cline et al., 2015). In addition, Li and Sullivan (2016) found a greener setting promoted recovery from stress more than a non-natural setting.

In terms of behavioural and emotional problems in children, Flouri, Midouhas, and Joshi (2014) concluded that increased neighbourhood green space could be advantageous for emotional well-being in young, urban children from a low-socioeconomic background. Joung et al. (2015) supported this finding, showing that negative emotions were lower when children were in the forest, compared to an isolated but urban setting. Markevych et al. (2014a) reported that living further than 500 m from urban green space was related to more behavioural problems than living within 500 m. Finally, Faber Taylor, Kuo, and Sullivan (2002) reported that girls (mean age 9.6 years) performed better on concentration, impulse inhibition and delay of gratification

measures when parents rated the naturalness of view from home as higher. Interestingly, they did not find the same for boys but suggested that boys may spend less time inside the home and therefore access to nearby green spaces may be more important to them. This suggestion is important as it echoes other research finding that access to green spaces may be regulated differently for boys and girls by parents (Fullagar & Harrington, 2009). In conclusion, evidence suggests some important associations between local nature, social context and young people's behavioural and emotional development. However, the mechanism by which this association occurs remains unknown.

Research has also investigated the impact of green space on academic performance. Matsuoka (2010) reported data from 101 schools in Michigan and demonstrated that views of greenery from a school were linked with positive performance and that featureless environments had the opposite association. Similarly, Wu et al. (2014) reported on a large-scale investigation into the relationship between greenness and academic performance. Their study controlled for variables such as socio-economic status and geography and found that increased greenness during assessment periods was positively associated with performance in both maths and English. Hodson and Sander (2017) enhanced our understanding of these associations, showing that tree canopy in particular, not shrubbery or grass, was associated with reading performance at school. Conversely, there was no association between greenery and maths performance.

Richardson and Murray (2017) focussed on the effect of the environment on speech and language development, finding more diverse language use in natural settings over both indoor and outdoor settings. They partly explained this finding through the concept of increased child-led learning during outdoor play compared to adult-led learning in the indoor and outdoor classrooms conditions. Similarly, Fägerstam and Blom (2013) found that students 13 to 15 years old who participated in an outdoor biology lessons recalled more specific details about the activities and content of lessons and used more course-related words than students in indoor lessons. They did not, however, perform better on an essay style assessment 6 months following class.

Finally, creativity has been found to be greater in natural settings, particularly those that are 'unpredictable' or 'spacious', or a combination of these two. These environments resulted in higher levels of creative performance and self-perceived creativity in 13 to 15-year olds (van Rompay & Jol, 2016). This finding suggests that performance in creative areas, such as writing or problem-solving may improve in natural settings.

2.3. Negative findings

The consistency of the positive findings provides persuasive evidence for the benefits of children's access to and interaction with nature. Nevertheless, it is important to report non-significant or negative outcomes. Gidlow and Ellis (2011) presented qualitative data from a disadvantaged urban setting in the UK. Anti-social behaviour, including concepts of 'ownership' over local green spaces, created stress around park usage rather than the park being used as a community space for wellbeing. Fullagar and Harrington (2009) presented findings from a similar Australian setting. Parents in their study reported that although bike paths were patrolled by police, they prevented their children from using them alone for fear of crime. Similarly, Tilt (2010) reported that some individuals found vegetated environments limited their visual and physical access and therefore were perceived as unsafe (see also Nasar & Jones, 1997).

Culturally different relationships with nature are not recognised in current literature and a culturally narrow research base exists. Approaches to nature-based research that can explore the diverse relationships with the natural environment may offer new insights, such as a 'decolonising' perspective (Lavelle & Poole, 2010; Walker, Fredericks, Mills and Anderson, 2013). Bixler and Floyd (1997) specifically aimed to explore negative perceptions of nature and found that

those who scored high on fear expectancy, disgust sensitivity and desire for modern comforts were more likely to prefer urban environments and manicured parks to wilderness settings. In support of this finding, Zheng, Zhang, and Chen (2011) found that preference for nature was influenced by parental education level and being a city or non-city dweller.

3. Systematic literature review

We now specifically explore pre-post or longitudinal studies to gauge the state of evidence that passive exposure to nature may facilitate change in young people's behaviour, cognition or emotions. To do this a systematic literature review was conducted.

3.1. Method

3.1.1. Search strategy

The databases Medline, CINAHL, Embase, PsychInfo and Scopus were searched for peer-reviewed literature on 30th May 2017 and backwards and forward searches were re-run in February 2018. The search string was separated into two domains 'nature' and young people'. The following nature search terms (Embase example) were used:

"Nature exposure" OR "Nature therap*" OR "Nature assist*" OR "Nature based" OR "Therapeutic Landscape" OR "therapeutic environment" OR "Natur* setting" OR "Green care" OR "Green space" OR "Natur* experience*" OR greenness OR Wilderness OR Bush OR Garden* OR park OR parks OR Forest OR Wood OR Woods OR "Green play" OR Ecotherap* OR countryside

And the following young people search terms (Embase example) were used:

Adolescen* OR Child* OR youth* OR "school-aged" OR "school aged" OR school* OR "school children" OR kid OR kids OR student* OR young OR teen*

The fields searched in each database and the number of articles identified are outlined in Table 1.

3.1.2. Eligibility criteria

Studies were included if that they met the following criteria:

- Sample of youth <18
- Activities in a natural setting or focus on effects of nature
- Behavioural, cognitive or emotional outcomes
- Pre/post with control condition or longitudinal design
- Did not use active nature programs
- Did not involve only a descriptive/correlational design
- Did not include additional interventions such as professional therapy
- Did not include simulated nature via photos or videos whilst indoors

3.1.3. Screening and study selection

The review process was completed according to the PRISMA 2009 guidelines (Moher, Liberati, Tetzlaff, Altman, & Group, 2009). Articles were screened in the following stages, (a) duplicate screening immediately following the initial searches using the software-based

Table 1
Database search information.

Database	Fields searched	Articles identified
MEDLINE	Title and Abstract	6542
CINAHL	Title and Abstract	1828
Embase	Title and Abstract	7926
PsychInfo	Title and Abstract	4469
Scopus	Title, Abstract and Keywords	38,456
Total		59,221

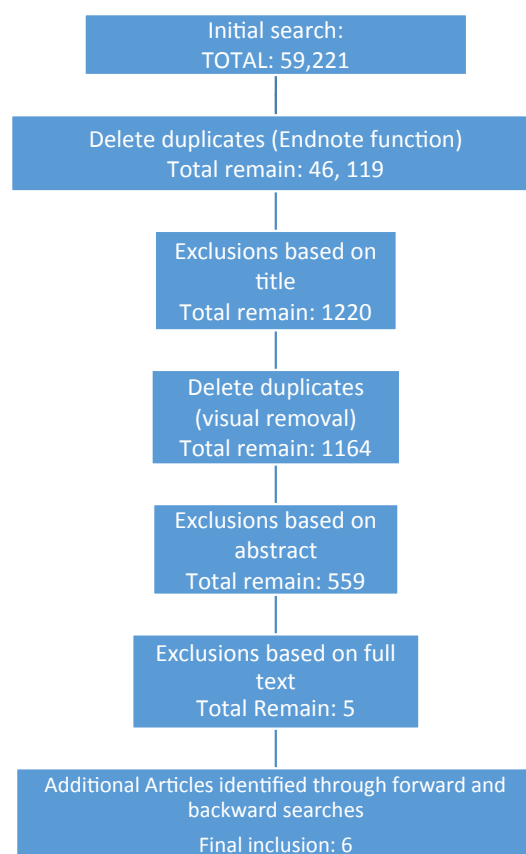


Fig. 1. Article selection process.

reference management system Endnote© (Reuters, 2013), (b) exclusions made based on title check, (c) second duplicate screening based on visual search, (d) exclusions made based on abstract, and finally (e) exclusions made based on full text. A single researcher reviewed the titles and abstracts of sources (MN). After, two researchers (MN and AL) completed the full-text review of sources. Any discrepancies relating to the final inclusion of articles were rectified via a consensus from the entire research team. The screening process can be seen in Fig. 1.

3.1.4. Data extraction and synthesis

Data was extracted and entered into a characteristics of study table in Microsoft Excel. This table was populated with information on the following from each study: (i) citation, (ii) sample, (iii) intervention or study target, and (iv) outcomes. In terms of 'intervention or study target' categories were broken down into: (i) description of nature exposure, (ii) description of control condition, (iii) description of type of nature, (iv) method and (v) analysis (Pickering & Byrne, 2014).

3.1.5. Quality appraisal

A rating of the methodology of included studies was informed using the quantitative versions of the McMasters methodological rating tool (Law et al., 1998). A single researcher (MN) completed a quality appraisal of studies and any queries or areas of uncertainty were rectified by the wider research team. The final assessments are presented in Table 2.

3.2. Results

After exclusion according to the criteria outlined above, six studies were included for final review.

Table 2
Quantitative studies review form.

Item	Dadvand et al. (2015)	Kuo et al. (2018)	Reed et al. (2013)	Roe and Aspinall (2011)	Wells (2000)	Wood et al. (2014)
1. Was the purpose clearly stated?	1	1	1	1	1	1
2. Was relevant background literature reviewed?	1	1	1	1	1	1
3. Was the sample described in detail?	1	1	1	1	1	1
4. Was sample size justified?	1	1	1	1	1	1
5. Were outcome measures reliable?	1	1	0	1	1	1
6. Were outcome measures valid?	1	1	1	1	1	1
7. Intervention was described in detail?	1	1	1	1	1	1
8. Contamination was avoided?	1	1	0	0	0	0
9. Cointervention was avoided?	1	1	0	1	0	0
10. Results were reported in terms of statistical significance?	1	1	1	1	1	1
11. Were the analysis method (s) appropriate?	1	1	1	1	1	1
12. Clinical importance was reported?	1	1	1	1	1	1
13. Drop-outs were reported?	1	1	0	0	1	1
14. Conclusions were appropriate given study?	1	1	1	1	1	1
	14/14	14/14	10/14	12/14	12/14	12/14

For each criterion: 1 = criterion met; 0 = criterion not met or unclear if met.

3.2.1. Characteristics of studies

Three of the six studies were conducted in the United Kingdom (Reed et al., 2013; Roe & Aspinall, 2011; Wood, Gladwell, & Barton, 2014) two in the United States of America (Kuo, Browning, & Penner, 2018; Wells, 2000), and one in Spain (Dadvand et al., 2015).

Three of the six studies involved passive exposure to nature in a school setting (Dadvand et al., 2015; Kuo et al., 2018; Reed et al., 2013). One study involved exposure via gardens (Dadvand et al., 2015), two via woods (Reed et al., 2013; Roe & Aspinall, 2011), one via urban parks (Dadvand et al., 2015) and one via fields (Kuo et al., 2018; Wood et al., 2014). In two studies, exposure to nature was measured by surrounding nature including the method ‘normalized difference vegetation index’ (NDVI) which is a way of measuring greenness using satellite imaging (Dadvand et al., 2015; Wells, 2000). Studies included samples from different age groups: four used children between 5 and 10 (Dadvand et al., 2015; Kuo et al., 2018; Wells, 2000; Wood et al., 2014) and two used children between 11 and 15 (Reed et al., 2013; Roe & Aspinall, 2011).

In all four studies employing a control, a non-natural school setting was employed; two used children participating in a traditional indoor school environment (Kuo et al., 2018; Roe & Aspinall, 2011) and two used a concrete school yard (Reed et al., 2013; Wood et al., 2014). The most common theoretical underpinning for the studies was attention restoration theory (ART; Kuo et al., 2018; Roe & Aspinall, 2011; Wells, 2000), the remaining studies did not discuss theory.

Nature exposure could be divided into either ‘immersive’ or ‘surrounding’ nature. Immersive studies specify the participant as physically being in nature. Immersive studies use activities such as unstructured play (Wood et al., 2014) and walking, running or sitting passively in nature (Dadvand et al., 2015; Kuo et al., 2018; Reed et al., 2013; Roe & Aspinall, 2011). ‘Immersive’ studies do not purposely ‘use’ nature or make it an active component of an intervention such as in adventure therapy and gardening therapy. Surrounding nature is measured through varying methods including judgement of green views from windows and NDVI (Dadvand et al., 2015; Kuo et al., 2018; Wells, 2000).

3.2.2. Surrounding/nearby green space

Two studies used a nature condition we classify as surrounding nature. They reported various positive outcomes including improved working memory, and improved attention (Dadvand et al., 2015; Wells, 2000).

Wells (2000) presented results from a longitudinal study assessing participant’s cognitive functions before and after relocation from housing low on natural resources to housing higher on natural

resources. Natural resources were measured by a researcher who visited the house and scored various rooms on the level of built or natural environment on view from the window. In this study, 17 children from low-income urban families were visited prior to the relocation and then on average 7 months following relocation with both visits occurring during the summer. Wells (2000) found that children living in the least natural setting at initial testing improved the most in attentional capacity following the relocation. She concluded that this was due to the increase in naturalness of the home, which was a statistically significant predictor of change of attentional capacity. Indeed, general improvement in housing quality was not a predictor, suggesting that surrounding nature might account for the change. Wells (2000) concluded that improving the naturalness of young children’s homes may initiate positive change in their attentional functioning.

A more systematic method to measure surrounding greenness is normalized difference vegetation index (NDVI), which measures greenness using satellite imaging. Dadvand et al. (2015) presented a longitudinal cohort study that tracked 2593 young people from 36 schools over the course of 12 months. They measured working memory and attention and found increases in these constructs correlated with the degree of greenness, as measured by NDVI, around a school. The effects were not as strong for residential greenness and commuter greenness but overall greenness (a measure including all measures of greenness) was associated with a change in developmental trajectory of working memory and inattentiveness. They also found air quality was significant mediator. They concluded that exposure to green space was positively associated with cognitive development and this was partly mediated by exposure to less air pollution.

3.2.3. Immersion in green space

Four of the six studies had participants immerse themselves in greenspace, usually physically sitting or walking in nature (Kuo et al., 2018; Reed et al., 2013; Roe & Aspinall, 2011; Wood et al., 2014). These studies compared a nature condition to a non-natural control to highlight effects of nature. Studies generally found improved cognitive function including improved concentration, mood and on-task behaviour (Kuo et al., 2018; Roe & Aspinall, 2011). Improvements were not found in anger (Roe & Aspinall, 2011). Similarly, self-esteem was measured in two studies, but no statistically significant effects were found (Reed et al., 2013; Wood et al., 2014).

Reed et al. (2013) measured green exercise in schools and the effects on self-esteem, which involved 75 students going on a run through either an urban route or a natural route. They found no significant difference in self-esteem between conditions. One explanation is that the stress related to completing the exercise with teachers, as part of a

PE class in school mitigated any potential benefits of green exercise. It is also possible that student reporting was affected by the return to school from the natural area, which involved crossing a road and completing the assessment in the PE department. Finally, it is possible green exercise has no effect on short term outcomes of self-esteem. It is also worth noting that although the self-esteem scale used (Rosenberg, 1965) is well-validated and shows good test-retest reliability, students completed the pre-post scale within 30 min of each other. It is unlikely the Rosenberg self-esteem scale is sufficiently sensitive to identify state changes as it is more generally used to measure trait self-esteem.

Roe and Aspinall (2011) compared forest school (school activities in a forest setting) with conventional school using a cohort design with 18 young people an average age of 11 years. They hypothesised that activities in a forest setting would increase mood in young people and that young people identified as displaying poor behaviour would show improved mood and greater reflection on life tasks in the forest setting. The results showed greater positive change in mood and emotion in all students following forest school than standard school. The poor behaviour group benefitted most in all areas apart from anger. The researchers concluded that young people with poor behaviour benefit most from using natural areas in terms of restoration of mood and emotions. They were unable to account for differences in social context and varying activities across the settings and suggested that future design could account for this. Further, they highlighted that improved mood does not equate to improved behaviour and encouraged future researchers to directly explore behavioural outcomes.

In the most recent of the studies Kuo et al. (2018) compared the aftereffects of exposure to nature. They used a counterbalanced cohort design to measure young people's concentration after exposure to either i) an outdoor classroom, or ii) an indoor classroom. Lessons were matched on several variables to ensure they were comparable in all ways except location (natural vs indoor). Students concentrated better in class following a lesson in nature as opposed to following a lesson in a standard classroom.

One study measured the effects of play in nature using an experimental design. Wood et al. (2014) measured the effect of nature in the context of a school play environment. Although their main aim was to study physical activity, they also measured self-esteem. Two play conditions were i) on a school playground and ii) a playing field. Using a cross-over design, students spent one week with play-time in each condition. They found no significant differences between self-esteem following play in the two environments. One suggestion they make is that simple exposure to nature does not elevate self-esteem but a relationship of 'connection' to nature may.

3.2.4. Summary of findings

Four studies included in this review used a nature immersion versus a non-natural control design, with walking being the most common way to experience nature. The most common setting for studies was a classroom or school setting and most focused on the general population of young people of a primary school age. Overall, there are few experimental studies examining the effects of increasing nature exposure on young people, with only two studies using longitudinal designs and only four others using pre-post measures with an appropriate comparison condition.

Generally, nature exposure appeared to have a positive impact on young people, although self-esteem did not present with positive changes (Reed et al., 2013; Wood et al., 2014). Studies employing immersive and surrounding nature conditions reported improvements in attention including in reduced inattentiveness (Dadvand et al., 2015; Wells, 2000) and working memory (Dadvand et al., 2015). Other immersive studies also reported positive behavioural outcomes (Kuo et al., 2018; Roe & Aspinall, 2011). Increased exposure to nature appeared to have positive benefits on young people's behaviour and cognitive capacities (see Table 3).

4. Discussion

This review aimed to highlight the current state of research regarding the benefits of increasing young people's exposure to nature for behaviour, cognition and emotion. It aimed to gauge the 'pure' effects of nature exposure, by excluding studies that had several other integrated components (e.g. wilderness therapy or gardening). It also sought to determine the potential for nature exposure to promote change, by including longitudinal or experimental studies only. These selection criteria do not discount the importance of cross-sectional or non-experimental studies. Indeed, these strict criteria resulted in a small number of studies being included in the systematic review, highlighting a limitation of this section. However, systematically selected evidence of this specific type allowed conclusions to be drawn about the long-term effects of nature exposure.

The impact of surrounding nature on young people was positive. Studies reported improvements in attentional capacity or reduced inattentiveness. Cross-sectional research has also supported this finding. For example, in a nationwide (US) study, Kuo and Faber Taylor (2004) asked parents to rate 49 after-school activities in terms of their impact on children's ADHD symptoms. Responses showed that after controlling for several variables including age, gender and income, greener activities reduced symptoms of ADHD more than indoor or non-green activities. In addition, Markevych et al. (2014b) measured distance to green space and behavioural problems in 1932 children and found hyperactivity/inattention was positively associated with distance. These studies confirm the findings of this review that greener homes and schools may be capable of promoting improved attention in young people. Future studies are encouraged to replicate these findings and extend research to explore whether the cognitive benefits of nature exposure will have ecological validity in terms of long-term academic success (Kuo et al., 2018; Li & Sullivan, 2016) and other real life outcomes in relation to issues of urban inequality.

An immersive nature experience is well-liked by school children and appears to promote positive outcomes on attention and concentration (Kuo et al., 2018) and behaviour following or during nature immersion (Kuo et al., 2018; Roe & Aspinall, 2011). This finding is supported by previous research. Mancuso, Rizzitelli, and Azzarello (2006) included 80 students who completed the 'trail making test' which measures directed attention. Students completed this test in either i) a standard classroom or ii) an outdoor natural area. Time taken to complete the test was significantly less in groups completing it in the natural setting than in the indoor setting. They concluded that exposure to green environments, no matter how brief, may increase children's ability to direct attention. The findings from the systematic review take this conclusion further and suggests repeated immersion in nature over time may have long term effects on a child's attention, however more evidence is needed to confirm this conclusion.

Two studies measured self-esteem as a secondary dependent variable (i.e., the primary focus of both studies was on physiological effects of nature). They both found no significant differences in self-esteem following nature experiences (Reed et al., 2013; Wood et al., 2014). This finding contrasted with adult studies where self-esteem was impacted by nature exposure. It is possible that short-term exposure to nature may not influence a trait-based quality such as self-esteem, but may have more significant impacts on state-based qualities such as self-efficacy. Future studies could explore the conditions needed to promote change in self-esteem following a nature experience.

The results of this review have highlighted the lack of studies employing longitudinal or experimental designs that could identify the effects of nature exposure as a 'prescription', as has been recommended by some primary care providers in the US (Coffey & Gauderer, 2016). Only two studies were longitudinal, and these lacked an experimental design. Although compelling, the current evidence is not sufficient to conclude that 'prescribing' nature will effect long-term change in young people. Nevertheless, exposure to nature appears to have a promising

Table 3
Included studies, design and outcomes.

	Immersive (I) or Surrounding (S)	Nature Setting	Outcome and effect of nature				
			Mood	Self-esteem	Concentration/on-task behaviour	Cognitive functioning (attention)	Working memory
Roe & Aspinall, 2011	I	Forest School	Positive				
Reed et al., 2013	I	Forest running route (school)		None			
Wood et al., 2014	I	Green school playing field		None			
Kuo et al., 2018	I	Outdoor classroom			Positive		
Wells, 2000	S	Surrounding home				Positive	
Dadvand et al., 2015	S	Surrounding (NDVI) home, school and commute				Positive	Positive

positive relationship with improved emotional states and cognitive capacity, at least in the short-term.

4.1. Future directions

Although the current body of literature provides a persuasive case for the positive effects of nature exposure on young people, controlled, experimental intervention studies are needed to clarify the situation. Researchers have expressed the need to include measures of academic performance as an ecologically valid outcome. Measures such as this are vital to highlighting the usefulness of increasing or preserving natural areas around homes and schools, evidence that is important for urban policy and school design.

It may also be useful to integrate objective measures such as physiological outcomes in future studies. Portable measures of brain activity have been used in various populations indicating nature exposure may facilitate a decrease in rumination (Bratman, Hamilton, Hahn, Daily, & Gross, 2015), frustration, and effortful engagement in the environment (Aspinall, Mavros, Coyne, & Roe, 2015; Neale et al., 2017). This type of design may be useful to clarify the mechanism of long-term changes associated with exposure to nature in young people with behavioural difficulties, for example, ADHD. An ADHD diagnosis has distinguishable brain activity which can be objectively measured (Janssen et al., 2018) and brain activity has been seen to diverge following different conditions (Siripornpanich, Sampoon, Chaithirayanon, Kotchabhakdi, & Chutabhakdikul, 2018). It is possible to measure whether nature influences specific brain activity associated with ADHD symptoms, which can illuminate the mechanisms of change. It is also important, however, to use qualitative data to understand how children interpret and create meaning in their nature-based relationships as part of a social ecology of change.

Research on the effects of nature over different age groups and its effects on youth development is recommended. For example, of the six studies included in this review, four used a sample of children aged between 5 and 10 years (average of 8 years). It is important to understand the impact of nature exposure on a wider range of youth. In addition, it is important to understand how the experience of nature differs for girls and boys and which factors contribute to this. There are key, unanswered, questions about how inequalities relating to socio-economic status, gender and ethnicity influence children's access to nature, types of relationships (cultural meanings both positive and negative) and the extent of potential benefits.

Although this paper has focused on the long-term, passive benefits of nature, it is important to determine the unique impacts nature can have in children and young people, particularly in relation to the role of organised sport, outdoor recreation and leisure in society. Young people need opportunities to contribute to their peer groups, engage with their communities, and learn leadership skills, problem solving and persistence. Reviews of active nature-based activities suggest these opportunities appear to be afforded by the natural environment, but we need to understand the pathways that lead to these outcomes if we are to successfully cultivate the benefits of nature, and to make informed

recommendations to urban planners on how much and what types of nature must be considered in town planning.

4.2. Strengths and limitations

The limited geographical spread of the papers included in the systematic review means the findings may not generalise to other cultures and climates. Cross-cultural studies and longitudinal studies from a variety of cultures and climates is encouraged. A strength of this paper is its synthesis of a variety of types of nature-based research in both a narrative and systematic review. However, this review could not investigate the impact of varying types of nature or the different dosages. Although the different forms of nature exposure were included in the studies, there is not enough evidence to use this as a variable. Similarly, comparing the different measures of 'nature' or 'greenness' is limiting. NDVI is not directly comparable to self-reported levels of nature and cannot give specific information on the nature included in the study. For example, it is hard for NDVI to distinguish between species. Further reviews with wider inclusion criteria may be capable of addressing this question which will benefit urban designers trying to understand the balance needed between the natural and built environment.

5. Conclusion

The findings from our narrative review show strong substantial evidence that natural settings are associated with better performance for youth in emotional, behavioural and cognitive domains. The findings from our systematic review show the potential for benefits in exposing children to the natural environment, especially in relation to their attentional capacity, mood and memory. Passive nature exposure may even promote change in these capacities. Schools and school commuting routes should include natural environments in their design to ensure benefits reach young people. However, research must now adopt pre-post and longitudinal studies to provide persuasive evidence detailing how exposure to nature can affect the trajectory of child development, and how this might affect school success in emotional, cognitive and behavioural domains. It is also recommended that experimental trials are conducted to investigate the use of nature as an intervention or 'prescription' and that qualitative methods are used to explore how relationships with nature are influenced by social circumstances.

Considering the minimal risks involved in prescribing nature exposure (Chawla, 2015), the results favour the use of nature, especially to promote attention, cognitive performance and mood. However, more studies are needed as evidence for parents, educators and policy makers to systematically apply this potentially low cost, population-based approach to promoting wellbeing and positive outcomes.

Declaration of interest

The authors report no conflicts of interest

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Appendix A. Supplementary data

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